

Features

HARDWARE

- 8-Bit HCMOS Microcontroller
- Extended Version of MC68HC05C4A/C8A Family
 - Pin for Pin Compatible
- Power-Saving Stop, Wait and Data Retention Modes
 - STOP Instruction can be Disabled via Mask Option
- Fully Static Operation
- On-Chip Memory
 - CDP68HC05C4B, 68HCL05C4B, 68HSC05C4B
 - 176 Bytes RAM, 4160 Bytes ROM
 - CDP68HC05C8B, 68HCL05C8B, 68HSC05C8B
 - 176 Bytes RAM, 7744 Bytes ROM
- Keyboard Scanning Logic
- Watchdog Timer (COP)
- 24 Bidirectional I/O Lines and 7 Input-Only Lines
 - 1 High Current Output for LED drive (PC7)
- Internal 16-Bit Timer
- Serial Communications Interface (SCI) System
- Serial Peripheral Interface (SPI) System
- Fixed Frequency Tone/Simple PWM Outputs (Mask Programmable)
- Self-Check Mode
- External, Timer, SCI, and SPI Interrupts
- Master Reset and Power-On Reset
- On-Chip Oscillator with RC or Crystal Mask Options
- CDP68HC05C4B, CDP68HC05C8B
 - 4.2MHz Oscillator (2.1MHz Internal Bus Frequency) at 5V; 2.0MHz (1.0MHz Internal Bus) at 3.0V
 - Single 3.0V to 6.0V Supply (1.2V Data Retention Mode)
- CDP68HCL05C4B, CDP68HCL05C8B
 - Lower Supply Current, I_{DD} in RUN, WAIT and STOP Modes at 5.5V, 2.5V and 1.8V
 - Single 1.8V to 6.0V Supply (1.2V Data Retention Mode)
- CDP68HSC05C4B, CDP68HSC05C8B
 - 8.0MHz Oscillator (4.0MHz Internal Bus Frequency)
 - Single 2.4V to 6.0V Supply (1.2V Data Retention Mode)

SOFTWARE

- Complete 68HC05 Instruction Set
- Efficient Use of Program Space
- Memory Mapped I/O
- Versatile Interrupt Handling
- True Bit Manipulation
- Addressing Modes with Indexed Addressing for Accessing Tables

Description

The CDP68HC05C4B HCMOS Microcomputer is a new member of the CDP68HC05 family of low-cost single chip microcomputers. It is an enhanced version of the CDP68HC05C4. The enhancements include keyboard scanning logic, a high current output pin, a watchdog timer, fixed tone outputs, and a maskable STOP instruction. This 8-bit microcomputer unit (MCU) also contains an on-chip oscillator, CPU, 176 bytes of RAM, 4160 bytes of user ROM in the CDP68HC05C4B and 7744 bytes of user ROM in the CDP68HC05C8B, I/O, two serial interface systems, and timer. The fully static design allows operation at frequencies down to DC, further reducing its already low-power consumption. All information pertaining to the CDP68HC05C4B MCU applies to the CDP68HC05C8B with the exception of the memory description.

The CDP68HCL05C4B and CDP68HCL05C8B MCU devices are low-power versions of the CDP68HC05C4B and CDP68HC05C8B, respectively. They contain all the features of the CDP68HC05C4B and CDP68HC05C8B with additional features of lower power consumption in the RUN, WAIT and STOP modes; and low voltage operation down to 2.4V. The CDP68HSC05C4B and CDP68HSC05C8B MCU devices are high-speed versions of the CDP68HC05C4B and CDP68HC05C8B, respectively. They also contain all the features of the CDP68HC05C4B and CDP68HC05C8B with the and have a higher frequency operation (up to 8.0MHz).

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Ordering Information

PART NUMBER	PACKAGE	PKG. NO.
CDP68HC05C4BE	40 Ld PDIP	E40.6
CDP68HC05C4BN	44 Ld PLCC	N44.65
CDP68HC05C4BQ	44 Ld MQFP	Q44.10x10
CDP68HC05C4BSE	42 Ld SPDIP	E42.6C
CDP68HC05C4BD	40 Ld SBDIP	D40.6
CDP68HC05C4BH	Chip	
CDP68HCL05C4BE	40 Ld PDIP	E40.6
CDP68HCL05C4BN	44 Ld PLCC	N44.65
CDP68HCL05C4BQ	44 Ld MQFP	Q44.10x10
CDP68HCL05C4BSE	42 Ld SPDIP	E42.6C
CDP68HCL05C4BD	40 Ld SBDIP	D40.6
CDP68HCL05C4BH	Chip	
CDP68HSC05C4BE	40 Ld PDIP	E40.6
CDP68HSC05C4BN	44 Ld PLCC	N44.65
CDP68HSC05C4BQ	44 Ld MQFP	Q44.10x10
CDP68HSC05C4BSE	42 Ld SPDIP	E42.6C
CDP68HSC05C4BD	40 Ld SBDIP	D40.6
CDP68HSC05C4BH	Chip	

NOTE: Pin number references throughout this specification refer to the 40 lead DIP. See pinouts for cross reference.

ROM Ordering Information

The CDP68HC05C4B and CDP68HC05C8B families of microcontrollers contain mask programmed ROMs. The contents of these ROMs are 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 end of this document contains a sheet 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 via e-mail**
- **S-Record Formatted Hex Data File on floppy disk**
- **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). Any unspecified locations will be filled with \$00 by Harris.

Procedure for Submitting Data

When submitting data via a physical medium such as a floppy disk or EPROM, the "Ordering Information Sheet" at the end of this document 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 e-mail, the message should include the same information as that specified on the "Ordering Information Sheet".

Harris Customer Pattern Retrieval System

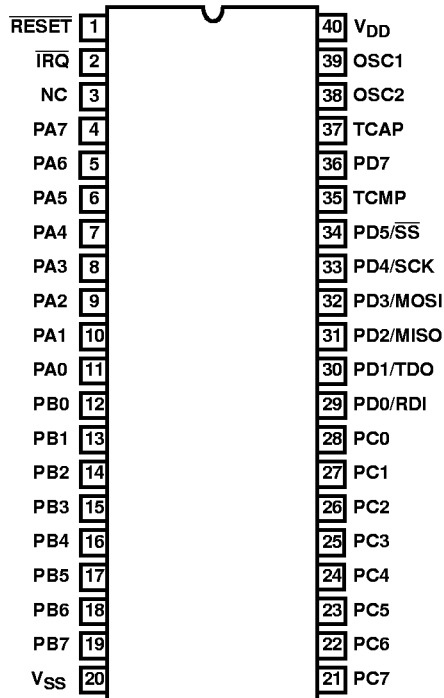
To access the Harris Customer Pattern Retrieval System, you must first obtain an account ID and password from your Harris sales representative. The system is accessed by dialing 1-908-685-6541. It is presently set to run with baud rates up to 2400 baud, with 8 data bits, 1 stop bit, and no parity bit.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

Check the Harris Corporate internet site, www.harris.com, for the latest information on the Harris Customer Pattern Retrieval System.

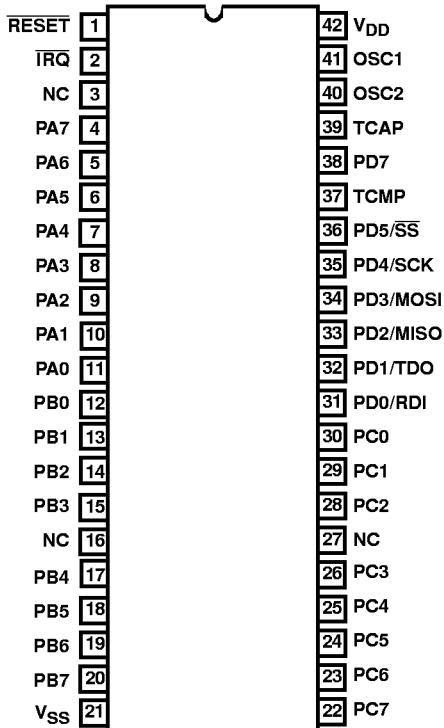
CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

Pinouts

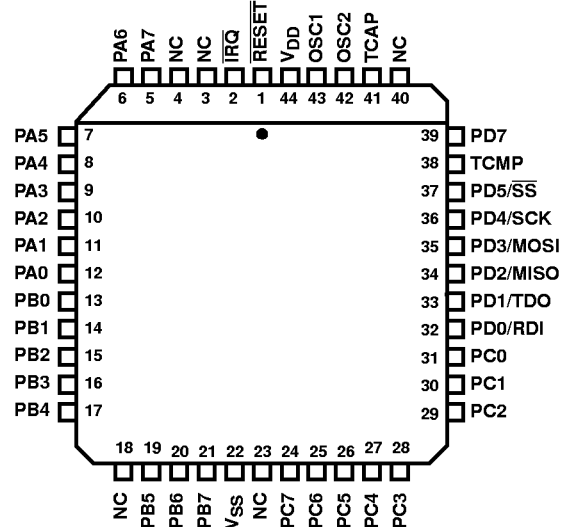
CDP68HC05C4B, CDP68HC05C8B
CDP68HCL05C4B, CDP68HCL05C8B
CDP68HSC05C4B, CDP68HSC05C8B
(SBDIP, PDIP)
TOP VIEW



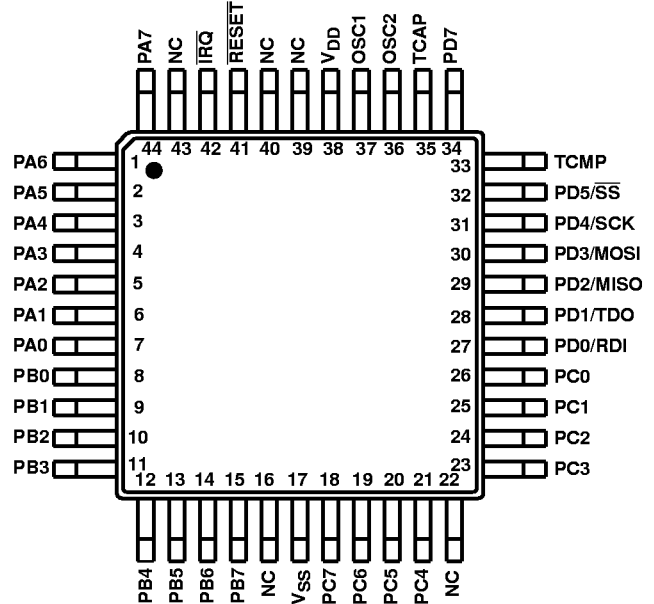
CDP68HC05C4B, CDP68HC05C8B
CDP68HCL05C4B, CDP68HCL05C8B
CDP68HSC05C4B, CDP68HSC05C8B
(SPDIP)
TOP VIEW



CDP68HC05C4B, CDP68HC05C8B
CDP68HCL05C4B, CDP68HCL05C8B
CDP68HSC05C4B, CDP68HSC05C8B
(PLCC)
TOP VIEW

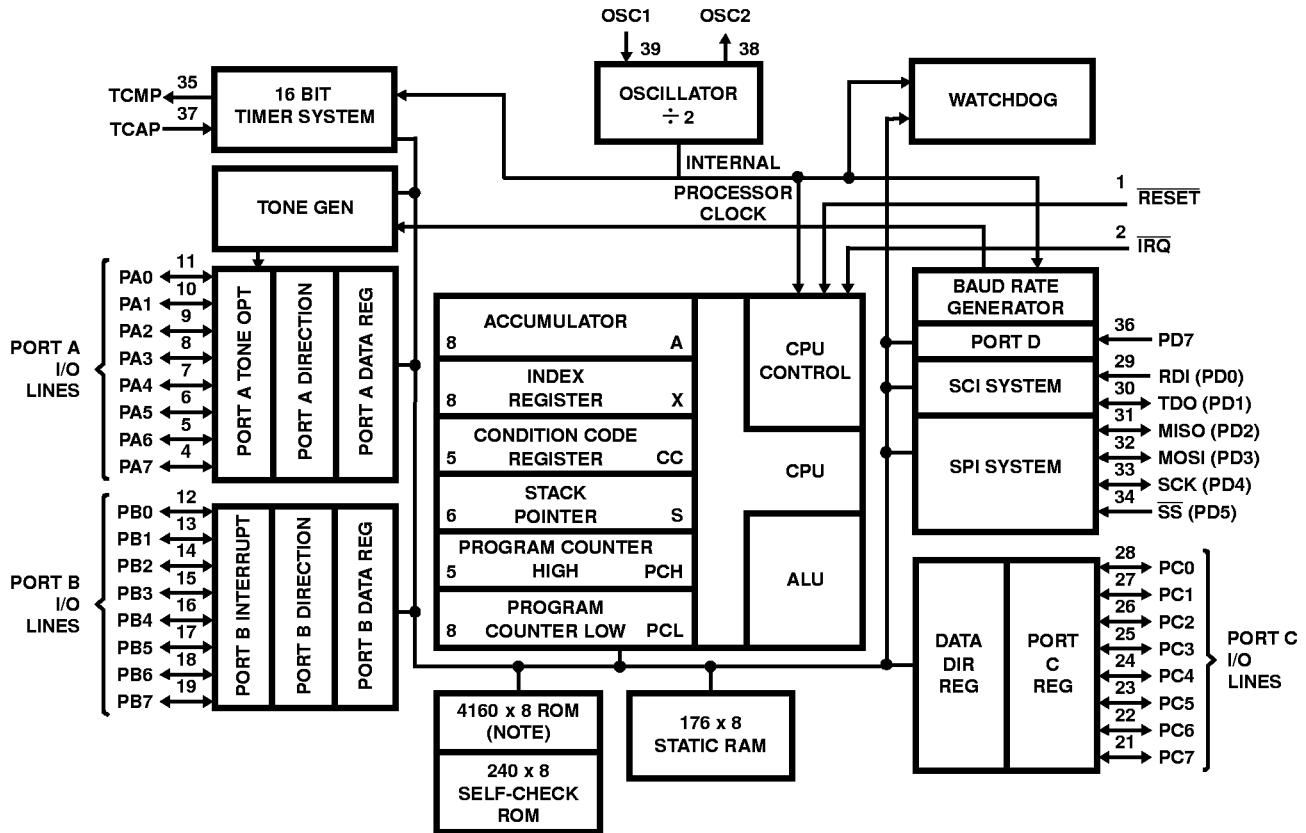


CDP68HC05C4B, CDP68HC05C8B
CDP68HCL05C4B, CDP68HCL05C8B
CDP68HSC05C4B, CDP68HSC05C8B
(MQFP)
TOP VIEW



NOTE: Low EMI Pinouts Available. Refer to Harris Tech Brief TB354 for more information

Microcomputer Block Diagram



NOTE: 7744 Bytes of ROM for: CDP68HC05C8B, CDP68HCL05C8B, CDP68HSC05C8B

Power Considerations

The average chip-junction temperature, T_J , in $^{\circ}\text{C}$ can be obtained from:

$$T_J = T_A + (P_D \cdot \theta_{JA}) \quad (\text{EQ. 1})$$

Where: T_A = Ambient Temperature, $^{\circ}\text{C}$
 θ_{JA} = Package Thermal Resistance, Junction-to-Ambient, $^{\circ}\text{C}/\text{W}$

$P_D = P_{INT} + P_{I/O}$
 $P_{INT} = I_{CC} \times V_{CC}$, Watts - Chip Internal Power
 $P_{I/O}$ = Power Dissipation on Input and Output Pins - User Determined

For most applications $P_{I/O} \ll P_{INT}$ and can be neglected.

An approximate relationship between P_D and T_J (if $P_{I/O}$ is neglected) is:

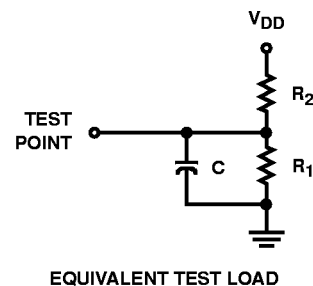
$$P_D = K \div (T_J + 273^{\circ}\text{C}) \quad (\text{EQ. 2})$$

Solving Equation 1 and Equation 2 for K gives:

$$K = P_D \cdot (T_A + 273^{\circ}\text{C}) + \theta_{JA} \cdot P_D^2 \quad (\text{EQ. 3})$$

Where K is a constant pertaining to the particular part. K can be determined from Equation 3 by measuring P_D (at equilibrium) for a known T_A . Using this value of K the values of P_D and T_J can be obtained by solving Equation 1 and Equation 2 iteratively for any value of T_A .

PINS	R1	R2	C
$V_{DD} = 4.5\text{V}$			
PA0-7, PB0-7, PC0-7, PD6	3.26k Ω	2.38k Ω	50pF
PD1-4	1.9k Ω	2.26k Ω	200pF
$V_{DD} = 3.0\text{V}$			
PA0-7, PB0-7, PC0-7, PD6	10.19k Ω	6.32k Ω	50pF
PD1-4	6k Ω	6k Ω	200pF



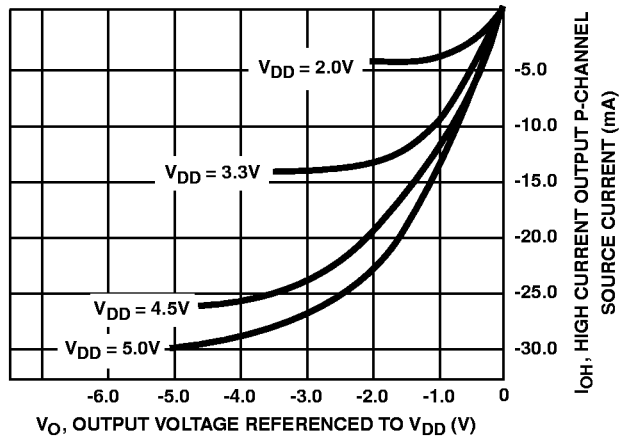


FIGURE 1A. TYPICAL PC7 PORT OUTPUT P-CHANNEL SOURCE CURRENT FOR $V_{DD} = 2V, 3.3V, 4.5V$ AND $5V$ AT $25^{\circ}C$

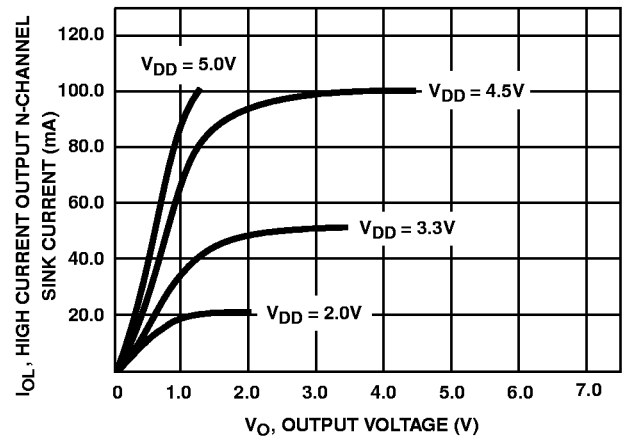


FIGURE 1B. TYPICAL PC7 PORT OUTPUT N-CHANNEL SINK CURRENT FOR $V_{DD} = 2V, 3.3V, 4.5V$ AND $5V$ AT $25^{\circ}C$

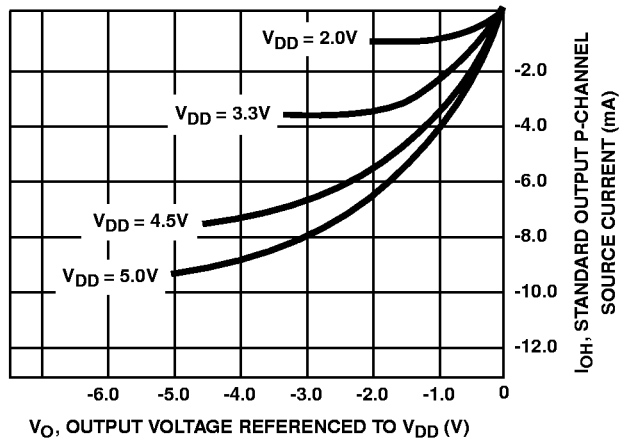


FIGURE 1C. TYPICAL PORT OUTPUT P-CHANNEL SOURCE CURRENT FOR $V_{DD} = 2V, 3.3V, 4.5V$ AND $5V$ AT $25^{\circ}C$

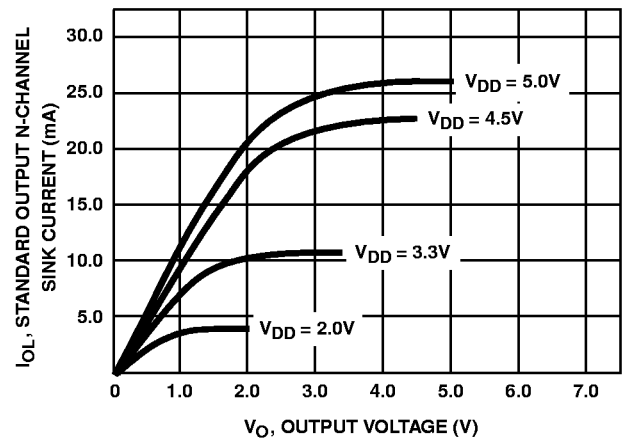


FIGURE 1D. TYPICAL PORT OUTPUT N-CHANNEL SINK CURRENT FOR $V_{DD} = 2V, 3.3V, 4.5V$ AND $5V$ AT $25^{\circ}C$

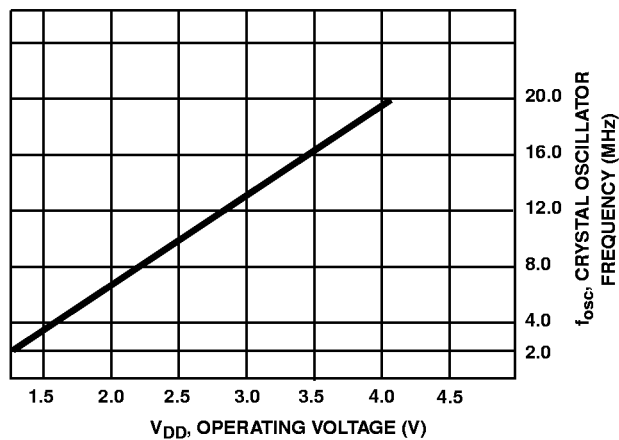


FIGURE 1E. TYPICAL CRYSTAL OSCILLATOR OPERATING FREQUENCIES vs OPERATING VOLTAGE, V_{DD} AT $25^{\circ}C$

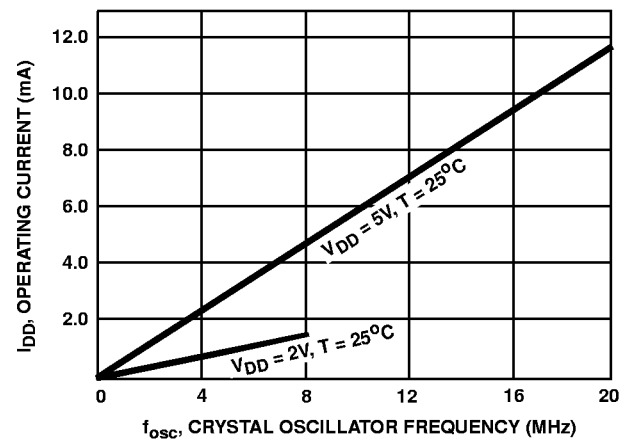


FIGURE 1F. TYPICAL SUPPLY CURRENT vs OPERATING FREQUENCY AT $25^{\circ}C$

CDP68HC05C4B/C8B Electrical Specifications

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 $2 \times V_{DD} + 0.3V$
 Current Drain Per Pin Excluding V_{DD} and V_{SS} , I 25mA

Operating Conditions

Operating Voltage Range +4.5V to +5.5V
 Operating Temperature Range -55°C to 125°C
 CDP68HC05C4B, CDP68HC05C8B -40°C to 85°C
 CDP68HCL05C4B, CDP68HCL05C8B 0°C to 70°C
 CDP68HSC05C4B, CDP68HSC05C8B -40°C to 85°C
 Input Low Voltage 0V to +0.8V

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
SPDIP Package	55	N/A
PDIP Package	55	N/A
PLCC Package	45	N/A
MQFP Package	70	N/A
SBDIP Package	45	14
Maximum Junction Temperature (Hermetic Package) 175°C		
Maximum Junction Temperature (Plastic Package) 150°C		
Maximum Storage Temperature Range -65°C to 150°C		
Maximum Lead Temperature (Soldering 10s) 300°C (PLCC, MQFP - 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 , $V_{DD} = 5.0V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HC05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^\circ C$ to $85^\circ C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.8mA$	$V_{DD} - 0.8$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -1.6mA$	$V_{DD} - 0.8$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -5.0mA$	$V_{DD} - 0.8$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 1.6mA$	-	-	0.4	V
PC7	V_{OL}	$I_{LOAD} = 10.0mA$	-	-	0.4	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^\circ C$ to $70^\circ C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 4.2MHz$ External Square Wave	-	3.5	5.25	mA
WAIT (Notes 7, 9)	I_{DD}		-	1.0	3.25	mA
STOP (Note 8)	I_{DD}	$T_A = 25^\circ C$	-	1.0	20.0	μA
STOP (Note 8)	I_{DD}	$T_A = -40^\circ C$ to $85^\circ C$	-	-	50	μA
I/O Ports Hi-Z Leakage Current:						
PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current						
RESET, IRQ, TCAP, OSC1, PD0, PD5, PD7	I_{IN}		-	-	± 1	μA
Capacitance Ports (As Input or Output) RESET, IRQ, TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		175	385	750	μA

CDP68HC05C4B/C8B Electrical Specifications

DC Electrical Specifications HC Product Type , $V_{DD} = 5.0V$ (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: \overline{RESET} , \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HC Product Type, $V_{DD} = 5.0V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HC05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^\circ C$ to $85^\circ C$				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	4.2	MHz
External Clock Option	f_{OSC}	DC	4.2	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	2.1	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	2.1	MHz
Cycle Time (See Figure 15)	t_{CYC}	476	-	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 12)	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 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH} , t_{OL}	90	-	ns

DC Electrical Specifications HC Product Type , $V_{DD} = 3.3V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HC05C4B/C8B $V_{DD} = 3.3V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^\circ C$ to $85^\circ C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.2mA$	$V_{DD} - 0.3$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -0.4mA$	$V_{DD} - 0.3$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -1.5mA$	$V_{DD} - 0.3$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 0.4mA$	-	-	0.3	V
PC7	V_{OL}	$I_{LOAD} = 6.0mA$	-	-	0.3	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V

CDP68HC05C4B/C8B Electrical Specifications

DC Electrical Specifications HC Product Type , $V_{DD} = 3.3V$ (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Low Voltage PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 2.1MHz$ External Square Wave	-	1.0	1.6	mA
WAIT (Notes 7, 9)	I_{DD}		-	0.5	0.9	mA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	8.0	μA
STOP (Note 8)	I_{DD}	$T_A = -40^{\circ}C$ to $85^{\circ}C$	-	-	20	μA
I/O Ports Hi-Z Leakage Current: PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current \overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0, PD5, PD7	I_{IN}		-	-	± 1	μA
Capacitance Ports (As Input or Output) \overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		75	175	350	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: \overline{RESET} , \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HC Product Type, $V_{DD} = 3.3V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HC05C4B/C8B $V_{DD} = 3.3V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$ (Note 2)				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	2.1	MHz
External Clock Option	f_{OSC}	DC	2.1	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	1.05	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	1.05	MHz
Cycle Time (See Figure 15)	t_{CYC}	952	-	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 12)	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 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH} , t_{OL}	200	-	ns

CDP68HCL05C4B/C8B Electrical Specifications

DC Electrical Specifications HCL Product Type, $V_{DD} = 5.0V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $70^\circ C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.8mA$	$V_{DD} - 0.8$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -1.6mA$	$V_{DD} - 0.8$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -5.0mA$	$V_{DD} - 0.8$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 1.6mA$	-	-	0.4	V
PC7	V_{OL}	$I_{LOAD} = 10.0mA$	-	-	0.4	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^\circ C$ to $70^\circ C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 4.2MHz$ External Square Wave	-	3.5	4.25	mA
WAIT (Notes 7, 9)	I_{DD}		-	1.6	2.25	mA
STOP (Note 8)	I_{DD}	$T_A = 25^\circ C$	-	1.0	15.0	μA
STOP (Note 8)	I_{DD}	$T_A = 0^\circ C$ to $70^\circ C$	-	-	25	μA
I/O Ports Hi-Z Leakage Current:						
PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current	I_{IN}		-	-	± 1	μA
\overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0, PD5, PD7						
Capacitance Ports (As Input or Output) \overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		5		250	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: \overline{RESET} , \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HCL Product Type, $V_{DD} = 5.0V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $70^\circ C$				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	4.2	MHz
External Clock Option	f_{OSC}	DC	4.2	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	2.1	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	2.1	MHz

CDP68HCL05C4B/C8B Electrical Specifications

Control Timing HCL Product Type, $V_{DD} = 5.0V$ (Continued)

PARAMETER	SYMBOL	MIN	MAX	UNITS
Cycle Time (See Figure 15)	t_{CYC}	476	-	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
RESET Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 12)	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 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	90	-	ns

DC Electrical Specifications HCL Product Type, $V_{DD} = 2.5V - 3.6V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 2.5V - 3.6V \pm 10\%$, $V_{SS} = 0V$, $T_A = 0^{\circ}C$ to $70^{\circ}C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.2mA$	$V_{DD} - 0.3$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -0.4mA$	$V_{DD} - 0.3$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -1.5mA$	$V_{DD} - 0.3$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 0.4mA$	-	-	0.3	V
PC7	V_{OL}	$I_{LOAD} = 6.0mA$	-	-	0.3	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 2.1MHz$ External Square Wave	-	1.0	1.4	mA
WAIT (Notes 7, 9)	I_{DD}		-	0.7	1.0	mA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	5.0	μA
STOP (Note 8)	I_{DD}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	-	-	10	μA
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 1.0MHz$ External Square Wave	-	0.5	0.75	mA
WAIT (Notes 7, 9)	I_{DD}		-	0.3	0.5	mA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	5.0	μA
STOP (Note 8)	I_{DD}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	-	-	10	μA

CDP68HCL05C4B/C8B Electrical Specifications

DC Electrical Specifications HCL Product Type, $V_{DD} = 2.5V - 3.6V$ (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
I/O Ports Hi-Z Leakage Current: PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current RESET, IRQ, TCAP, OSC1, PD0, PD5, PD7	I_{IN}		-	-	± 1	μA
Capacitance Ports (As Input or Output) RESET, IRQ, TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		40	160	300	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: RESET, IRQ, OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HCL Product Type, $V_{DD} = 2.4V - 3.6V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 2.4V$ to $3.6V$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $70^\circ C$ ($V_{DC} = 3.6$)				
Frequency Of Operation Crystal Option	f_{OSC}	-	2.1	MHz
External Clock Option	f_{OSC}	DC	2.1	MHz
Internal Operating Frequency Crystal ($f_{OSC} \div 2$)	f_{OP}	-	1.05	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	1.05	MHz
Cycle Time (See Figure 15)	t_{CYC}	952	-	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
RESET Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer Resolution (Note 12)	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 11)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	250	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 13)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	200	-	ns

DC Electrical Specifications HCL Product Type, $V_{DD} = 1.8V - 2.4V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 1.8V - 2.4V$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $70^\circ C$, 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, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.1mA$	$V_{DD} - 0.3$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -0.2mA$	$V_{DD} - 0.3$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -0.75mA$	$V_{DD} - 0.3$	-	-	V

CDP68HCL05C4B/C8B Electrical Specifications

DC Electrical Specifications HCL Product Type, $V_{DD} = 1.8V - 2.4V$ (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 0.2mA$	-	-	0.3	V
PC7	V_{OL}	$I_{LOAD} = 2.0mA$	-	-	0.3	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , RESET, OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , RESET, OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 1.0MHz$ External Square Wave	-	300	600	μA
WAIT (Notes 7, 9)	I_{DD}		-	250	400	μA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	2.0	μA
STOP (Note 8)	I_{DD}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	-	-	5.0	μA
I/O Ports Hi-Z Leakage Current:						
PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current						
RESET, \overline{IRQ} , TCAP, OSC1, PD0, PD5, PD7	I_{IN}		-	-	± 1	μA
Capacitance Ports (As Input or Output)						
RESET, \overline{IRQ} , TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		15	110	200	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: RESET, \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HCL Product Type, $V_{DD} = 1.8V - 2.4V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HCL05C4B/C8B $V_{DD} = 1.8V$ to $2.4V$, $V_{SS} = 0V$, $T_A = 0^{\circ}C$ to $70^{\circ}C$ ($V_{DC} = 2.4$)				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	1.0	MHz
External Clock Option	f_{OSC}	DC	1.0	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	0.5	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	0.5	MHz
Cycle Time (See Figure 15)	t_{CYC}	2000	-	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
RESET Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}

CDP68HCL05C4B/C8B Electrical Specifications

Control Timing HCL Product Type, $V_{DD} = 1.8V - 2.4V$ (Continued)

PARAMETER	SYMBOL	MIN	MAX	UNITS
Timer				
Resolution (Note 12)	t_{RES}	4.0	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	500	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	500	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	400	-	ns

CDP68HSC05C4B/C8B Electrical Specifications

DC Electrical Specifications HSC Product Type, $V_{DD} = 5.0V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HSC05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} < 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.8mA$	$V_{DD} - 0.8$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -1.6mA$	$V_{DD} - 0.8$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -5.0mA$	$V_{DD} - 0.8$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 1.6mA$	-	-	0.4	V
PC7	V_{OL}	$I_{LOAD} = 10.0mA$	-	-	0.4	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, \overline{IRQ} , \overline{RESET} , OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 8.0MHz$ External Square Wave	-	7.0	11.0	mA
WAIT (Notes 7, 9)	I_{DD}		-	2.0	6.5	mA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	20.0	μA
STOP (Note 8)	I_{DD}	$T_A = -40^{\circ}C$ to $85^{\circ}C$	-	-	50	μA
I/O Ports Hi-Z Leakage Current:						
PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current	I_{IN}		-	-	± 1	μA
\overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0, PD5, PD7						
Capacitance Ports (As Input or Output)	C_{OUT}		-	-	12	pF
\overline{RESET} , \overline{IRQ} , TCAP, OSC1, PD0-5, PD7	C_{IN}		-	-	8	pF
Input Pullup Current (Note 10)	I_{IN}		175	385	750	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: \overline{RESET} , \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HSC Product Type, $V_{DD} = 5.0V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HSC05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$ (Note 2)				
Frequency Of Operation				
Crystal Option	f_{OSC}	-	8.2	MHz
External Clock Option	f_{OSC}	DC	8.2	MHz
Internal Operating Frequency				
Crystal ($f_{OSC} \div 2$)	f_{OP}	-	4.1	MHz
External Clock ($f_{OSC} \div 2$)	f_{OP}	DC	4.1	MHz

CDP68HSC05C4B/C8B Electrical Specifications

Control Timing HSC Product Type, $V_{DD} = 5.0V$ (Continued)

PARAMETER	SYMBOL	MIN	MAX	UNITS
Cycle Time (See Figure 15)	t_{CYC}	244	-	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
RESET Pulse Width (See Figure 15)	t_{RL}	1.5	-	t_{CYC}
Timer				
Resolution (Note 12)	t_{RES}	4	-	t_{CYC}
Input Capture Pulse Width (See Figures 2, 23)	t_{TH}, t_{TL}	64	-	ns
Input Capture Pulse Period (See Figures 2, 23)	t_{TLTL}	(Note 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	64	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH}, t_{OL}	50	-	ns

DC Electrical Specifications HSC Product Type, $V_{DD} = 2.6V - 3.6V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CDP68HSC05C4B/C8B $V_{DD} = 2.4V - 3.6V$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$ (Note 2)						
Output Voltage	V_{OL}	$I_{LOAD} \leq 10\mu A$	-	-	0.1	V
	V_{OH}		$V_{DD} - 0.1$	-	-	V
Output High Voltage						
PA0-7, PB0-7, PC0-6, TCMP	V_{OH}	$I_{LOAD} = -0.2mA$	$V_{DD} - 0.3$	-	-	V
PD1-4	V_{OH}	$I_{LOAD} = -0.4mA$	$V_{DD} - 0.3$	-	-	V
PC7	V_{OH}	$I_{LOAD} = -1.5mA$	$V_{DD} - 0.3$	-	-	V
Output Low Voltage						
PA0-7, PB0-7, PC0-6, PD1-4, TCMP	V_{OL}	$I_{LOAD} = 0.4mA$	-	-	0.3	V
PC7	V_{OL}	$I_{LOAD} = 6.0mA$	-	-	0.3	V
Input High Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IH}		$0.7 \cdot V_{DD}$	-	V_{DD}	V
Input Low Voltage						
PA0-7, PB0-7, PC0-7, PD0-5, PD7, TCAP, IRQ, RESET, OSC1	V_{IL}		V_{SS}	-	$0.2 \cdot V_{DD}$	V
Data Retention Mode	V_{RM}	$T_A = 0^{\circ}C$ to $70^{\circ}C$	1.2	-	-	V
Supply Current						
RUN (Note 6)	I_{DD}	$f_{OSC} = 4.2MHz$ External Square Wave	-	2.5	4.0	mA
WAIT (Notes 7, 9)	I_{DD}		-	1.0	2.0	mA
STOP (Note 8)	I_{DD}	$T_A = 25^{\circ}C$	-	1.0	8.0	μA
STOP (Note 8)	I_{DD}	$T_A = -40^{\circ}C$ to $85^{\circ}C$	-	-	20	μA
I/O Ports Hi-Z Leakage Current:						
PA0-7, PB0-7 (without pullups), PC0-7, PD1-4	I_{OZ}		-	-	± 10	μA
Input Current						
RESET, IRQ, TCAP, OSC1, PD0, PD5, PD7	I_{IN}		-	-	± 1	μA
Capacitance Ports (As Input or Output)						
RESET, IRQ, TCAP, OSC1, PD0-5, PD7	C_{OUT}		-	-	12	pF
	C_{IN}		-	-	8	pF

CDP68HSC05C4B/C8B Electrical Specifications

DC Electrical Specifications HSC Product Type, $V_{DD} = 2.6V - 3.6V$

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Pullup Current (Note 10)	I_{IN}		50	160	350	μA
Input Hysteresis Voltage: PB0-7	V_{HYS}		-	0.5	-	V
Input Hysteresis Voltage: \overline{RESET} , \overline{IRQ} , OSC1, TCAP	V_{HYS}		$0.1 \cdot V_{DD}$	1.0	$0.5 \cdot V_{DD}$	V

Control Timing HSC Product Type, $V_{DD} = 2.4V - 3.6V$

PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HSC05C4B/C8B $V_{DD} = 2.4V - 3.6V$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$ (Note 2)				
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}	476	-	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 12)	t_{RES}	4.0	-	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 13)	-	t_{CYC}
Interrupt Pulse Width Low (Edge-Triggered) (See Figure 16B)	t_{ILIH}	125	-	ns
Interrupt Pulse Period (See Figure 16B)	t_{ILIH}	(Note 11)	-	t_{CYC}
OSC1 Pulse Width	t_{OH} , t_{OL}	90	-	ns

NOTES:

- 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 $V_{SS} < (V_{IN} \text{ or } V_{OUT}) < V_{DD}$. 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}).
- Includes ports used as input/output pins; Ports used as input only pins, Ports used as output only pins.
- All values shown reflect average measurement.
- Typical values at midpoint of voltage range, $25^{\circ}C$ only.
- 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.
- Wait, Stop I_{DD} : All ports configured as inputs, $V_{IL} = 0.2V$, $V_{IH} = V_{DD} - 0.2V$.
- Stop I_{DD} measured with OSC1 = V_{SS} .
- Wait I_{DD} is affected linearly by the OSC2 capacitance.
- Input pullup current measured with $V_{IL} = 0.2V$.
- 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} .
- 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.
- 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} .

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

Serial Peripheral Interface (SPI) Timing - HC, HCL Product Type, $V_{DD} = 5.0V$

NUMBER	PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = -40^{\circ}C$ to $85^{\circ}C$, Unless Otherwise Specified					
	Operating Frequency				
	Master	$f_{OP(M)}$	DC	0.5	f_{OP} (Note 16)
	Slave	$f_{OP(S)}$	DC	2.1	MHz
1	Cycle Time				
	Master	$t_{CYC(M)}$	2.0	-	t_{CYC}
	Slave	$t_{CYC(S)}$	480	-	ns
2	Enable Lead Time				
	Master	$t_{LEAD(M)}$	(Note 14)	-	-
	Slave	$t_{LEAD(S)}$	240	-	ns
3	Enable Lag Time				
	Master	$t_{LAG(M)}$	(Note 14)	-	-
	Slave	$t_{LAG(S)}$	720	-	ns
4	Clock (SCK) High Time				
	Master	$t_{W(SCKH)M}$	340	-	ns
	Slave	$t_{W(SCKH)S}$	190	-	ns
5	Clock (SCK) Low Time				
	Master	$t_{W(SCKL)M}$	340	-	ns
	Slave	$t_{W(SCKL)S}$	190	-	ns
6	Data Setup Time (Inputs)				
	Master	$t_{SU(M)}$	100	-	ns
	Slave	$t_{SU(S)}$	100	-	ns
7	Data Hold Time (Inputs)				
	Master	$t_{H(M)}$	100	-	ns
	Slave	$t_{H(S)}$	100	-	ns
8	Access Time (Time to Data Active from High Impedance State)				
	Slave	t_A	0	120	ns
9	Disable Time (Hold Time to High Impedance State)				
	Slave	t_{DIS}	-	240	ns
10	Data Valid Time				
	Master (Before Capture Edge)	$t_{V(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge) (Note 15)	$t_{V(S)}$	-	240	ns
11	Data Hold Time (Outputs)				
	Master (After Capture Edge)	$t_{HO(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge)	$t_{HO(S)}$	0	-	ns
12	Rise Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{R(M)}$	-	100	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{R(S)}$	-	2.0	μs
13	Fall Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{F(M)}$	-	100	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{F(S)}$	-	2.0	μs

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

Serial Peripheral Interface (SPI) Timing - HC, HCL Product Type, $V_{DD} = 3.3V$

NUMBER	PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B $V_{DD} = 3.3V \pm 10\%$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $70^\circ C$, Unless Otherwise Specified					
	Operating Frequency Master	$f_{OP(M)}$	DC	0.5	f_{OP} (Note 16)
	Slave	$f_{OP(S)}$	DC	1.0	MHz
1	Cycle Time Master	$t_{CYC(M)}$	2.0	-	t_{CYC}
	Slave	$t_{CYC(S)}$	1.0	-	μs
2	Enable Lead Time Master	$t_{LEAD(M)}$	(Note 14)	-	-
	Slave	$t_{LEAD(S)}$	500	-	ns
3	Enable Lag Time Master	$t_{LAG(M)}$	(Note 14)	-	-
	Slave	$t_{LAG(S)}$	1.5	-	μs
4	Clock (SCK) High Time Master	$t_{W(SCKH)M}$	720	-	ns
	Slave	$t_{W(SCKH)S}$	400	-	ns
5	Clock (SCK) Low Time Master	$t_{W(SCKL)M}$	720	-	ns
	Slave	$t_{W(SCKL)S}$	400	-	ns
6	Data Setup Time (Inputs) Master	$t_{SU(M)}$	200	-	ns
	Slave	$t_{SU(S)}$	200	-	ns
7	Data Hold Time (Inputs) Master	$t_{H(M)}$	200	-	ns
	Slave	$t_{H(S)}$	200	-	ns
8	Access Time (Time to Data Active from High Impedance State) Slave	t_A	0	250	ns
9	Disable Time (Hold Time to High Impedance State) Slave	t_{DIS}	-	500	ns
10	Data Valid Time Master (Before Capture Edge)	$t_{V(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge) (Note 15)	$t_{V(S)}$	-	500	ns
11	Data Hold Time (Outputs) Master (After Capture Edge)	$t_{HO(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge)	$t_{HO(S)}$	0	-	ns
12	Rise Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$) SPI Outputs (SCK, MOSI, MISO)	$t_{R(M)}$	-	200	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{R(S)}$	-	2.0	μs
13	Fall Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$) SPI Outputs (SCK, MOSI, MISO)	$t_{F(M)}$	-	200	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{F(S)}$	-	2.0	μs

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

Serial Peripheral Interface (SPI) Timing - HSC, $V_{DD} = 5.0V$

NUMBER	PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HSC05C4B/C8B $V_{DD} = 5V \pm 10\%$, $V_{SS} = 0V$, $T_A = 0^\circ C$ to $85^\circ C$, Unless Otherwise Specified					
	Operating Frequency				
	Master	$f_{OP(M)}$	DC	0.5	f_{OP} (Note 16)
	Slave	$f_{OP(S)}$	DC	4.1	MHz
1	Cycle Time				
	Master	$t_{CYC(M)}$	2.0	-	t_{CYC}
	Slave	$t_{CYC(S)}$	244	-	ns
2	Enable Lead Time				
	Master	$t_{LEAD(M)}$	(Note 14)	-	-
	Slave	$t_{LEAD(S)}$	122	-	ns
3	Enable Lag Time				
	Master	$t_{LAG(M)}$	(Note 14)	-	-
	Slave	$t_{LAG(S)}$	366	-	ns
4	Clock (SCK) High Time				
	Master	$t_{W(SCKH)M}$	166	-	ns
	Slave	$t_{W(SCKH)S}$	93	-	ns
5	Clock (SCK) Low Time				
	Master	$t_{W(SCKL)M}$	166	-	ns
	Slave	$t_{W(SCKL)S}$	93	-	ns
6	Data Setup Time (Inputs)				
	Master	$t_{SU(M)}$	49	-	ns
	Slave	$t_{SU(S)}$	49	-	ns
7	Data Hold Time (Inputs)				
	Master	$t_{H(M)}$	49	-	ns
	Slave	$t_{H(S)}$	49	-	ns
8	Access Time (Time to Data Active from High Impedance State)				
	Slave	t_A	0	61	ns
9	Disable Time (Hold Time to High Impedance State)				
	Slave	t_{DIS}	-	122	ns
10	Data Valid Time				
	Master (Before Capture Edge)	$t_{V(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge) (Note 15)	$t_{V(S)}$	-	122	ns
11	Data Hold Time (Outputs)				
	Master (After Capture Edge)	$t_{HO(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge)	$t_{HO(S)}$	0	-	ns
12	Rise Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{R(M)}$	-	50	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{R(S)}$	-	1.0	μs
13	Fall Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{F(M)}$	-	50	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{F(S)}$	-	1.0	μs

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

Serial Peripheral Interface (SPI) Timing - HSC, $V_{DD} = 2.4V - 3.6V$

NUMBER	PARAMETER	SYMBOL	MIN	MAX	UNITS
CDP68HSC05C4B/C8B, $V_{DD} = 2.4V$ to $3.6V$, $V_{SS} = 0V$, $T_A = 0^{\circ}C$ to $85^{\circ}C$ Unless Otherwise Specified					
	Operating Frequency				
	Master	$f_{OP(M)}$	DC	0.5	f_{OP} (Note 16)
	Slave	$f_{OP(S)}$	DC	2.1	MHz
1	Cycle Time				
	Master	$t_{CYC(M)}$	2.0	-	t_{CYC}
	Slave	$t_{CYC(S)}$	480	-	ns
2	Enable Lead Time				
	Master	$t_{LEAD(M)}$	(Note 14)	-	-
	Slave	$t_{LEAD(S)}$	240	-	ns
3	Enable Lag Time				
	Master	$t_{LAG(M)}$	(Note 14)	-	-
	Slave	$t_{LAG(S)}$	720	-	ns
4	Clock (SCK) High Time				
	Master	$t_{W(SCKH)M}$	340	-	ns
	Slave	$t_{W(SCKH)S}$	190	-	ns
5	Clock (SCK) Low Time				
	Master	$t_{W(SCKL)M}$	340	-	ns
	Slave	$t_{W(SCKL)S}$	190	-	ns
6	Data Setup Time (Inputs)				
	Master	$t_{SU(M)}$	100	-	ns
	Slave	$t_{SU(S)}$	100	-	ns
7	Data Hold Time (Inputs)				
	Master	$t_{H(M)}$	100	-	ns
	Slave	$t_{H(S)}$	100	-	ns
8	Access Time (Time to Data Active from High Impedance State)				
	Slave	t_A	0	120	ns
9	Disable Time (Hold Time to High Impedance State)				
	Slave	t_{DIS}	-	240	ns
10	Data Valid Time				
	Master (Before Capture Edge)	$t_{V(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge) (Note 15)	$t_{V(S)}$	-	240	ns
11	Data Hold Time (Outputs)				
	Master (After Capture Edge)	$t_{HO(M)}$	0.25	-	$t_{CYC(M)}$
	Slave (After Enable Edge)	$t_{HO(S)}$	0	-	ns
12	Rise Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{R(M)}$	-	100	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{R(S)}$	-	2.0	μs
13	Fall Time ($V_{DD} = 20\%$ to 70% , $C_L = 200pF$)				
	SPI Outputs (SCK, MOSI, MISO)	$t_{F(M)}$	-	100	ns
	SPI Inputs (SCK, MOSI, MISO, \overline{SS})	$t_{F(S)}$	-	2.0	μs

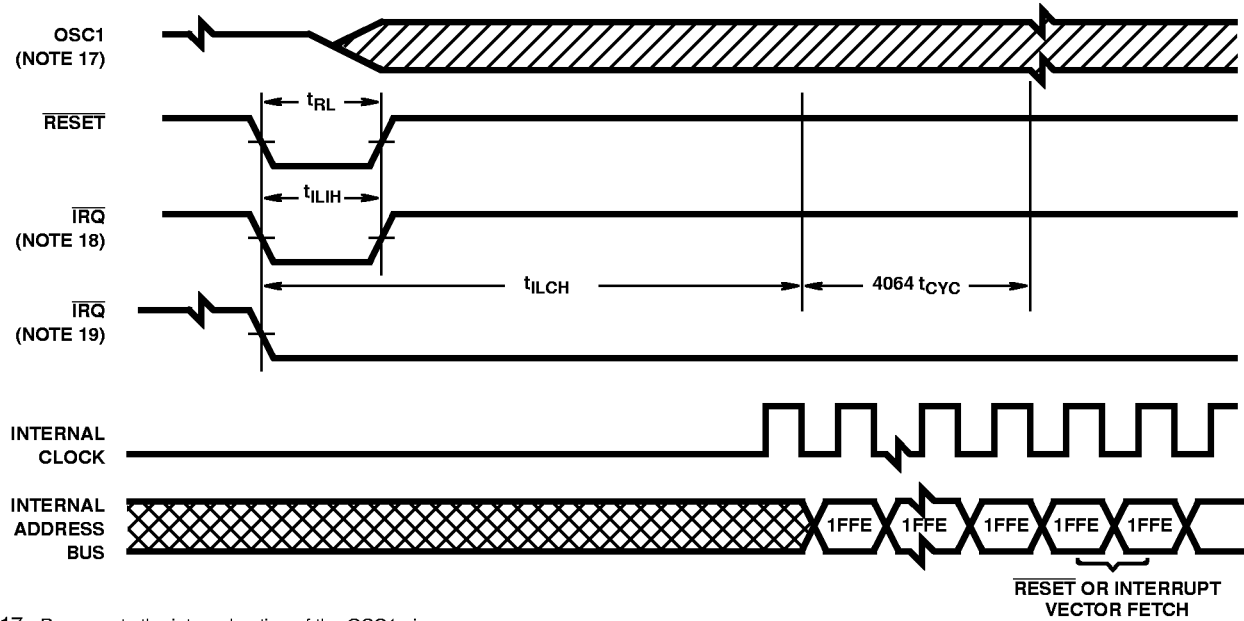
NOTES:

14. Signal Production depends on software.

15. Assumes 200pF load on all SPI pins.

16. Note that the units this specification uses is f_{OP} (internal operating frequency), not MHz! In the master mode the SPI bus is capable of running at one-half of the device's internal operating frequency, therefore 5V: 2.0MHz and 2.4V to 3.6V: 500kHz maximum.

Waveforms



- 17. Represents the internal gating of the OSC1 pin
- 18. $\overline{\text{IRQ}}$ pin edge-sensitive mask option
- 19. $\overline{\text{IRQ}}$ pin level and edge-sensitive mask option

FIGURE 2. STOP RECOVERY TIMING DIAGRAM

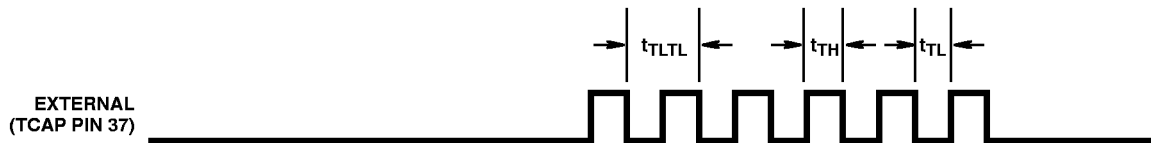


FIGURE 3. TIMER RELATIONSHIPS

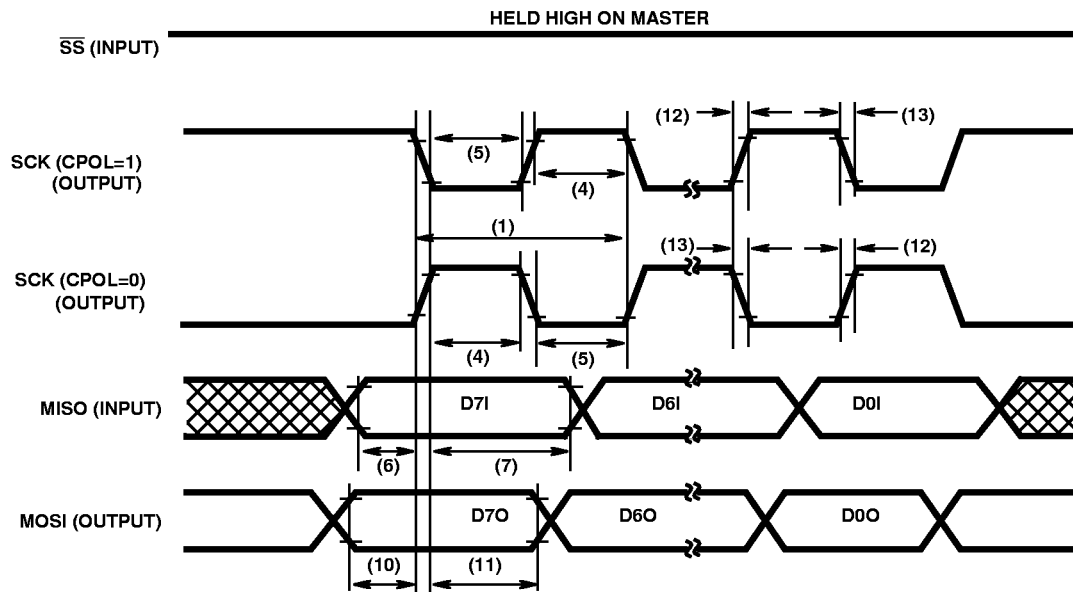


FIGURE 4A. SPI MASTER TIMING CPHA = 0

Waveforms (Continued)

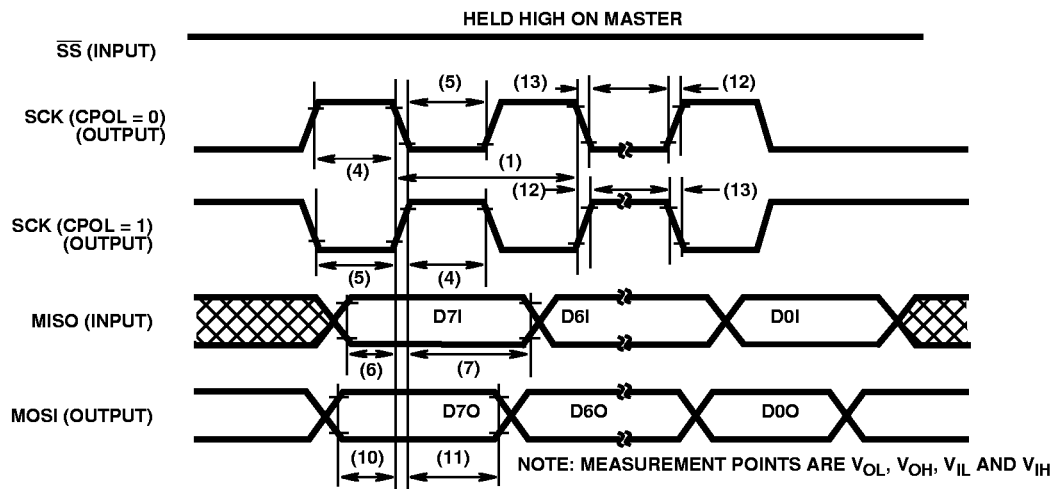


FIGURE 4B. SPI MASTER TIMING CPHA = 0

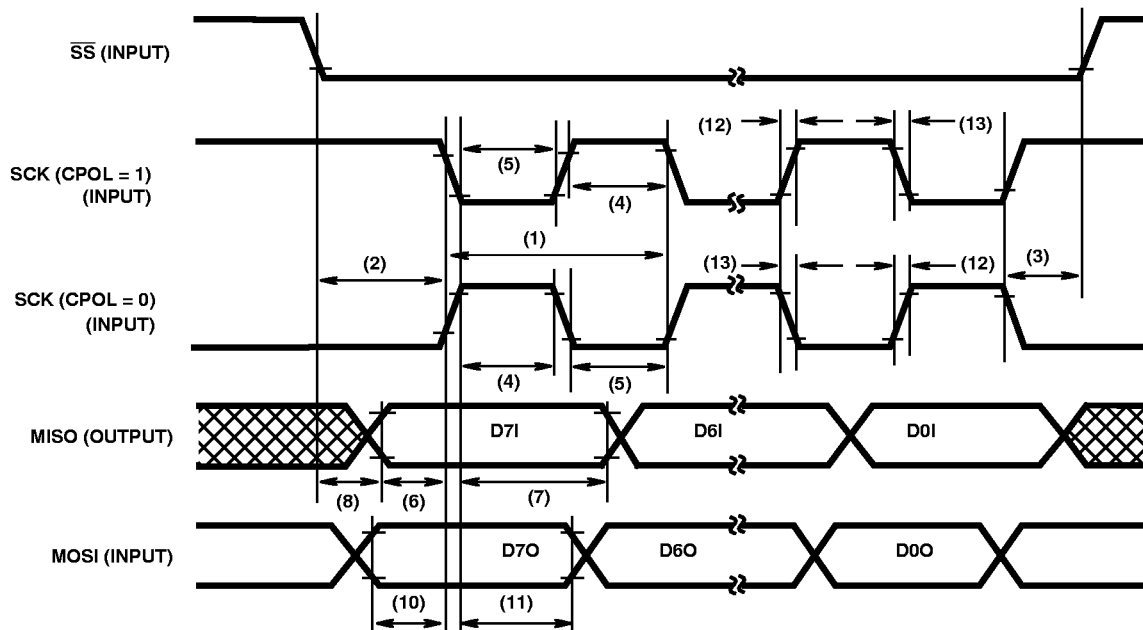


FIGURE 4C. SPI SLAVE TIMING CPHA = 0

Waveforms (Continued)

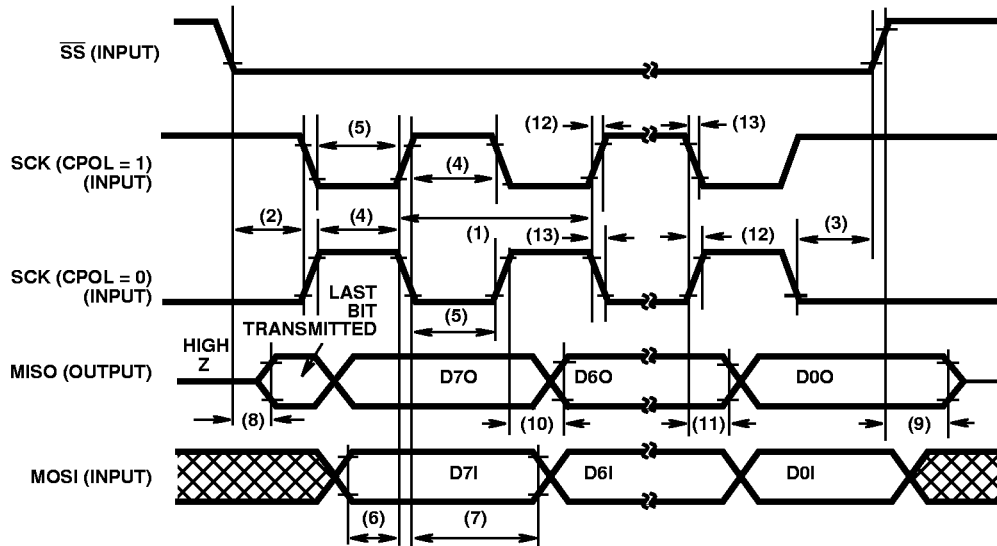


FIGURE 4D. SPI SLAVE TIMING CPHA = 1

Functional Pin Description

V_{DD} and V_{SS}

Power is supplied to the MCU using these two pins. V_{DD} is power and V_{SS} is ground.

$\overline{\text{IRQ}}$ (Maskable Interrupt Request)

$\overline{\text{IRQ}}$ is a programmable option which provides two different choices of interrupt triggering sensitivity. 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 $\overline{\text{IRQ}}$ pin will produce the interrupt. The MCU completes the current instruction before it responds to the interrupt request. When the $\overline{\text{IRQ}}$ pin goes low for at least one t_{LH} , 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.

If the option is selected to include level-sensitive triggering, then the $\overline{\text{IRQ}}$ input requires an external resistor to V_{DD} for "wire-OR" operation. See **Resets, Interrupts and Low Power Modes** for more detail concerning interrupts.

RESET

The RESET input is not required for startup but can be used to reset the MCU internal state and provide an orderly software startup 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 (35) 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 CDP68HC05C4B family of MCUs can be configured to accept either a crystal input or an RC network to control the internal oscillator. The internal clocks are derived by a divide-by-two of the internal oscillator frequency (f_{OSC}).

Crystal

The circuit shown in Figure 5B 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 startup stabilization time. Refer to DC 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 5B is recommended when using a ceramic resonator. Figure 5A lists the recommended capacitance and feedback resistance values. The manufacturer of the particular ceramic resonator being considered should be consulted for specific information.

RC

If the RC oscillator option is selected, then a resistor is connected to the oscillator pins as shown in Figure 5D.

External Clock

An external clock should be applied to the OSC1 input with the OSC2 input not connected, as shown in Figure 4E. An external clock may be used with either the RC or crystal

oscillator option. The t_{OXOV} or t_{LCH} specifications do not apply when using an external clock input. The equivalent specification of the external clock source should be used in lieu of t_{OXOV} or t_{LCH} .

PA0 - PA7

These eight I/O lines comprise port A. The state of any pin is software programmable and all port A lines are configured as inputs during power-on or reset. Port A pins PA7 - PA4 are mask programmable to provide fixed tone/simple PWM outputs. The port A data register (PORTA) is at location \$0000 and the port A data direction register (DDRA) is at location \$0004. Refer to **Input/Output Programming** paragraph for a detailed description of I/O programming.

PB0 - PB7

These eight lines comprise port B. The state of any pin is software programmable and all port B lines are configured

PD0 - PD5, PD7

These seven lines comprise port D, a fixed input port that is enabled during power-on. Two of the CDP68HC05C4B's subblocks make use of the pins on this port. Four of the lines, PD2/MISO, PD3/MOSI, PD4/SCK, and PD5/SS, are used for the serial peripheral interface (SPI). Two of these lines, PD0/RDI and PD1/TD0, are used for the serial com-

as inputs during power-on or reset. Each of the port B pins has a mask programmable interrupt and pullup option. This makes port B ideal for keyboard scanning. The port B data register (PORTB) is at location \$0001 and the port B data direction register (DDRB) is at location \$0005. Refer to **Input/Output Programming** paragraph for a detailed description of I/O programming.

PC0 - PC7

These eight lines comprise port C. The state of any pin is software programmable and all port C lines are configured as inputs during power-on reset. PC7 has a high current sink and source output stage. The port C data register (PORTC) is at location \$0002 and the port C data direction register (DDRC) is at location \$0006. Refer to **Input/Output Programming** paragraph for a detailed description of I/O programming.

munications interface (SCI). Both the SCI and the SPI systems are disabled during power-on or reset configuring all pins as inputs. The port D data register (PORTD) is at location \$0003. Port D does not have a data direction register. Refer to **Input/Output Programming** for a detailed description of I/O programming.

CRYSTAL

	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	M Ω
Q	30	40	K

CERAMIC RESONATOR

	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	M Ω
Q	1250	-

FIGURE 5A. CRYSTAL/CERAMIC RESONATOR PARAMETERS

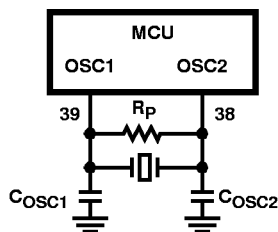


FIGURE 5B. CRYSTAL OSCILLATOR CONNECTIONS

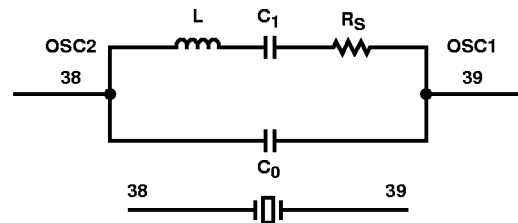


FIGURE 5C. EQUIVALENT CRYSTAL CIRCUIT

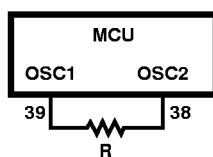


FIGURE 5D. RC OSCILLATOR CONNECTIONS

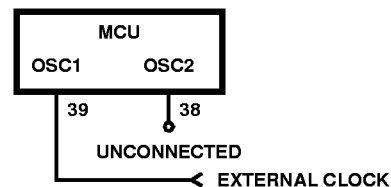


FIGURE 5E. EXTERNAL CLOCK SOURCE CONNECTIONS

Input/Output Programming

Bidirectional Parallel Ports A, B, and C

Each I/O pin of ports A, B, and C can be programmed as an input or an output under software control. Each 8-bit port has an 8-bit data register (PORTn) and an associated 8-bit data direction register (DDRn). The direction of the pins is determined by the state of the corresponding bit in the DDRn.

TABLE 1. I/O PIN FUNCTIONS

(NOTE 20) R/W	DDRn BIT	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 an output mode. The output data latch is read.

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

The data direction registers are capable of being written to or read by the processor. Refer to Figure 6 and Table 1. Any port A, port B, or port C pin is configured as an output if its corresponding DDRn bit is set to a logic one. When configured as an output, the pin will be driven to V_{DD} if the associated PORTn bit is a 1 and it will be driven to V_{SS} if the associated PORTn bit is a 0. During the programmed output state, a read of the data register actually reads the value of the output data latch and not the I/O pin (see Figure 6A).

At power-on or reset, all DDR bits are cleared, which configures all port A, B, and C pins as inputs.

Port A4 - A7 Tone/Simple PWM Output Option

In addition to being a standard bidirectional port, four bits of Port A (PA4 - PA7) have a mask option to connect an internal "tone" signal to the output (see Figure 6D). When the option is selected a fixed frequency will appear on the output pin whenever the appropriate PORTA and DDRA bits are set. A second mask option disables the output NMOS device allowing wire-ORing of the pins to produce various duty cycle outputs creating a simple PWM (see Figure 6D). Refer to **Port A Tone And Simple PWM Circuitry** for detailed explanation of the Tone/Simple PWM option.

Port B Interrupts and Pullups

In addition to being a standard bidirectional port, each bit of Port B has a mask option to connect a pullup device to the I/O pad and to simultaneously feed the input to the internal interrupt logic. When the mask option is not selected, each Port B pin behaves as a standard bidirectional port pin.

When the mask option is selected, a pull-up PMOS device with an impedance of approximately 20k Ω is connected between the pad and V_{DD} (see Pull-up Current, I_{IN} , in the DC Electrical Specifications tables for more details) and the input signal is inverted and internally ORed with the \overline{IRQ} signal (refer to Figure 6E)

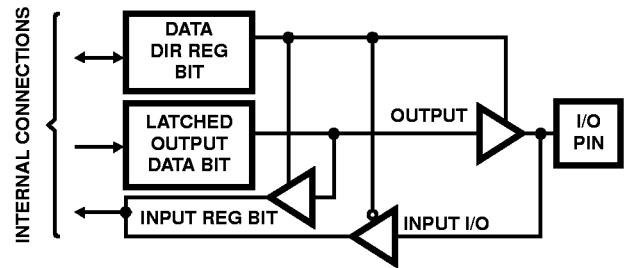


FIGURE 6A. TYPICAL PARALLEL PORT I/O CIRCUITRY

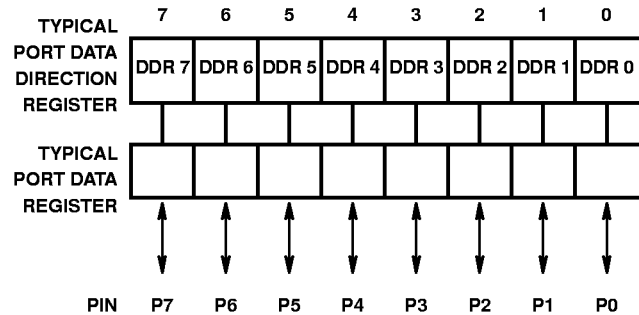
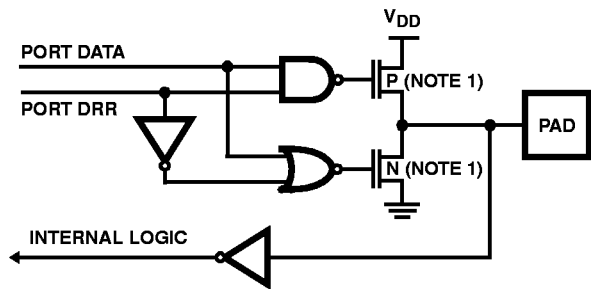


FIGURE 6B. TYPICAL PARALLEL PORT I/O CIRCUITRY



NOTES:

1. Denotes devices are enhancement type.
2. Input Protection and Latch-up protection not shown.

FIGURE 6C. TYPICAL PARALLEL PORT I/O CIRCUITRY

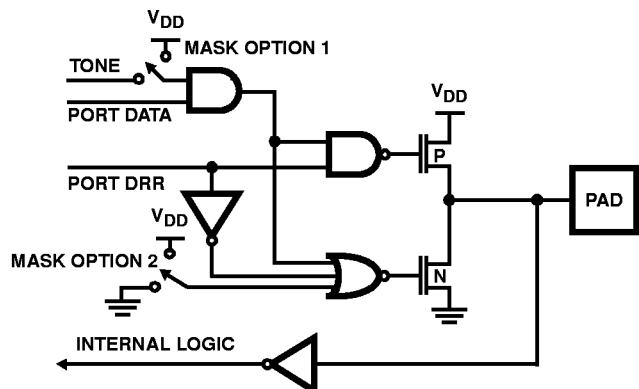


FIGURE 6D. PORT A7 - A4 TONE OUTPUT MASK OPTION

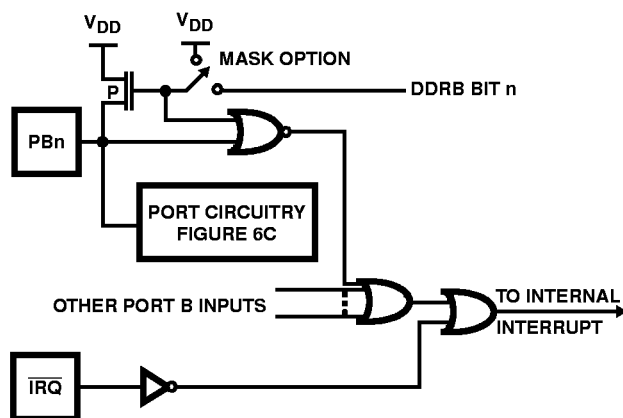


FIGURE 6E. PORT B INTERRUPT AND PULLUP MASK OPTION

The interrupt behavior of any port B pin which has the pull-up/interrupt mask option activated is identical to the results one would achieve by externally ORing (active low) the signal with the $\overline{\text{IRQ}}$ signal.

NOTE: The BIH and BIL instructions apply to the output of the logic OR of the Port B $\overline{\text{IRQ}}$ and $\overline{\text{IRQ}}$ pin signals and cannot be used to test the IRQ pin exclusively.

If the edge sensitive interrupt mask option has been selected (see **External Interrupt** and Figure 15 for details) when any one of the interrupt sources (port B inputs or $\overline{\text{IRQ}}$) goes low an interrupt will be generated. A second interrupt will not be generated until all of the interrupt lines go high and one or more again goes low.

If the edge and level sensitive interrupt mask option has been selected (see **External Interrupt** and Figure 15 for details) when any one of the interrupt sources (port B inputs or $\overline{\text{IRQ}}$) goes low an interrupt will be generated. Interrupts will continue to be generated until all of the interrupt lines go high.

The pullup device and the interrupt function are disabled when the associated DDRB bit is set high. When its DDRB bit is a 1, each port B pin acts as a normal output regardless of whether or not the pullup/interrupt mask option has been selected. Thus the DDRB bit can be used as an interrupt enable for the interruptible port B pins. Care should be taken when re-enabling a port B interrupt to avoid false interrupts. False interrupts can be avoided by first driving the PORTB bit high before clearing the DDRB bit. Further note, that all DDRB bits are cleared by reset, thus enabling port B interrupts (no interrupt will be recognized until execution of the first CLI instruction following reset).

Port C7 High Current Output

Bit 7 of port C (PC7) is a high current sink and source output. Refer to the DC Electrical Specifications table for details.

Fixed Port D

The 7 bits of port D (PD0 - PD5, PD7). are shared with the SPI and SCI systems. Refer to details in **Serial Ports**. When these systems are disabled the port D lines serve as dedicated input port lines. During power-on reset or external reset all seven bits become inputs because the SPI and SCI are disabled. When reading PORTD, bit 6 is always a 0. Bits being used for the serial ports also read as 0's.

NOTE: It is recommended that all unused inputs, except OSC2, and I/O ports (configured as outputs) be tied to an appropriate logic level (e.g. either V_{DD} or V_{SS}).

Serial Ports (SCI and SPI)

The serial communications interface (SCI) and serial peripheral interface (SPI) use the port D pins for their functions. The SCI function requires two of the pins (PD0 - PD1) for its receive data input (RDI) and transmit data output (TDO) respectively, whereas the SPI function requires four of the pins (PD2 - PD5) for its serial data input/output (MISO), serial data output/input (MOSI), system clock (SCK), and slave select ($\overline{\text{SS}}$) respectively. Bits being used for the serial ports cannot be read via PORTD. Refer to **Serial Communications Interface** and **Serial Peripheral Interface** for more detailed discussions.

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

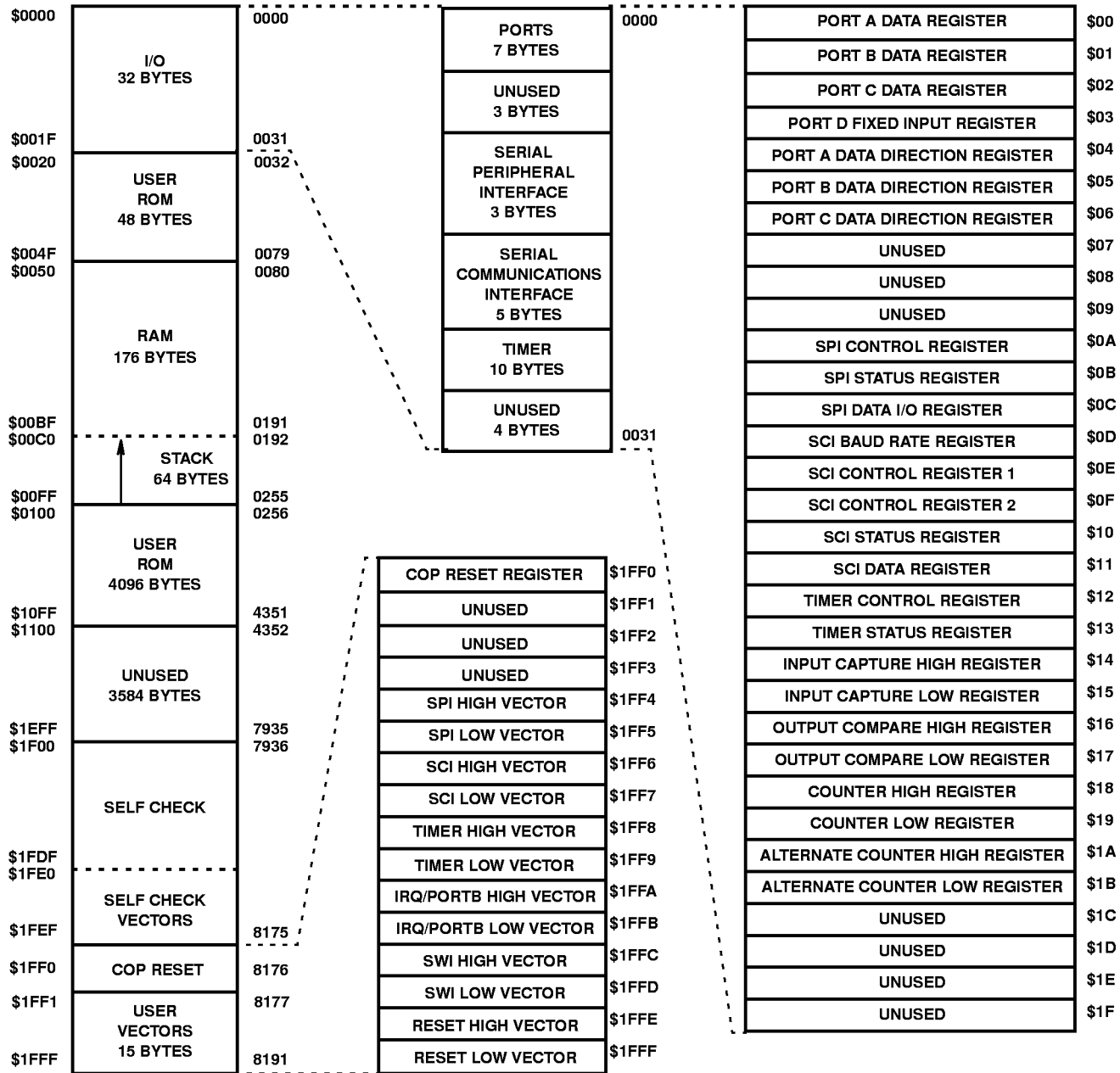


FIGURE 7. ADDRESS MAP FOR CDP68HC05C4B, CDP68HCL05C4B AND CDP68HSC05C4B

Memory

As shown in Figure 7, the CDP68HC05C4B, CDP68HCL05C4B and CDP68HSC05C4B MCUs are capable of addressing 8192 bytes of memory and I/O registers with their program counter. These MCUs utilize 4601 bytes of these locations. The first 256 bytes of memory (page zero) include 25 bytes of I/O features such as data ports, the port DDRs, timer, serial peripheral interface (SPI), and serial communication interface (SCI); 48 bytes of user ROM, and 176 bytes of RAM. The next 4096 bytes complete the user ROM. The self-check ROM (224 bytes) and self-check vectors (16 bytes) are contained in memory locations \$1F00 through \$1FEF. The 16 highest address bytes contain the COP Reset Register and the user

defined reset and interrupt vectors. Seven bytes of the lowest 32 memory locations are unused and the 176 bytes of user RAM include up to 64 bytes for the stack. Since most programs use only a small part of the allocated stack locations for interrupts and/or subroutine stacking purposes, the unused bytes are usable for program data storage. Figure 8 illustrates the memory map for CDP68HC05C8B, CDP68HCL05C8B and CDP68HSC05C8B MCUs. It is similar to the memory map in Figure 5, except for 3584 bytes of additional user ROM at memory locations \$1100 through \$1EFF for a total of 8185 of 8192 possible locations utilized

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

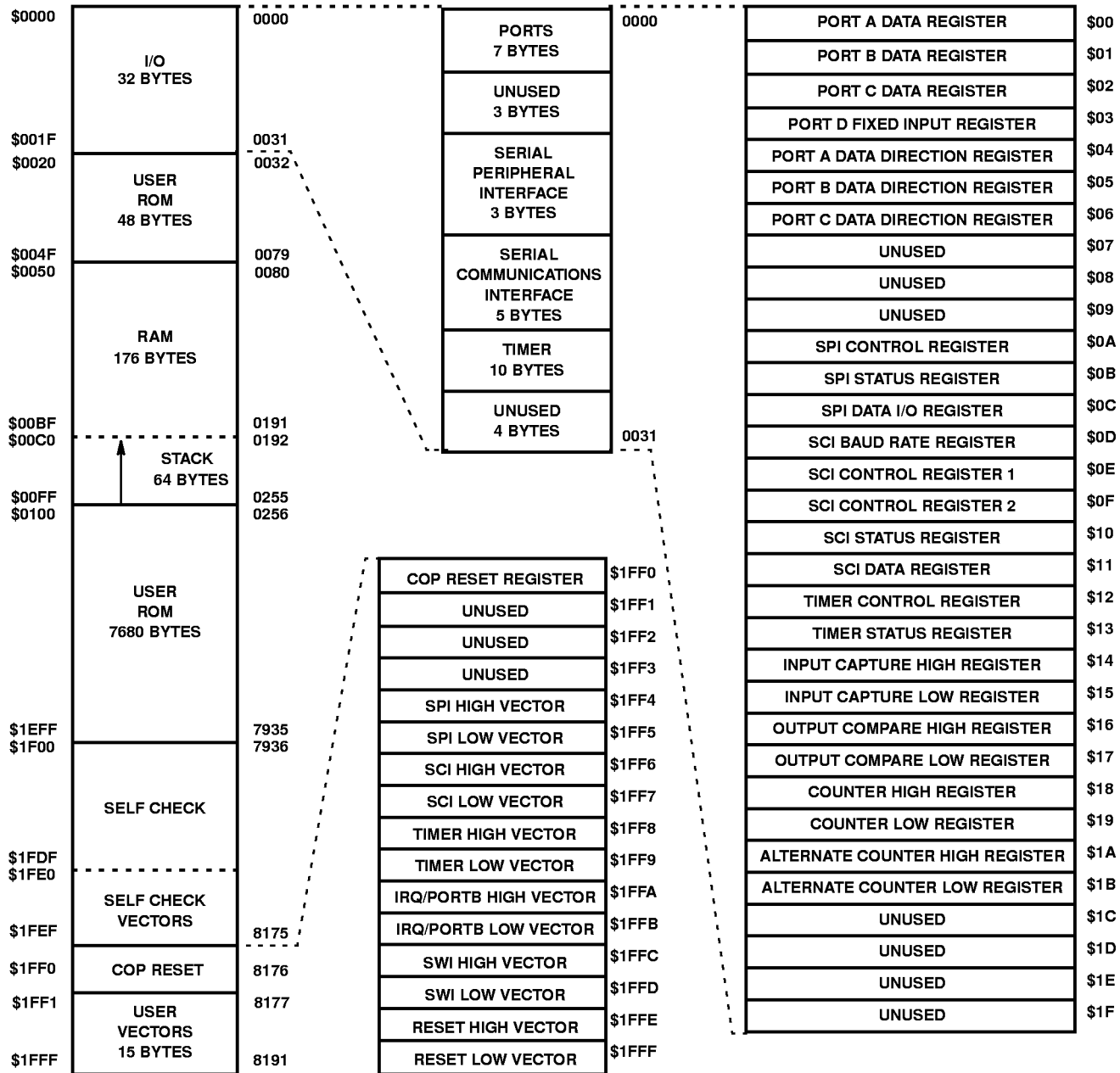


FIGURE 8. ADDRESS MAP FOR CDP68HC05C8B, CDP68HCL05C8B AND CDP68HSC05C8B

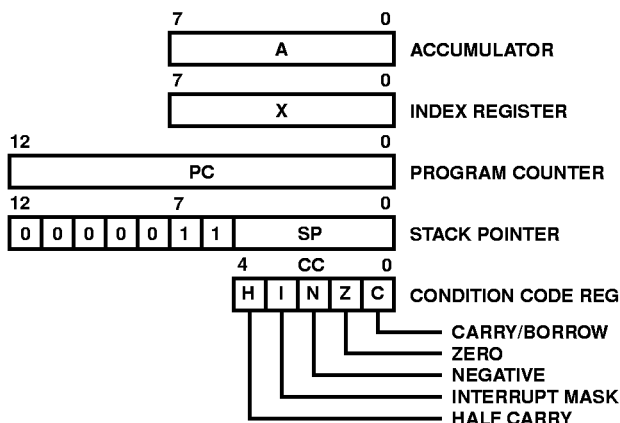
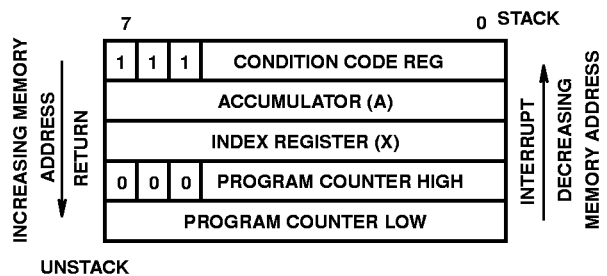


FIGURE 9. PROGRAMMING MODEL



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.

FIGURE 10. STACKING ORDER

CPU REGISTERS

The CPU contains five registers, as shown in the programming model of Figure 9. The interrupt stacking order is shown in Figure 10.

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 locations on the push-down/pop-up 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, losing the previously stored information. A subroutine call occupies two RAM bytes on the stack, while an interrupt uses five RAM bytes.

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 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, Serial Communications Interface, and Serial Peripheral Interface Sections 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.

Self Check

The self-check capability of the CDP68HC05C4B/C8B MCU provides an internal check to determine if the device is functional. Self-check is performed using the circuit shown in the schematic diagram of Figure 11. As shown in the diagram, port C pins PC0 - PC3 are monitored (light emitting diodes are shown but other devices could be used) for the self-check results. The self-check mode is entered by applying a 9V input (through a 4.7kΩ resistor) to the IRQ pin (2) and 5V input (through a 4.7kΩ resistor) to the TCAP pin (37) and then depressing the reset switch to execute a reset. After reset, the following seven tests are performed automatically:

I/O - Functionally exercises ports A, B and C

RAM - Counter test for each RAM byte

Timer - Tracks counter register and checks OCF flags

SCI - Transmission Test; checks for RDRF, TDRE, TC, and FE flags

ROM - Exclusive OR with odd ones parity result

SPI - Transmission test with check for SPIF, WCOL, and MODF flags

Interrupts - Tests external, timer, SCI, and SPI interrupts

Self-check results (using the LEDs as monitors) are shown in Table 2. The following subroutines are available to user programs and do not require any external hardware.

TABLE 2. SELF-CHECK RESULTS

PC3	PC2	PC1	PC0	REMARKS
OFF	ON	ON	ON	Bad I/O
OFF	ON	ON	OFF	Bad RAM
OFF	ON	OFF	ON	Bad Timer
OFF	ON	OFF	OFF	Bad SCI
OFF	OFF	ON	ON	Bad ROM
OFF	OFF	ON	OFF	Bad SPI
Flashing				Good Device
All Others				Bad Device, Bad Port C, etc.

NOTE: ON implies LED on, port = 0; OFF implies LED off, port = 1.

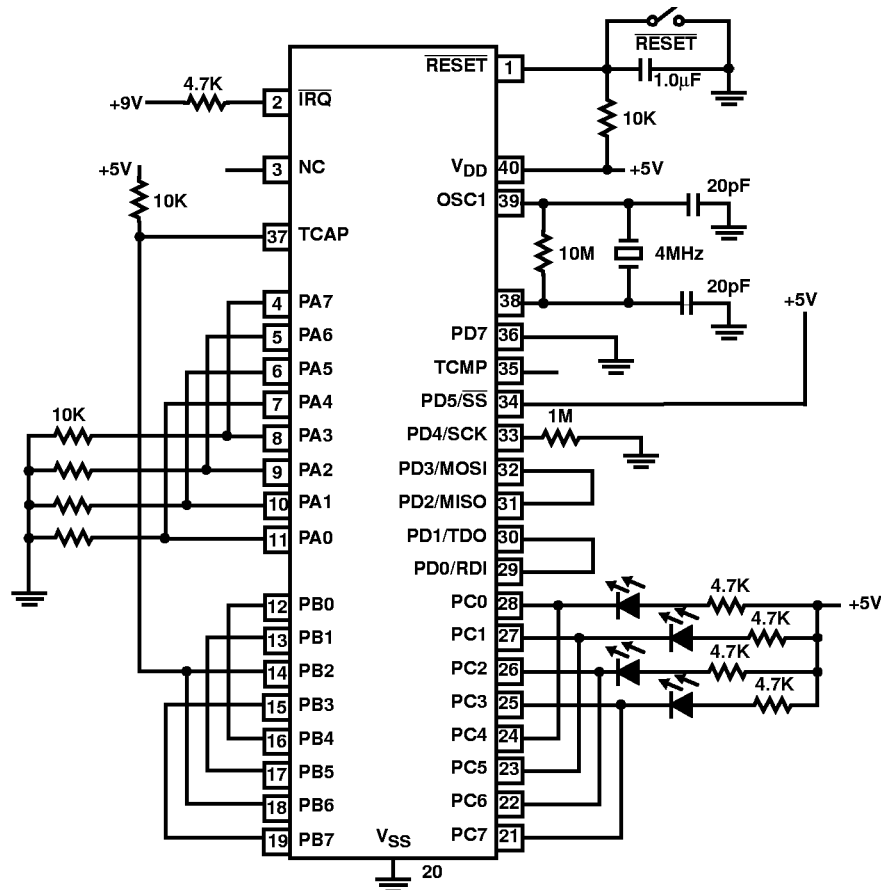


FIGURE 11. SELF-CHECK CIRCUIT SCHEMATIC DIAGRAM

TIMER TEST SUBROUTINE

This subroutine returns with the Z bit cleared if any error is detected; otherwise, the Z bit is set.

This subroutine is called at location \$1F0E. The output compare register is first set to the current timer state. Because the timer is free running and has only a divide-by-four prescaler, each timer count cannot be tested. The test tracks the counter until the timer wraps around, triggering the output compare flag in the timer status register. RAM locations \$0050 and \$0051 are overwritten. Upon return to the user's program, X = 40. If the test passed, A = 0.

ROM CHECKSUM SUBROUTINE

This subroutine returns with the Z bit cleared if any error is detected; otherwise, the Z bit is set. This subroutine is called at location \$1F93 with RAM location \$0053 equal to \$01 and A = 0. A short routine is set up and executed in RAM to compute a checksum of the entire ROM pattern. Upon return to the user's program, X = 0. If the test passed, A = 0. RAM locations \$0050 through \$0053 are overwritten.

Resets, Interrupts, and Low Power Modes

RESETS

The MCU has two reset modes: an active low external reset pin (RESET) and a power-on reset function; refer to Figure 12.

RESET Pin

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

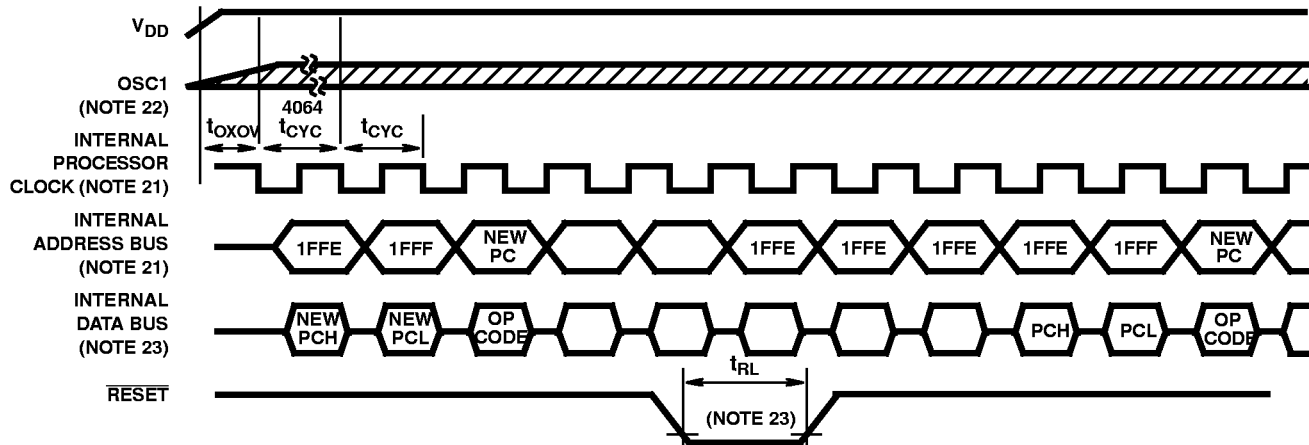
Power-On Reset

The power-on reset occurs when a positive transition is detected on VDD. 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. The power-on circuitry provides for a 4064 t_{CYC} delay from the time that the oscillator becomes active. If the external RESET pin is low at the end of the 4064 t_{CYC} time out, the processor remains in the reset condition until RESET goes high.

Table 3 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 CDP68HC05C4B 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 65.5 millisecond timeout with a 4MHz crystal. Whenever the COP is allowed to timeout, a system reset will occur, and the MCU will be re-initialized as if a power-on or external reset had occurred.



NOTES:

21. Internal signal and bus information is not available externally.
22. OSC1 is not meant to represent frequency. It is only meant to represent time.
23. The next rising edge of the internal processor clock following the rising edge of $\overline{\text{RESET}}$ initiates the reset sequence.

FIGURE 12. POWER-ON RESET AND $\overline{\text{RESET}}$

TABLE 3. RESET ACTION ON INTERNAL CIRCUIT

CONDITION	RESET PIN	POWER-ON $\overline{\text{RESET}}$
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. The OLVL timer bit is also cleared by reset.	X	X
All data direction registers cleared to zero (input)	X	X
Reset COP timer	X	X
Configure stack pointer to \$00FF	X	X
Force internal address bus to restart vector (See Table 4)	X	X
Set I bit in condition code register to a logic one	X	X
Clear STOP latch	X	X
Clear external interrupt latch	X	X
Clear WAIT latch	X	X
Disable SCI (serial control bits TE = 0 and RE = 0). Other SCI bits cleared by reset include: TIE, TCIE, RIE, ILIE, RWU, SBK, RDRF, IDLE, OR, NF, and FE.	X	X
Disable SPI (serial output enable control bit SPE = 0). Other SPI bits cleared by reset include: SPIE, MSTR, SPIF WCOL, and MODF.	X	X
Set serial status bits TDRE and TC	X	X
Clear all serial interrupt enable bits (SPIE, TIE and TCIE)	X	X
Place SPI system in slave mode (MSTR = 0)	X	X
Clear SCI prescaler rate control bits	X	X

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.

During self-check mode the COP is disabled.

INTERRUPTS

Systems often require that normal processing be interrupted so that some external event may be serviced. The CDP68HC05C4B may be interrupted by one of five different methods: either one of four maskable hardware interrupts ($\overline{\text{IRQ}}$, SPI, SCI, or Timer) and one non-maskable software interrupt (SWI). Interrupts such as Timer, SPI, and SCI have several flags which will cause the interrupt. Generally, interrupt flags are located in read-only status registers, 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 one, 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 10) 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 7 for vector location). Upon completion of the interrupt service routine, the RTI 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 10.

NOTE: The interrupt mask bit (I bit) will be cleared if and only if the corresponding bit stored in the stack is zero.

A table listing vector addresses for all interrupts including reset, in the MCU is provided in Table 4.

Hardware Controlled Interrupt Sequence

The following three functions ($\overline{\text{RESET}}$, 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 13, and for STOP and WAIT are provided in Figure 14. A discussion is provided below.

- (a) A low input on the $\overline{\text{RESET}}$ input pin, a power-on, or a COP timeout 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 (IRQ) or reset occurs.
- (c) WAIT - The WAIT instruction causes all processor clocks to stop, but leaves the Timer, SCI, and SPI clocks running. This "rest" state of the processor can be cleared by reset, an external interrupt (IRQ), Timer interrupt, SPI interrupt, or SCI interrupt.

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

If the interrupt mask (I bit) of the condition code register has been cleared and the external interrupt pin ($\overline{\text{IRQ}}$) 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 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. Figure 15 shows both a functional and mode timing diagram for the interrupt line. The timing diagram shows two different treatments of the interrupt line ($\overline{\text{IRQ}}$) to the processor. The first method shows single pulses on the interrupt line 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 the interrupt line remains low, then the next interrupt is recognized.

NOTE: The BIH and BIL instructions apply to the output of the logic OR of the Port B $\overline{\text{IRQ}}$ and $\overline{\text{IRQ}}$ pin signals and cannot be used to test the IRQ pin exclusively.

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 tILIL and serviced as soon as the I bit is cleared.

TABLE 4. VECTOR ADDRESS FOR INTERRUPTS AND RESET

REGISTER	FLAG NAME	INTERRUPTS	CPU INTERRUPT	VECTOR ADDRESS
N/A	N/A	Reset	$\overline{\text{RESET}}$	\$1FFE - \$1FFF
N/A	N/A	Software	SWI	\$1FFC - \$1FFD
N/A	N/A	External Interrupt	$\overline{\text{IRQ}}$	\$1FFA - \$1FFB
Timer Status	ICF OCF TOF	Input Capture Output Compare Timer Overflow	Timer	\$1FF8 - \$1FF9
SCI Status	TDRE TC RDRF IDLE OR	Transmit Buffer Empty Transmit Complete Receiver Buffer Full Idle Line Detect Overrun	SCI	\$1FF6 - \$1FF7
SPI Status	SPIF MODF	Transfer Complete Mode Fault	SPI	\$1FF4 - \$1FF5

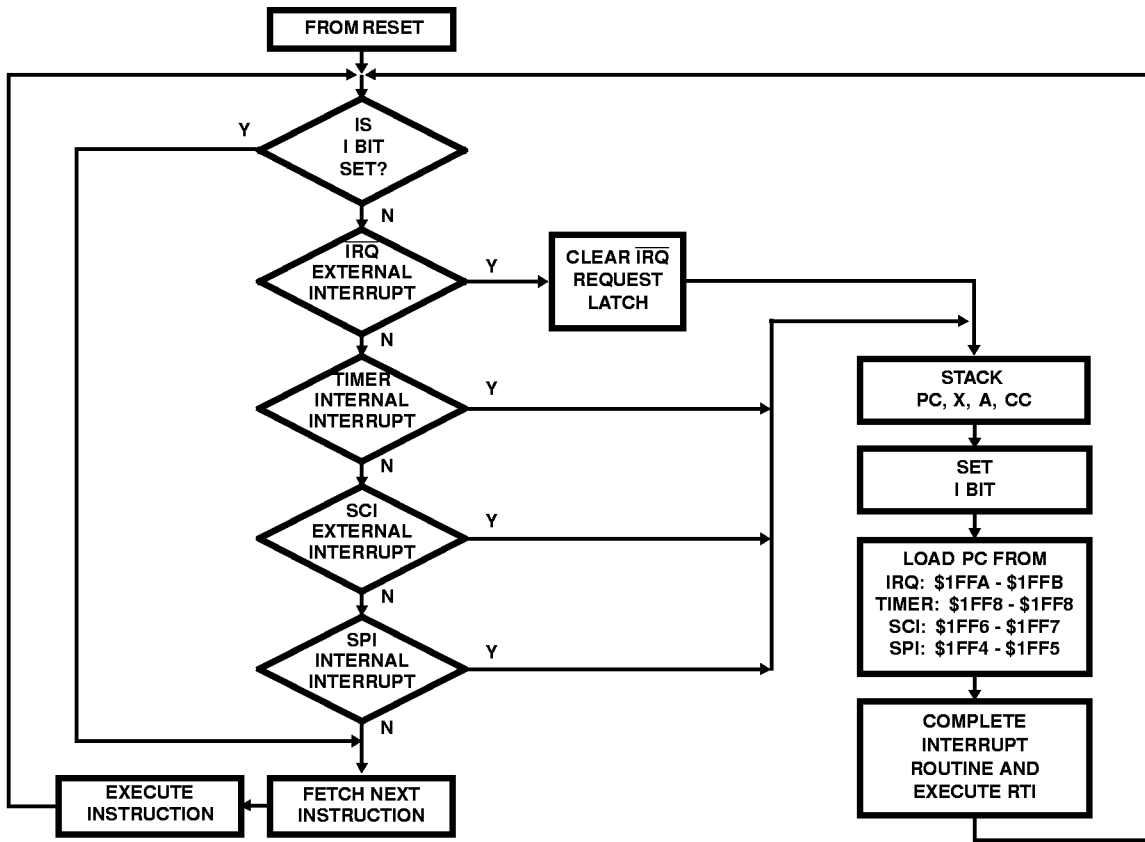


FIGURE 13. HARDWARE INTERRUPT FLOW DIAGRAM

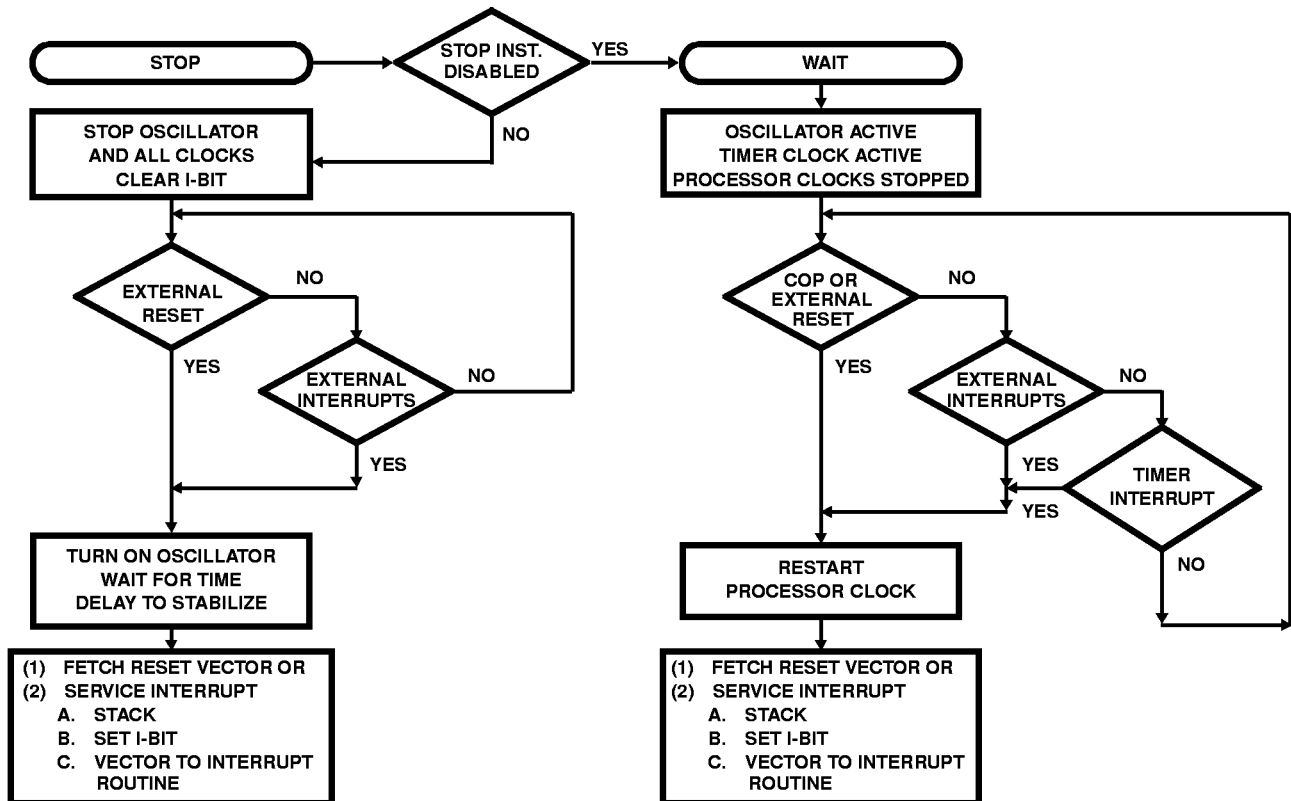


FIGURE 14. STOP/WAIT FLOW DIAGRAM

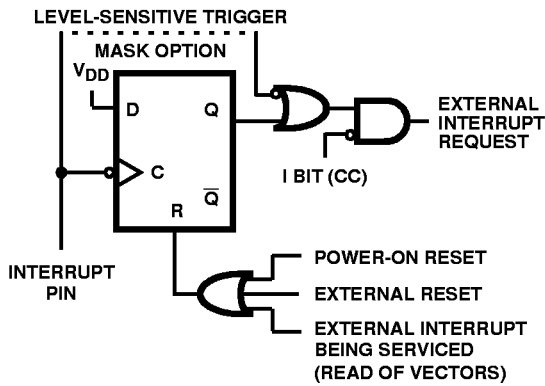
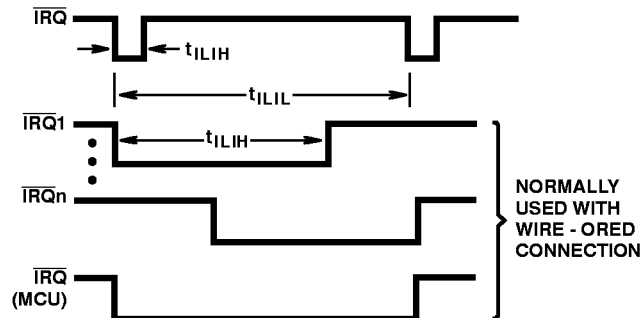


FIGURE 15A. EXTERNAL INTERRUPT FUNCTION DIAGRAM



NOTES:

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

FIGURE 15B. EXTERNAL INTERRUPT MODE DIAGRAM

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 (ICIE, OCIE, and TOIE) in the timer control register (TCR, location \$12). 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 location \$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 circuitry.

Serial Communications Interface (SCI) Interrupts

An interrupt in the serial communications interface (SCI) occurs when one of the interrupt flag bits in the serial communications status register is set, provided the I bit in the condition code register is clear and the enable bit in the serial communications

control register 2 (locations \$0F) is enabled. When the interrupt is recognized, the current state of the machine is pushed onto the stack and the I bit in the condition code register is set. This masks further interrupts until the present one is serviced. The SCI interrupt causes the program counter to vector to memory location \$1FF6 and \$1FF7 which contains the starting address of the interrupt service routine. Software in the serial interrupt service routine must determine the priority and cause of the SCI interrupt by examining the interrupt flags and the status bits located in the serial communications status register (location \$10). The general sequence for clearing an interrupt is a software sequence of accessing the serial communications status register while the flag is set followed by a read or write of an associated register. Refer to **Serial Communications Interface** for a description of the SCI system and its interrupts.

Serial Peripheral Interface (SPI) Interrupts

An interrupt in the serial peripheral interface (SPI) occurs when one of the interrupt flag bits in the serial peripheral status register (location \$0B) is set, provided the I bit in the condition code register is clear and the enable bit in the serial peripheral control register (location \$0A) is enabled. When the interrupt is recognized, the current state of the machine is pushed onto the stack and the I bit in the condition code register is set. This masks further interrupts until the present one is serviced. The SPI interrupt causes the program counter to vector to memory location \$1FF4 and \$1FF5 which contain the starting address of the interrupt service routine. Software in the serial peripheral interrupt service routine must determine the priority and cause of the SPI interrupt by examining the interrupt flag bits located in the SPI status register. 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 **Serial Peripheral Interface** for a description of the SPI system and its interrupts.

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 14. During the STOP mode, the I bit in the condition code register is cleared to enable external interrupts and the COP timer is reset. All other registers and memory remain unaltered and all input/output lines remain unchanged. This continues until an external interrupt (\overline{IRQ}) or reset is sensed at which time the internal oscillator is turned on. The external interrupt or reset causes the program counter to vector to memory location \$1FFA and \$1FFB or \$1FFE and \$1FFF which contains the starting address of the interrupt or reset service routine respectively.

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 an internal clock to keep running and subsequently a COP timeout 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.

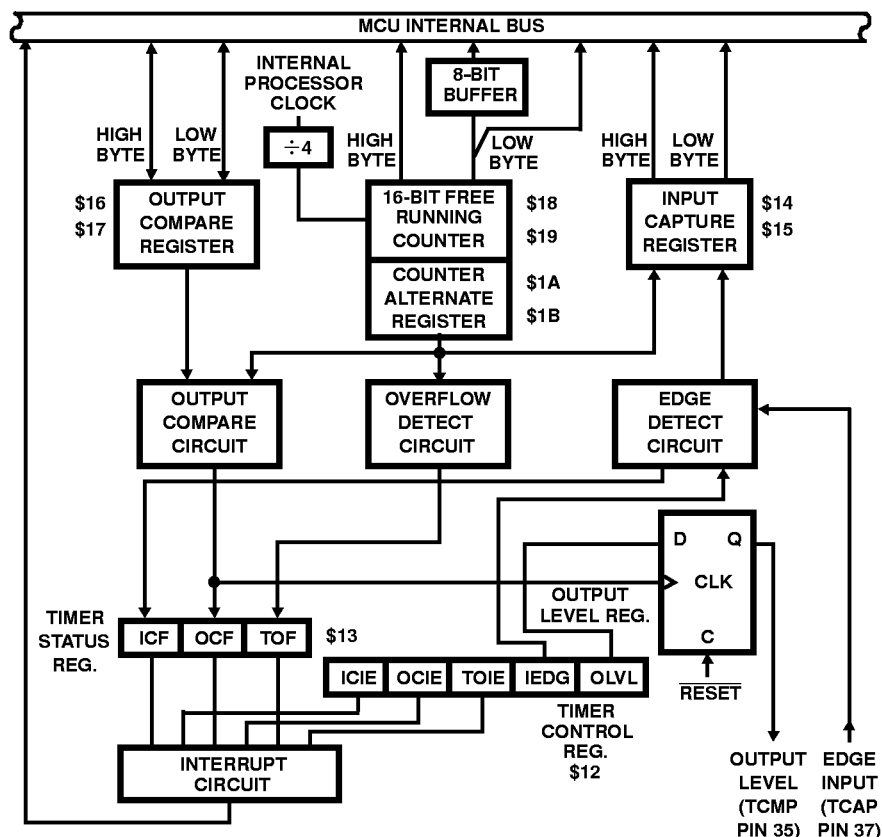


FIGURE 16. PROGRAMMABLE TIMER BLOCK DIAGRAM

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 COP timer, programmable timer, serial peripheral interface, and serial communications interface systems remain active. Refer to Figure 14. During the WAIT mode, the I bit in the condition code register is cleared to enable all interrupts. 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 vectors to the memory location (\$1FF4 through \$1FFF) 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 1.2V. This is referred to as the DATA RETENTION mode, where the data is held, but the device is not guaranteed to operate.

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

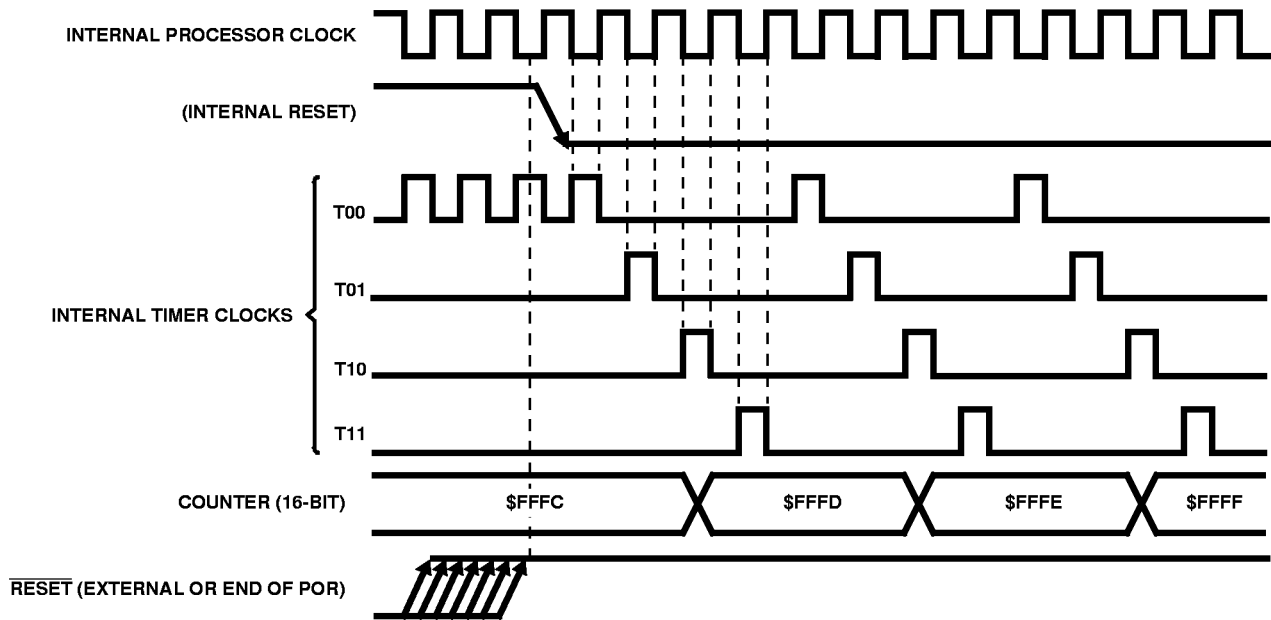
vary from several microseconds to many seconds. A block diagram of the timer is shown in Figure 16 and timing diagrams are shown in Figure 17 through Figure 20.

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 bytes 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.

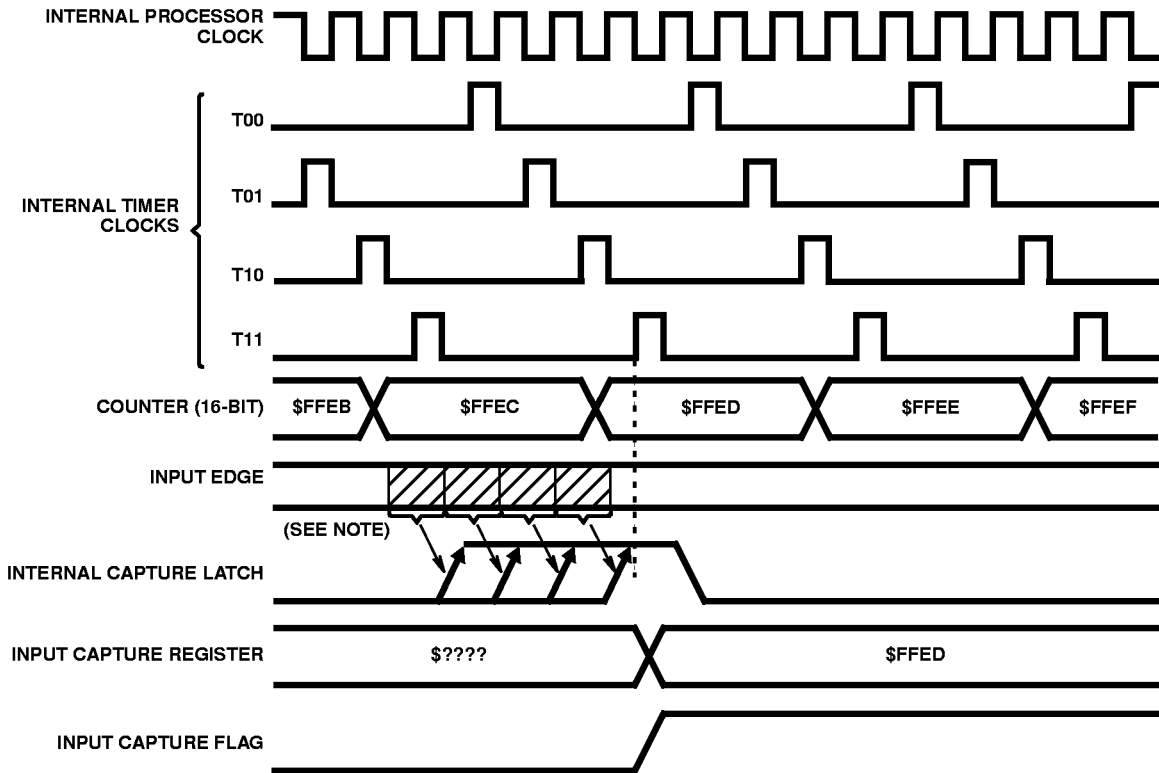
Timer Control Register (TCR) locations \$12,
 Timer Status Register (TSR) location \$13,
 Input Capture High Register location \$14,
 Input Capture Low Register location \$15,
 Output Compare High Register location \$16,
 Output Compare Low Register location \$17,
 Counter High Register location \$18,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



NOTE:

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

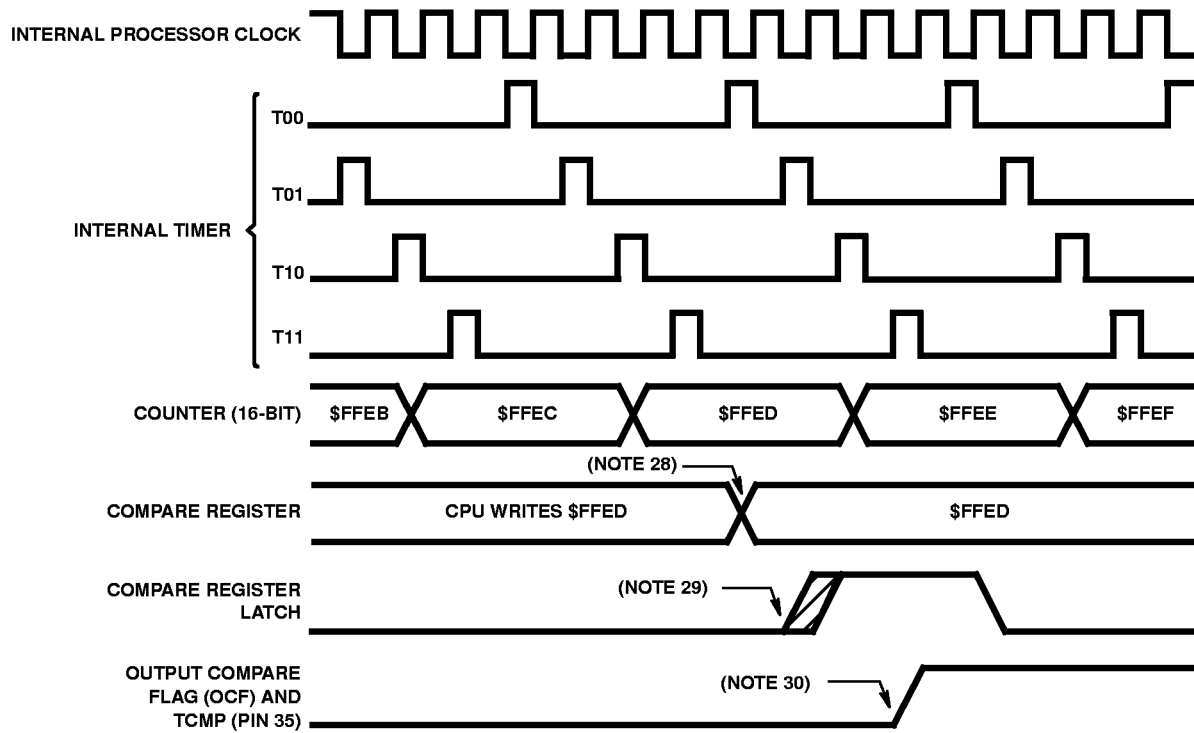
FIGURE 17. TIMER STATE DIAGRAM FOR RESET



NOTE:

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

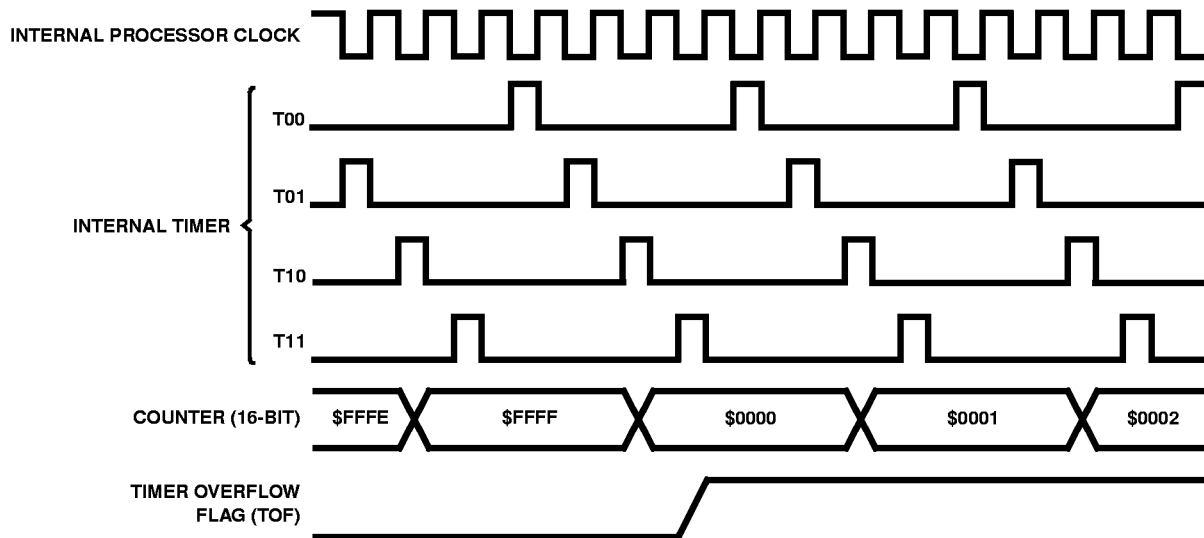
FIGURE 18. TIMER STATE DIAGRAM FOR INPUT CAPTURE



NOTES:

28. 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.
29. Internal compare takes place during timer state T01.
30. OCF is set at the timer state T11 which follows the comparison match (\$FFED in this example).

FIGURE 19. TIMER STATE DIAGRAM FOR OUTPUT COMPARE



NOTE:

31. 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 20. 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 2.0ms 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) or a COP reset, 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 rollover 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 timeout. 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 bytes (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) or 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 to prevent 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 18). 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.
- B1, IEDG** The value of the input edge (IEDG) bit determines which level transition on pin 37 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 35. 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 pin 37 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 17, 18, and 19 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 capture 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.

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.

During STOP and WAIT instructions, the programmable timer functions as follows: during the wait mode, the timer continues to operate normally and may generate an interrupt to trigger the CPU out of the wait state; during the stop mode, the timer holds at its current state, retaining all data, and resumes operation from this point when an external interrupt is received.

Serial Communications Interface (SCI)

INTRODUCTION

A full-duplex asynchronous serial communications interface (SCI) is provided with a standard NRZ format and a variety of baud rates. The SCI transmitter and receiver are functionally independent, but use the same data format and bit rate. The serial data format is standard mark/space (NRZ) which provides one start bit, eight or nine data bits, and one stop bit. "Baud" and "bit rate" are used synonymously in the following description.

SCI Two Wire System Features

- Standard NRZ (mark/space) format
- Advanced error detection method includes noise detection for noise duration of up to 1/16 bit time.
- Full-duplex operation (simultaneous transmit and receive)
- Software programmable for one of 32 different baud rates
- Software selectable word length (eight or nine bit words)
- Separate transmitter and receiver enable bits.
- SCI may be interrupt driven
- Four separate enable bits available for interrupt control

SCI Receiver Features

- Receiver wake-up function (idle or address bit)
- Idle line detect
- Framing error detect
- Noise detect
- Overrun detect
- Receiver data register full flag

SCI Transmitter Features

- Transmit data register empty flag
- Transmit complete flag
- Break send

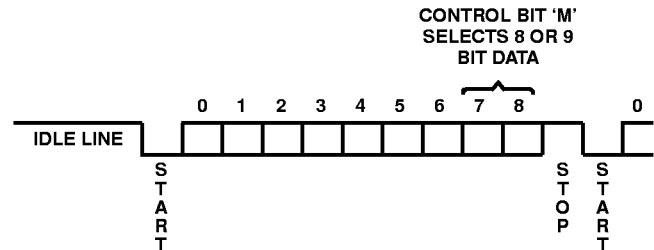
Any SCI two-wired system requires receive data in (RDI) and transmit data out (TDO).

DATA FORMAT

Receive data in (RDI) or transmit data out (TDO) is the serial data which is presented between the internal data bus and the output pin (TDO), and between the input pin (RDI) and the internal data bus. Data format is as shown for the NRZ in Figure 21 and must meet the following criteria:

1. A high level indicates a logic one and a low level indicates a logic zero.
2. The idle line is in a high (logic one) state prior to transmission/reception of a message.

3. A start bit (logic zero) is transmitted/received indicating the start of a message.
4. The data is transmitted and received least-significant-bit first.
5. A stop bit (high in the tenth or eleventh bit position) indicates the byte is complete.
6. A break is defined as the transmission or reception of a low (logic zero) for some multiple of the data format.



NOTE: Stop bit is always high

FIGURE 21. DATA FORMAT

WAKE-UP FEATURE

In a typical multiprocessor configuration, the software protocol will usually identify the addressee(s) at the beginning of the message. In order to permit uninterested MPUs to ignore the remainder of the message, a wake-up feature is included whereby all further SCI receiver flag (and interrupt) processing can be inhibited until its data line returns to the idle state. An SCI receiver is re-enabled by an idle string of at least ten (or eleven) consecutive ones. Software for the transmitter must provide for the required idle string between consecutive messages and prevent it from occurring within messages.

The user is allowed a second method of providing the wake-up feature in lieu of the idle string discussed above. This method allows the user to insert a logic one in the most significant bit of the transmit data word which needs to be received by all "sleeping" processors.

RECEIVE DATA IN

Receive data in is the serial data which is presented from the input pin via the SCI to the internal data bus. While waiting for a start bit, the receiver samples the input at a rate which is 16 times higher than the set baud rate. This 16 times higher-than-baud rate is referred to as the RT rate in Figures 22 and 23, and as the receiver clock in Figure 27. When the input (idle) line is detected low, it is tested for three more sample times (referred to as the start edge verification samples in Figure 22). If at least two of these three verification samples detect a logic low, a valid start bit is assumed to have been detected (by a logic low following the three start qualifiers) as shown in Figure 22; however, if in two or more of the verification samples a logic high is detected, the line is assumed to be idle. (A noise flag is set if one of the three verification sample detects a logic high, thus a valid start bit could be assumed and a noise flag still set.) The receiver clock generator is controlled by the baud rate register (see Figures 26 and 27); however, the serial communications interface is synchronized by the start bit (independent of the transmitter).

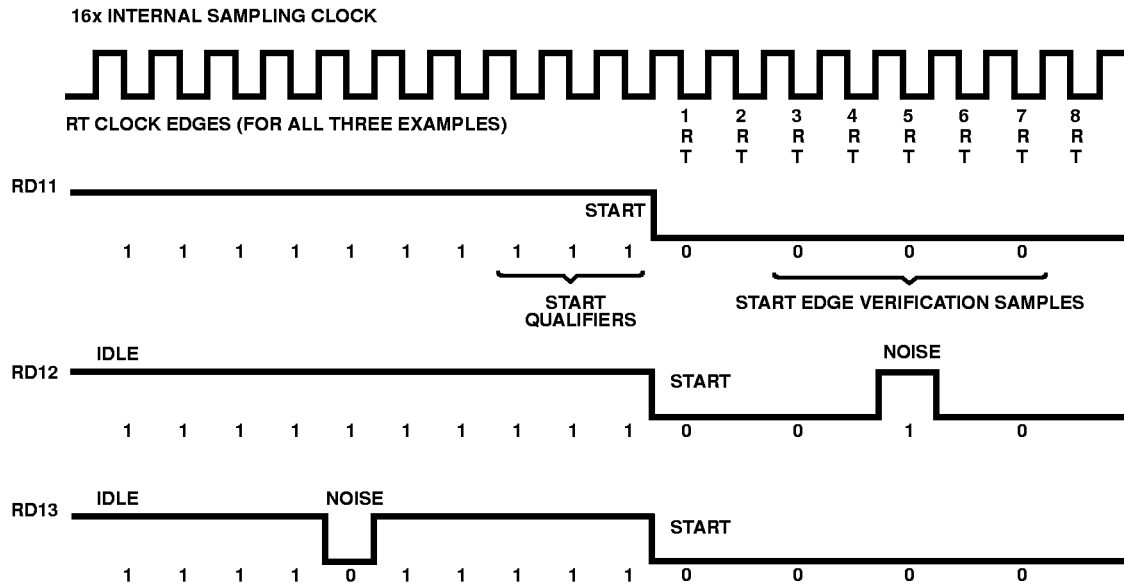


FIGURE 22. EXAMPLES OF START BIT SAMPLING TECHNIQUE

Once a valid start bit is detected, the start bit, each data bit, and the stop bit are sampled three times at RT intervals of 8RT, 9RT, and 10RT (1RT is the position where the bit is expected to start as shown in Figure 23). The value of the bit is determined by voting logic which takes the value of the majority of samples (two or three out of three). A noise flag is set when all three samples on a valid start bit or a data bit or the stop bit do not agree. (As discussed above, a noise flag is also set when the start bit verification samples do not agree).

PREVIOUS BIT	PRESENT BIT	SAMPLES			NEXT BIT
RDI		V	V	V	
16 R T	1 R T	8 R T	9 R T	10 R T	16 R T

FIGURE 23. DATA FORMAT

START BIT DETECTION FOLLOWING A FRAMING ERROR

If there has been a framing error without detection of a break (10 zeros for 8-bit format or 11 zeros for 9-bit format), the circuit continues to operate as if there actually were a stop bit and the start edge will be placed artificially. The last bit received in the data shift register is inverted to a logic one, and the three logic one start qualifiers (shown in Figure 22) are forced into the sample shift register during the interval when detection of a start bit is anticipated (see Figure 24); therefore the start bit will be accepted no sooner than it is anticipated.

If the receiver detects that a break (RDRF = 1, FE = 1, receiver data register = \$00) produced the framing error, the start bit will not be artificially induced and the receiver must actually receive a logic one bit before start. See Figure 25.

REGISTERS

There are five different registers used in the serial communications interface (SCI) and the internal configuration of these registers is discussed in the following paragraphs. A block diagram of the SCI system is shown in Figure 26.

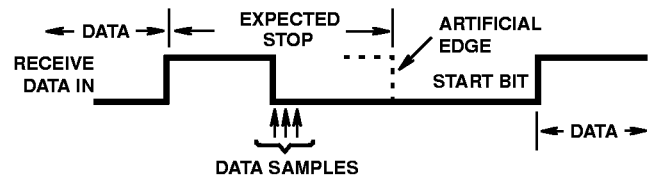


FIGURE 24A. CASE 1, RECEIVE LINE LOW DURING ARTIFICIAL EDGE

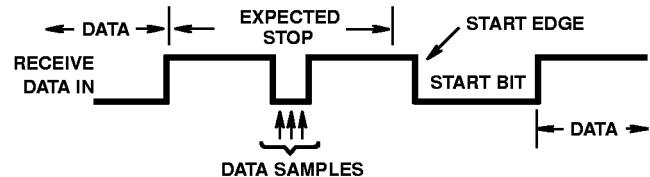


FIGURE 24B. CASE 2, RECEIVE LINE HIGH DURING EXPECTED START EDGE

FIGURE 24. SCI ARTIFICIAL START FOLLOWING A FRAMING ERROR

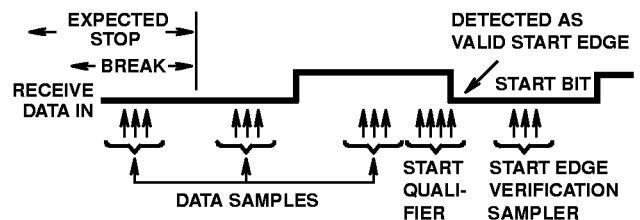
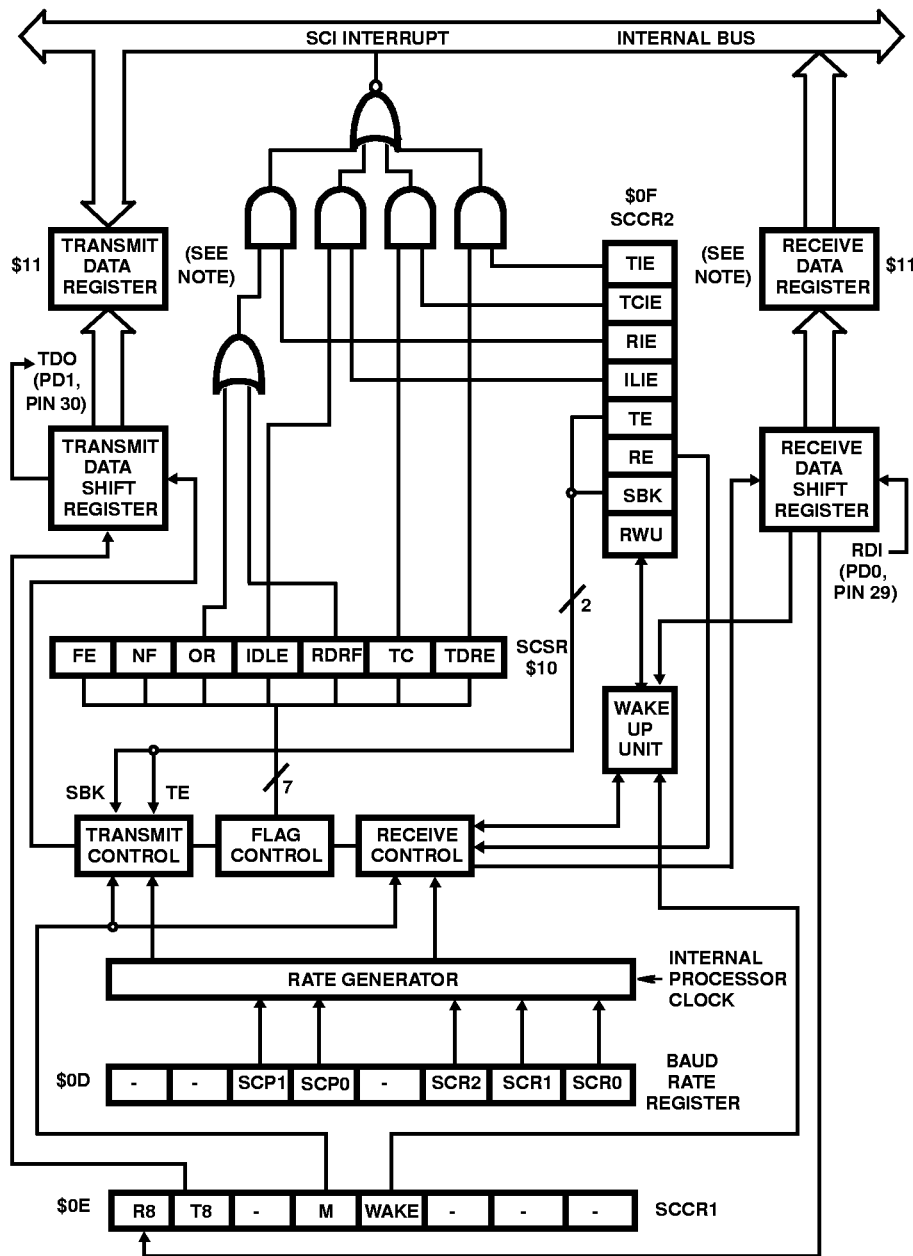


FIGURE 25. SCI START BIT FOLLOWING A BREAK



NOTE: The serial communications data register (SCDAT) is controlled by the internal R/W signal it is the transmit data register when written and receive data register when read.

FIGURE 26. SERIAL COMMUNICATIONS INTERFACE BLOCK DIAGRAM

Serial Communications Data Register (SCDAT)

7	6	5	4	3	2	1	0
Serial Communications Data Register							

\$11

The serial communications data register performs two functions in the serial communications interface; i.e. it acts as the receive data register when it is read and as the transmit data register when it is written. Figure 26 shows the register as two separate registers, namely: the receive data register (RDR) and the transmit data register (TDR). As shown in Figure 26, the TDR (transmit data register) provides the parallel interface

from the internal data bus to the transmit shift register and the receive data register (RDR) provides the interface from the receive shift register to the internal data bus.

When SCDAT is written, it becomes the transmit data register and contains the next byte of data to be transmitted. The transmit data register, also represented above, is a write-only register containing the next byte of data to be applied to the transmit shift register from the internal data bus. As long as the transmitter is enabled, data stored in the serial communications data register is transferred to the transmit shift register (after the current byte in the shift register has been transmitted). The transfer from the SCDAT to the transmit shift register is synchronized with the bit rate clock (from the

transmit control) as shown in Figure 26. All data is transmitted least-significant-bit first.

Serial Communications Control Register 1 (SCCR1)

7	6	5	4	3	2	1	0
R8	T8	0	M	WAKE	0	0	0

\$0E

The serial communications control register 1 (SCCR1) provides the control bits which: 1) determine the word length (either 8 or 9 bits), and 2) selects the method used for the wake-up feature. Bits 6 and 7 provide a location for storing the ninth bit for longer bytes.

- B7, R8** If the M bit is a one, then this bit provides a storage location for the ninth bit in the receive data byte. Reset does not affect this bit.
- B6, T8** If the M bit is one, then this bit provides a storage locations for the ninth bit in the transmit data byte. Reset does not affect this bit.
- B4, M** The option of the word length is selected by the configuration of this bit and is shown below. Reset does not affect this bit. 0 = 1 start bit, 8 data bits, 1 stop bit 1 = 1 start bit, 9 data bits, 1 stop bit
- B3, WAKE** This bit allows the user to select the method for receiver "wake up". If the WAKE bit is a logic zero, an idle line condition will "wake up" the receiver. If the WAKE bit is set to a logic one, the system acknowledges an address bit (most significant bit). The address bit is dependent on both the WAKE bit and the M bit level (table shown below). (Additionally, the receiver does not use the wake-up feature unless the RWU control bit in serial communications control register 2 is set as discussed below.) Reset does not affect this bit.

WAKE	M	METHOD OF RECEIVER "WAKE-UP"
0	X	Detection of an idle line allows the next data byte received to cause the receive data register to fill and produce an RDRF flag.
1	0	Detection of a received one in the eighth data bit allows an RDRF flag and associated error flags.
1	1	Detection of a received one in the ninth data bit allows an RDRF flag and associated error flags.

Serial Communications Control Register 2 (SCCR2)

7	6	5	4	3	2	1	0
TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK

\$0F

The serial communications control register 2 (SCCR2) provides the control bits which: individually enable/disable the transmitter or receiver, enable the system interrupts, and provide the wake-up enable bit and a "send break code" bit. Each of these bits is described below. (The individual flags are discussed in the **Serial Communications Status Register Section**.)

B7, TIE When the transmit interrupt enable bit is set, the SCI interrupt occurs provided TDRE is set (see Figure 26). When TIE is clear, the TDRE interrupt is disabled. Reset clears the TIE bit.

B6, TCIE When the transmission complete interrupt enable bit is set, the SCI interrupt occurs provided TC is set (see Figure 26). When TCIE is clear, the TC interrupt is disabled. Reset clears the TCIE bit.

B5, RIE When the receive interrupt enable bit is set, the SCI interrupt occurs provided OR is set or RDRF is set (see Figure 26). When RIE is clear, the OR and RDRF interrupts are disabled. Reset clears the RIE bit.

B4, ILIE When the idle line interrupt enable bit is set, the SCI interrupt occurs provided IDLE is set (see Figure 26). When ILIE is clear, the IDLE interrupt is disabled. Reset clears the ILIE bit.

B3, TE When the transmit enable bit is set, the transmit shift register output is applied to the TDO line. Depending on the state of control bit M in serial communications control register 1, a preamble of 10(M = 0) or 11(M = 1) consecutive ones is transmitted when software sets the TE bit from a cleared state. If a transmission is in progress, and TE is written to a zero, then the transmitter will wait until after the present byte has been transmitted before placing the TDO pin in the idle high-impedance state. If the TE pin has been written to a zero and then set to a one before the current byte is transmitted, the transmitter will wait until that byte is transmitted and will then initiate transmission of a new preamble. After the preamble is transmitted, and provided the TDRE bit is set (no new data to transmit), the line remains idle (driven high while TE = 1); otherwise, normal transmission occurs. This function allows the user to "neatly" terminate a transmission sequence. After loading the last byte in the serial communications data register and receiving the interrupt from TDRE, indicating the data has been transferred into the shift register, the user should clear TE. The last byte will then be transmitted and the line will go idle (high impedance). Reset clears the TE bit.

B2, RE When the receive enable bit is set, the receiver is enabled. When RE is clear, the receiver is disabled and all of the status bit associated with the receiver (RDRF, IDLE, OR, NF, and FE) are inhibited. Reset clears the RE bit.

B1, RWU When the receiver wake-up bit is set, it enables the "wake up" function. The type of "wake up" mode for the receiver is determined by the WAKE bit discussed above (in the SCCR1). When the RWU bit is set, no status flags will be set. Flags which were set previously will not be cleared when RWU is set. If the WAKE bit is cleared, RWU is cleared after receiving 10(M = 0) or 11(M = 1) consecutive ones. Under these conditions, RWU cannot be set if the line is idle. If the WAKE bit is set, RWU is cleared after receiving an address bit. The RDRF flag will then be set and the address byte will be stored in the receiver data register. Reset clears the RWU bit.

B0, SBK When the send break bit is set the transmitter sends zeros in some number equal to a multiple of the data format bits. If the SBK bit is toggled set and clear, the transmitter sends 10(M = 0) or 11(M = 1) zeros and then reverts to idle or sending data. The actual number of zeros sent when SBK is toggled depends on the data format set by the M bit in the serial communications control register 1; therefore, the break code will be synchronous with respect to the data stream. At the completion of the break code, the transmitter sends at least one high bit to guarantee recognition of a valid start bit. Reset clears the SBK bit.

Serial Communications Status Register (SCSR)

7	6	5	4	3	2	1	0
TDRE	TC	RDRF	IDLE	OR	NF	FE	0

\$10

The serial communications status register (SCSR) provides inputs to the interrupt logic circuits for generation of the SCI system interrupt. In addition, a noise flag bit and a framing error bit are also contained in the SCSR.

B7, TDRE The transmit data register empty bit is set to indicate that the contents of the serial communications data register have been transferred to the transmit serial shift register. If the TDRE bit is clear, it indicates that the transfer has not yet occurred and a write to the serial communications data register will overwrite the previous value. The TDRE bit is cleared by accessing the serial communications status register (with TDRE set), followed by writing to the serial communication data register. Data can not be transmitted unless the serial communications status register is accessed before writing to the serial communications data register to clear the TDRE flag bit. Reset sets the TDRE bit.

B6, TC The transmit complete bit is set at the end of a data frame, preamble, or break condition if:

1. TE = 1, TDRE = 1, and no pending data, preamble, or break is to be transmitted; or
2. TE = 0, and the data, preamble, or break (in the transmit shift register) has been transmitted.

The TC bit is a status flag which indicates that one of the above conditions has occurred. The TC bit is cleared by accessing the serial communications status register (with TC set), followed by writing to the serial communications data register. It does not inhibit the transmitter function in any way. Reset sets the TC bit.

B5, RDRF When the receive data register full bit is set, it indicates that the receiver serial shift register is transferred to the serial communications data register. If multiple errors are detected in any one received word, the NF, FE, and RDRF bits will be affected as appropriate during the same clock cycle. The RDRF bit is cleared when the serial communications status register is accessed (with RDRF set) followed by a read of the serial communications data register. Reset clears the RDRF bit.

B4, IDLE When the idle line detect bit is set, it indicates that a receiver idle line is detected (receipt of a minimum number of ones to constitute the number of bits in the byte format). The minimum number of ones needed will be 10(M = 0) or 11(M = 1). This allows a receiver that is not in the wake-up mode to detect the end of a message, detect the preamble of a new message, or to resynchronize with the transmitter. The IDLE bit is cleared by accessing the serial communications status register (with IDLE set) followed by a read of the serial communications data register. The IDLE bit will not be set again until after an RDRF has been set; i.e., a new idle line occurs. The IDLE bit is not set by an idle line when the receiver "wakes up" from the wake-up mode. Reset clears the IDLE bit.

B3, OR When the overrun error bit is set the next byte is ready to be transferred from the receive shift register to the serial communications data register when it is already full (RDRF bit is set). Data transfer is then inhibited until the RDRF bit is cleared. Data in the serial communications data register is valid in this case, but additional data received during an overrun condition (including the byte causing the overrun) will be lost. The OR bit is cleared when the serial communications status register is accessed (with OR set), followed by a read of the serial communications data register. Reset clears the OR bit.

B2, NF The noise flag bit is set if there is noise on a "valid" start bit or if there is noise on any of the data bits or if there is noise on the stop bit. It is not set by noise on the idle line nor by invalid (false) start bits. If there is noise, the NF bit is not set until the RDRF flag is set. Each data bit is sampled three times as described above in RECEIVE DATA IN and shown in Figure 23. The NF bit represents the status of the byte in the serial communications data register. For the byte being received (shifted in) there will also be a "working" noise flag the value of which will be transferred to the NF bit when the serial data is loaded into the serial communications data register. The NF bit does not generate an interrupt

because the RDRF bit gets set with NF and can be used to generate the interrupt. The NF bit is cleared when the serial communications status register is accessed (with NF set), followed by a read of the serial communications data register. Reset clears the NF bit.

B1, FE

The framing error bit is set when the byte boundaries in the bit stream are not synchronized with the receiver bit counter (generated by a "lost" stop bit). The byte is transferred to the serial communications data register and the RDRF bit is set. The FE bit does not generate an interrupt because the RDRF bit is set at the same time as FE and can be used to generate the interrupt. Note that if the byte received causes a framing error and it will also cause an overrun if transferred to the serial communications data register, then the overrun bit will be set, but not the framing error bit, and the byte will not be transferred to the serial communications data register. The FE bit is cleared when the serial communications status register is accessed (with FE set) followed by a read of the serial communications data register. Reset clears the FE bit.

Baud Rate Register

7	6	5	4	3	2	1	0	
0	0	SCP1	SCP0	0	SCR2	SCR1	SCR0	\$0D

The baud rate register provides the means for selecting different baud rates which may be used as the rate control for the transmitter and receiver. The SCP0 - SCP1 bits function as a prescaler for the SCR0 - SCR2 bits. Together, these five bits provide multiple, baud rate combinations for a given crystal frequency.

B5, SCP1, These two bits in the baud rate register are used as a prescaler to increase the range of standard baud rates controlled by the SCR0 - SCR2 bits. A table of the prescaler internal processor clock division versus bit levels is provided below. Reset clears SCP1 - SCP0 bits (divide-by-one).

SCP1	SCP0	INTERNAL PROCESSOR CLOCK DIVIDE BY
0	0	1
0	1	3
1	0	4
1	1	13

B2, SCR2, These three bits in the baud rate register are used to select the baud rates of both the transmitter and receiver. A table of baud rates versus bit levels is shown below. Reset does not affect the SCR2 - SCR0 bits.

SCR2	SCR1	SCR0	PRESCALER OUTPUT DIVIDE BY
0	0	0	1
0	0	1	2
0	1	0	4
0	1	1	8

SCR2	SCR1	SCR0	PRESCALER OUTPUT DIVIDE BY
1	0	0	16
1	0	1	32
1	1	0	64
1	1	1	128

The diagram of Figure 27 and Tables 5 and 6 illustrate the divided chain used to obtain the baud rate clock (transmit clock). Note that there is a fixed rate divide-by-16 between the receive clock (RT) and the transmit clock (Tx). The actual divider chain is controlled by the combined SCP0 - SCP1 and SCR0 - SCR2 bits in the baud rate register as illustrated. All divided frequencies shown in the first table represent the final transmit clock (the actual baud rate) resulting from the internal processor clock division shown in the "divide-by" column only (prescaler division only). The second table illustrates how the prescaler output can be further divided by action of the SCI select bits (SCR0 - SCR2). For example, assume that a 9600Hz baud rate is required with a 2.4576MHz external crystal. In this case the prescaler bits (SCP0 - SCP1) could be configured as a divide-by-one or a divide-by-four. If a divide-by-four prescaler is used, then the SCR0 - SCR2 bits must be configured as a divide-by-two. This results in a divide-by-128 of the internal processor clock to produce a 9600Hz baud rate clock. Using the same crystal, the 9600 baud rate can be obtained with a prescaler divide-by-one and the SCR0 - SCR2 bits configured for a divide-by-eight.

NOTE: The crystal frequency is internally divided-by-two to generate the internal processor clock.

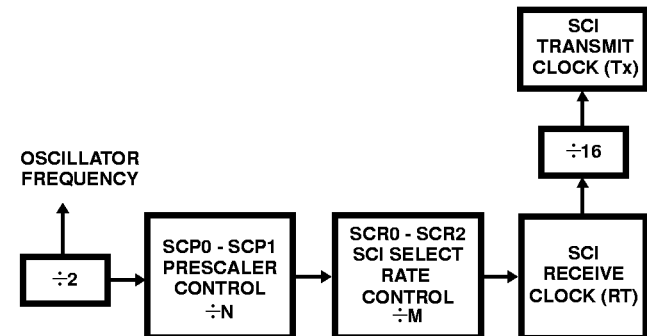


FIGURE 27. RATE GENERATOR DIVISION

Serial Peripheral Interface (SPI)

INTRODUCTION AND FEATURES

Introduction

The serial peripheral interface (SPI) is an interface built into the MCU which allows several MCUs, or one MCU plus peripheral devices, to be interconnected within a single "black box" or on the same printed circuit board. In a serial peripheral interface (SPI), separate wires (signals) are required for data and clock. In the SPI format, the clock is not included in the data stream and must be furnished as a separate signal. An SPI system may be configured as one containing one master MCU and several slave MCUs, or in a system in which an MCU is capable of being either a master or a slave.

TABLE 5. PRESCALER HIGHEST BAUD RATE FREQUENCY OUTPUT

SCP BIT		(NOTE 32) CLOCK DIVIDED BY	CRYSTAL FREQUENCY MHz					
1	0		(NOTE 33) 8.0	4.194304	4.0	2.4576	2.0	1.8432
0	0	1	250.000kHz	131.072kHz	125.000kHz	76.80kHz	62.50kHz	57.60kHz
0	1	3	83.332kHz	43.691kHz	41.666kHz	25.60kHz	20.833kHz	19.20kHz
1	0	4	62.500kHz	32.768kHz	31.250kHz	19.20kHz	15.625kHz	14.40kHz
1	1	13	19.200kHz	10.082kHz	9600Hz	5.907kHz	4800Hz	4430Hz

NOTES:

32. The clock in the "CLOCK DIVIDED BY" column is the internal processor clock.

33. CDP68HSC05C4B and CDP68HSC05C8B types.

34. The divided frequencies shown in Table 5 represent baud rates which are the highest transmit baud rate (Tx) that can be obtained by a specific crystal frequency and only using the prescaler division. Lower baud rates may be obtained by providing a further division using the SCI rate select bits as shown below for some representative prescaler outputs.

TABLE 6. TRANSMIT BAUD RATE OUTPUT FOR A GIVEN PRESCALER OUTPUT

SCR BITS			PORT A TONE OUTPUT	DIVIDE BY	REPRESENTATIVE HIGHEST PRESCALER BAUD RATE OUTPUT					
2	1	0			(NOTE 35) 250.000kHz	131.072kHz	32.768kHz	76.80kHz	19.20kHz	9600Hz
0	0	0	-	1	-	131.072kHz	32.768kHz	76.80kHz	19.20kHz	9600Hz
0	0	1	-	2	125.000kHz	65.536kHz	16.384kHz	38.40kHz	9600Hz	4800Hz
0	1	0	-	4	62.500kHz	32.678kHz	8.192kHz	19.20kHz	4800Hz	2400Hz
0	1	1	PA7	8	31.250kHz	16.384kHz	4.096kHz	9600Hz	2400Hz	1200Hz
1	0	0	PA6	16	15.625kHz	8.192kHz	2.048kHz	4800Hz	1200Hz	600Hz
1	0	1	PA5	32	7.813kHz	4.096kHz	1.024kHz	2400Hz	600Hz	300Hz
1	1	0	PA4	64	3.906kHz	2.048kHz	512Hz	1200Hz	300Hz	150Hz
1	1	1	-	128	1.953kHz	1.024kHz	256Hz	600Hz	150Hz	75Hz

NOTES:

35. CDP68HSC05C4B and CDP68HSC05C8B types.

36. Table 6 illustrates how the SCI select bits can be used to provide lower transmitter baud rates by further dividing the prescaler output frequency. The five examples are only representative samples. In all cases, the baud rates shown are transmit baud rates (transmit clock) and the receiver clock is 16 times higher in frequency than the actual baud rate.

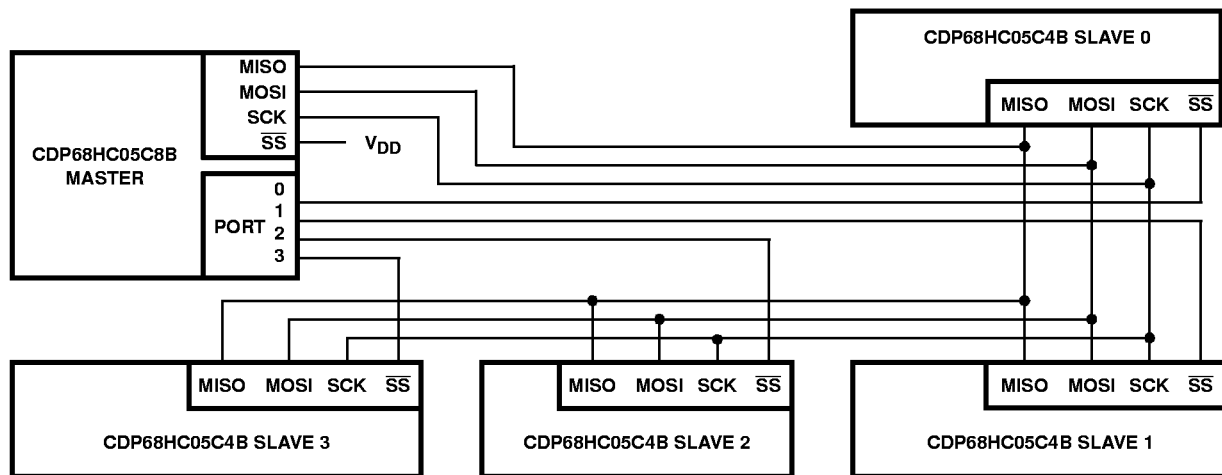


FIGURE 28. MASTER-SLAVE SYSTEM CONFIGURATION (SINGLE MASTER, FOUR SLAVES)

Figure 28 illustrates a typical multi-computer system configuration. Figure 28 represents a system of five different MCUs in which there are one master and four slave (0, 1, 2, 3). In this system four basic line (signals) are required for the MOSI (master out slave in), MISO (master in slave out), SCK serial clock, and \overline{SS} (slave select) lines.

Features

- Full Duplex, Three-Wire Synchronous Transfers
- Master or Slave Operation
- Master Bit Frequency
 - 1.05MHz Maximum (CDP68HC05C4B, CDP68HC05C8B, and CDP68HCL05C4B, CDP68HCL05C8B)
 - 2.0MHz Maximum (CDP68HSC05C4B, CDP68HSC05C8B)
- Slave Bit Frequency
 - 2.1MHz Maximum (CDP68HC05C4B, CDP68HC05C8B, and CDP68HCL05C4B, CDP68HCL05C8B)
 - 4.0MHz Maximum (CDP68HSC05C4B, CDP68HSC05C8B)
- Four Programmable Master Bit Rates
- Programmable Clock Polarity and Phase
- End of Transmission Interrupt Flag
- Write Collision Flag Protection
- Master-Master Mode Fault Protection Capability

SIGNAL DESCRIPTION

The four basic signals (MOSI, MISO, SCK, \overline{SS}) discussed above are described in the following paragraphs. Each signal function is described for both the master and slave mode.

Master Out Slave In (MOSI)

The MOSI pin is configured as a data output in a master (mode) device and as a data input in a slave (mode) device. In this manner data is transferred serially from a master to a slave on this line; most significant bit first, least significant bit last. The timing diagrams of Figure 29 summarize the SPI timing and show the relationship between data and clock (SCK). As shown in Figure 29, four possible timing relationships may be chosen by using control bits CPOL and CPHA. The master device always allows data to be applied on the MOSI line a half-cycle before the clock edge (SCK) in order for the slave device to latch the data.

NOTE: Both the slave device(s) and a master device must be programmed to similar timing modes for proper data transfer.

When the master device transmits data to a second (slave) device via the MOSI line, the slave device responds by sending data to the master device via the MISO line. This implies full duplex transmission with both data out and data in synchronized with the same clock signal (one which is provided by the master device). Thus, the byte transmitted is replaced by the byte received and eliminates the need for separate transmit-empty and receiver-full status bits. A single status bit (SPIF) is used to signify that the I/O operation is complete.

Configuration of the MOSI pin is a function of the MSTR bit in the serial peripheral control register (SPCR, location \$0A). When a device is operating as a master, the MOSI pin is an output because the program in firmware sets the MSTR bit to a logic one.

Master In Slave Out (MISO)

The MISO pin is configured as an input in a master (mode) device and as an output in a slave (mode) device. In this manner data is transferred serially from a slave to a master on this line; most significant bit first, least significant bit last. The MISO pin of a slave device is placed in the high-impedance state if it is not selected by the master; i.e., its \overline{SS} pin is a logic one. The timing diagram of Figure 29 shows the relationship between data and clock (SCK). As shown in Figure

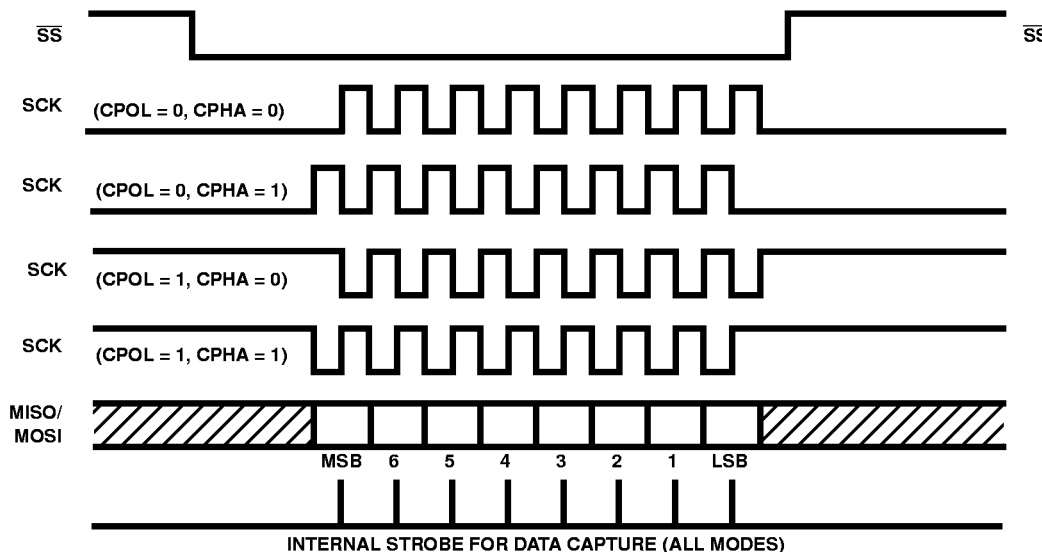


FIGURE 29. DATA CLOCK TIMING DIAGRAM

29, four possible timing relationships may be chosen by using control bits CPOL and CPHA. The master device always allows data to be applied on the MOSI line a half-cycle before the clock edge (SCK) in order for the slave device to latch the data.

NOTE: The slave device(s) and a master device must be programmed to similar timing modes for proper data transfer.

When the master device transmits data to a slave device via the MOSI line, the slave device responds by sending data to the master device via the MISO line. This implies full duplex transmission with both data out and data in synchronized with the same clock signal (one which is provided by the master device). Thus, the byte transmitted is replaced by the byte received and eliminates the need for separate transmit-empty and receiver-full status bits. A single status bit (SPIF) in the serial peripheral status register (SPSR, location \$0B) is used to signify that the I/O operation is complete.

In the master device, the MSTR control bit in the serial peripheral control register (SPCR, location \$0A) is set to a logic one (by the program) to allow the master device to receive data on its MISO pin. In the slave device, its MISO pin is enable by the logic level of the \overline{SS} pin; i.e., if $\overline{SS} = 1$ then the MISO pin is placed in the high-impedance state, whereas, if $\overline{SS} = 0$ the MISO pin is an output for the slave device.

Serial Clock (SCK)

The serial clock is used to synchronize the movement of data both in and out of the device through its MOSI and MISO pins. The master and slave devices are capable of exchanging a data byte of information during a sequence of eight clock pulses. The SCK is generated by the master device, is an input on all slave devices, and synchronizes master/slave data transfers. The type of clock and its relationship to data are controlled by the CPOL and CPHA bits in the Serial Peripheral Control Register (SPCR, location \$0A) discussed below. Refer to Figure 29 for timing.

The master device generates the SCK through a circuit driven by the internal processor clock. Two bits (SPR0 and SPR1) in the SPCR of the master device select the clock rate. The master device uses the SCK to latch incoming slave device data on the MISO line and shifts out data to the slave device on the MOSI line. Both master and slave devices must be operated in the same timing mode as controlled by the CPOL and CPHA bits in the SPCR. In slave devices, SPR0, SPR1 have no effect on the operation of the SPI. Timing is shown in Figure 29.

Slave Select (\overline{SS})

The slave select (\overline{SS}) pin is a fixed input, which receives an active low signal to enable slave device(s) to transfer data. A high level \overline{SS} signal forces the MISO line to the high-impedance state. Also, SCK and MOSI are ignored by a slave device when its \overline{SS} signal is high. The \overline{SS} signal must be driven low prior to the first SCK and must remain low throughout a transfer. The \overline{SS} input on a Master must be held high at all times (see description of MODF under **Serial Peripheral Status Register** for more details).

As shown in Figure 29, with CPHA = 0, the first bit of data must be applied to the MISO line prior to the first transition of

the SCK. In this case, \overline{SS} going low is used to provide the first clock edge of a transfer. A device is prevented from writing to its SPI data register while \overline{SS} is low and CPHA = 0 (see description of WCOL under **Serial Peripheral Status Register** for more details). **These facts require that \overline{SS} go high between SPI data transfers whenever CPHA = 0.**

When CPHA = 1, the \overline{SS} of a slave can be held low throughout a series of SPI transfers and in a single slave system can even be permanently wired low.

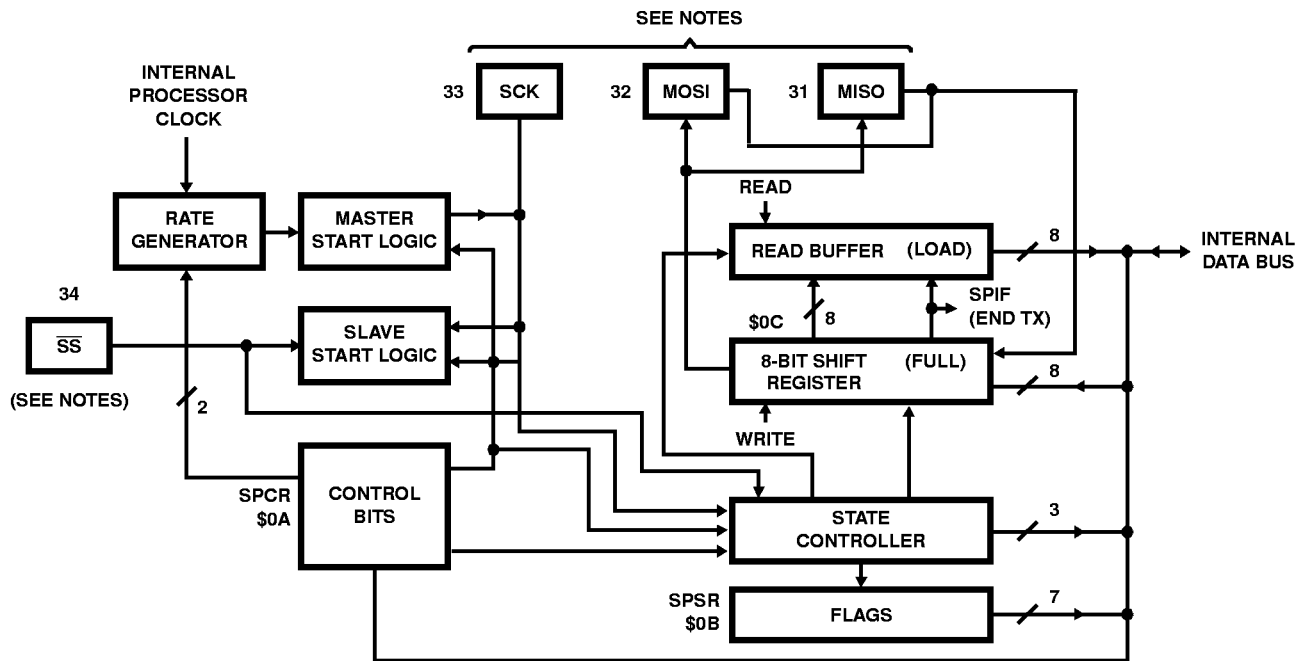
When a device is a master, it constantly monitors its \overline{SS} signal input for a logic low. The master device will become a slave device any time its \overline{SS} signal input is detected low. This ensures that there is only one master controlling the \overline{SS} line for a particular system. When the \overline{SS} line is detected low, it clears the MSTR control bit (serial peripheral control register, location \$0A). Also, control bit SPE in the serial peripheral control register is cleared which causes the serial peripheral interface (SPI) to be disabled. The MODF flag bit in the serial peripheral status register (location \$0B) is also set to indicate to the master device that another device is attempting to become a master. Two devices attempting to be outputs are normally the result of a software error; however, a system could be configured which would contain a default master which would automatically "take-over" and restart the system.

FUNCTIONAL DESCRIPTION

A block diagram of the serial peripheral interface (SPI) is shown in Figure 30. In a master configuration, the master start logic receives an input from the CPU (in the form of a write to the SPI rate generator) and originates the system clock (SCK) based on the internal processor clock. This clock is also used internally to control the state controller as well as the 8-bit shift register. As a master device, data is parallel loaded into the 8-bit shift register (from the internal bus) during a write cycle, data is applied serially from a slave device via the MISO pin to the 8-bit shift register. After the 8-bit shift register is loaded, its data is parallel transferred to the read buffer and then is made available to the internal data bus during a CPU read cycle.

In a slave configuration, the slave start logic receives a logic low (from a master device) at the \overline{SS} pin and a system clock input (from the same master device) at the SCK pin. Thus, the slave is synchronized with the master. Data from the master is received serially at the slave MOSI pin and loads the 8-bit shift register. After the 8-bit shift register is loaded, its data is parallel transferred to the read buffer and then is made available to the internal data bus during a CPU read cycle. During a write cycle, data is parallel loaded into the 8-bit shift register from the internal data bus and then shifted out serially to the MISO pin for application to the master device.

Figure 31 illustrates the MOSI, MISO, and SCK master-slave interconnections. Note that in Figure 31 the master \overline{SS} pin is tied to a logic high and the slave \overline{SS} pin is a logic low. Figure 28 provides a larger system connection for these same pins. Note that in Figure 28, all \overline{SS} pins are connected to a port pin of a master/slave device. In this case any of the devices can be a slave.



NOTES:

37. The \overline{SS} , SCK, MOSI and MISO are external pins which provide the following functions:
38. MOSI - Provides serial output to slave unit(s) when device is configured as a master. Receives serial input from master unit when device is configured as a slave unit.
39. MISO - Receives serial input from slave unit(s) when device is configured as a master. Provides serial output to master when device is configured as a slave unit.
40. SCK - Provides system clock when device is configured as a master unit. Receives system clock when device is configured as a slave unit.
41. \overline{SS} - Provides a logic low to select device for a transfer with a master device.

FIGURE 30. SERIAL PERIPHERAL INTERFACE BLOCK DIAGRAM

REGISTERS

There are three register in the serial parallel interface which provide control, status, and data storage functions. These registers which include the serial peripheral control register (SPCR, location \$0A), serial peripheral status register (SPSR, location \$0B), and serial peripheral data I/O register (SPDR, location \$0C) are described below.

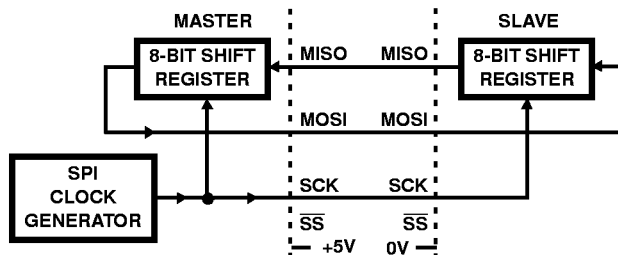


FIGURE 31. SERIAL PERIPHERAL INTERFACE MASTER-SLAVE INTERCONNECTION

Serial Peripheral Control Register (SPCR)

7	6	5	4	3	2	1	0
SPIE	SPE	0	MSTR	CPOL	CPHA	SPR1	SPR0

\$0A

The serial peripheral control register bits are defined as follows:

- B7, SPIE When the serial peripheral interrupt enable is high, it allows the occurrence of a processor interrupt, and forces the proper vector to be loaded into the program counter if the serial peripheral status register flag bit (SPIF and/or MODE) is set to a logic one. It does not inhibit the setting of a status bit. The SPIE bit is cleared by reset.
- B6, SPE When the serial peripheral output enable control bit is set, all output drive is applied to the external pins and the system is enabled. When the SPE bit is set, it enables the SPI system by connecting it to the external pins thus allowing it to interface with the external SPI bus. The pins that are defined as output depend on which mode (master or slave) the device is in. Because the SPE bit is cleared by reset, the SPI system is not connected to the external pins upon reset.
- B4, MSTR The master bit determines whether the device is a master or a slave. If the MSTR bit is a logic zero it indicates a slave device and a logic one denotes a master device. If the master mode is selected, the function of the SCK pin changes

from an input to an output and the function of the MISO and MOSI pins are reversed. This allows the user to wire device pins MISO to MISO, and MOSI to MOSI, and SCK to SCK without incident. The MSTR bit is cleared by reset; therefore, the device is always placed in the slave mode during reset.

B3, CPOL The clock polarity bit controls the normal or steady state value of the clock when data is not being transferred. The CPOL bit affects both the master and slave modes. It must be used in conjunction with the clock phase control bit (CPHA) to produce the wanted clock-data relationship between a master and a slave device. When the CPOL bit is a logic zero, it produces a steady state low value at the SCK pin of the master device. If the CPOL bit is a logic one, a high value is produced at the SCK pin of the master device when data is not being transferred. The CPOL bit is not affected by reset. Refer to Figure 29.

B2, CPHA The clock phase bit controls the relationship between the data on the MISO and MOSI pins and the clock produced or received at the SCK pin. This control has effect in both the master and slave modes. It must be used in conjunction with the clock polarity control bit (CPOL) to produce the wanted clock-data relation. The CPHA bit in general selects the clock edge which captures data and allows it to change states. It has its greatest impact on the first bit transmitted (MSB) in that it does or does not allow a clock transition before the first data capture edge. The CPHA bit is not affected by reset. Refer to Figure 29.

SPR1	SPR0	INTERNAL PROCESSOR CLOCK DIVIDE BY
0	0	2
0	1	4
1	0	16
1	1	32

B1, SPR1 These two serial peripheral rate bits select one

B0, SPR0 of four baud rates to used as SCK if the device is a master; however they have no effect in the slave mode. The slave device is capable of shifting data in and out at a maximum rate which is equal to the CPU clock. A rate table is given below for the generation of the SCK from the master. The SPR1 and SPR0 bits are not affected by reset.

Serial Peripheral Status Register (SPSR)

7	6	5	4	3	2	1	0	
SPIF	WCOL	0	MODF	0	0	0	0	\$0B

The status flags which generate a serial peripheral interface (SPI) interrupt may be blocked by the SPIE control bit in the serial peripheral control register. The WCOL bit does not cause an interrupt. The serial peripheral status register bits are defined as follows:

B7, SPIF

The serial peripheral data transfer flag bit notifies the user that a data transfer between the device and an external device has been completed. With the completion of the data transfer, SPIF is set, and if SPIE is set, a serial peripheral interrupt (SPI) is generated. During the clock cycle that SPIF is being set, a copy of the received data byte in the shift register is moved to a buffer. When the data register is read, it is the buffer that is read. During an overrun condition, when the master device has sent several bytes of data and the slave device has not responded to the first SPIF, only the first byte sent is contained in the receiver buffer and all other bytes are lost.

The transfer of data is initiated by the master device writing its serial peripheral data register.

Clearing the SPIF bit is accomplished by a software sequence of accessing the serial peripheral status register while SPIF is set and followed by a write to or a read of the serial peripheral data register. While SPIF is set, all writes to the serial peripheral data register are inhibited until the serial peripheral status register is read. This occurs in the master device. In the slave device, SPIF can be cleared (using a similar sequence) during a second transmission; however, it must be cleared before the second SPIF in order to prevent an overrun condition. The SPIF bit is cleared by reset.

B6, WCOL

The function of the write collision status bit is to notify the user that an attempt was made to write the serial peripheral data register while a data transfer was taking place with an external device. The transfer continues uninterrupted; therefore, a write will be unsuccessful. A "read collision" will never occur since the received data byte is placed in a buffer in which access is always synchronous with the MCU operation. If a "write collision" occurs, WCOL is set but no SPI interrupt is generated. The WCOL bit is a status flag only.

Clearing the WCOL bit is accomplished by a software sequence of accessing the serial peripheral status register while WCOL is set, followed by 1) a read of the serial peripheral data register prior to the SPIF bit being set, or 2) a read or write of the serial peripheral data register after the SPIF bit is set. A write to the serial peripheral data register (SPDR) prior to the SPIF bit being set, will result in generation of another WCOL status flag. Both the SPIF and WCOL bits will be cleared in the same sequence. If a second transfer has started while trying to clear (the previously set) SPIF and WCOL bits with a clearing sequence containing a write to the serial peripheral data register, only the SPIF bit will be cleared.

A collision of a write to the serial peripheral data register while an external data transfer is taking place can occur in both the master mode and the slave mode, although with proper programming the master device should have sufficient information to preclude this collision.

Collision in the master device is defined as a write of the serial peripheral data register while the internal rate clock (SCK) is in the process of transfer. The signal on the \overline{SS} pin is always high on the master device.

A collision in a slave device is defined in two separate modes. One problem arises in a slave device when the CPHA control bit is a logic zero. When CPHA is a logic zero, data is latched with the occurrence of the first clock transition. The slave device does not have any way of knowing when that transition will occur; therefore, the slave device collision occurs when it attempts to write the serial peripheral data register after its \overline{SS} pin has been pulled low. The \overline{SS} pin of the slave device freezes the data in its serial peripheral data register and does not allow it to be altered if the CPHA bit is a logic zero. The master device must raise the \overline{SS} pin of the slave device high between each byte it transfers to the slave device.

The second collision mode is defined for the state of the CPHA control bit being a logic one. With the CPHA bit set, the slave device will be receiving a clock (SCK) edge prior to the latch of the first data transfer. This first clock edge will freeze the data in the slave device I/O register and allow the MSB onto the external MISO pin of the slave device. The \overline{SS} pin low state enables the slave device but the drive onto the MISO pin does not take place until the first data transfer clock edge. The WCOL bit will only be set if the I/O register is accessed while a transfer is taking place. By definition of the second collision mode, a master device might hold a slave device \overline{SS} pin low during a transfer of several bytes of data without a problem.

A special case of WCOL occurs in the slave device. This happens when the master device starts a transfer sequence (an edge on SCK for CPHA = 1; or an active \overline{SS} transition for CPHA = 0) at the same time the slave device CPU is writing to its serial peripheral interface data register. In this case it is assumed that the data byte written (in the slave device serial peripheral interface) is lost and the contents of the slave device read buffer becomes the byte that is transferred. Because the master device receives back the last byte transmitted, the master device can detect that a fatal WCOL occurred.

Since the slave device is operating asynchronously with the master device, the WCOL bit may be used as an indicator of a collision occur-

rence. This helps alleviate the user from a strict real-time programming effort. The WCOL bit is cleared by reset.

B4, MODF The function of the mode fault flag is defined for the master mode (device). If the device is a slave device the MODF bit will be prevented from toggling from a logic zero to a logic one; however, this does not prevent the device from being in the slave mode with the MODF bit set. The MODF bit is normally a logic zero and is set only when the master device has its \overline{SS} pin pulled low. Toggling the MODF bit to a logic one affects the internal serial peripheral interface (SPI) system in the following ways:

1. MODF is set and SPI interrupt is generated if SPIE = 1.
2. The SPE bit is forced to a logic zero. This blocks all output drive from the device, disables the SPI system.
3. The MSTR bit is forced to a logic zero, thus forcing the device into the slave mode.

Clearing the MODF is accomplished by a software sequence of accessing the serial peripheral status register while MODF is set followed by a write to the serial peripheral control register. Control bit SPE and MSTR may be restored to their original set state during this cleared sequence or after the MODF bit has been cleared. Hardware does not allow the user to set the SPE and MSTR bit while MODF is a logic one unless it is during the proper clearing sequence. The MODF flag bit indicates that there might have been a multi-master conflict for system control and allows a proper exit from system operation to a reset or default system state. The MODF bit is cleared by reset.

Serial Peripheral Data I/O Register (SPDR)

7	6	5	4	3	2	1	0
Serial Peripheral Data I/O Register							

\$0C

The serial peripheral data I/O register is used to transmit and receive data on the serial bus. Only a write to this register will initiate transmission/reception of another byte and this will only occur in the master device. A slave device writing to its data I/O register will not initiate a transmission. At the completion of transmitting a byte of data, the SPIF status bit is set in both the master and slave devices. A write or read of the serial peripheral data I/O register, after accessing the serial peripheral status register with SPIF set, will clear SPIF.

During the clock cycle that the SPIF bit is being set, a copy of the received data byte in the shift register is being moved to a buffer. When the user reads the serial peripheral data I/O register, the buffer is actually being read. During an overrun condition, when the master device has sent several bytes of data and the slave device has not internally responded to clear the first SPIF, only the first byte is contained in the receive buffer of the slave device; all others

are lost. The user may read the buffer at any time. The first SPIF must be cleared by the time a second transfer of data from the shift register to the read buffer is initiated or an overrun condition will exist.

A write to the serial peripheral data I/O register is not buffered and places data directly into the shift register for transmission.

The ability to access the serial peripheral data I/O register is limited when a transmission is taking place. It is important to read the discussion defining the WCOL and SPIF status bit to understand the limits on using the serial peripheral data I/O register.

SERIAL PERIPHERAL INTERFACE (SPI) SYSTEM CONSIDERATIONS

There are two types of SPI systems; single master system and multi-master systems. Figure 28 illustrates a single master system and a discussion of both is provided below.

Figure 28 illustrates how a typical single master system may be configured, using a CDP68HC05 family device as the master and four CDP68HC05 family devices as slaves. As shown, the MOSI, MISO, and SCK pins are all wired to equivalent pins on each of the five devices. The master device generates the SCK clock, the slave devices all receive it. Since the CDP68HC05 master device is the bus master, it internally controls the function of its MOSI and MISO lines, thus writing data to the slave devices on the MOSI and reading data from the slave devices on the MISO lines. The master device selects the individual slave devices by using four pins of a parallel port to control the four \overline{SS} pins of the slave devices. A slave device is selected when the master device pulls its \overline{SS} pin low. The \overline{SS} pins are pulled high during reset since the master device ports will be forced to be inputs at that time, thus disabling the slave devices. Note that the slave devices do not have to be enabled in a mutually exclusive fashion except to prevent bus contention on the MISO line. For example, three slave devices, enabled for a transfer, are permissible if only one has the capability of being read by the master. An example of this is a write to several display drivers to clear a display with a single I/O operation. To ensure that proper data transmission is occurring between the master device and a slave device, the master device may have the slave device respond with a previously received data byte (this data byte could be inverted or at least be a byte that is different from the last one sent by the master device). The master device will always receive the previous byte back from the slave device if all MISO and MOSI lines are connected and the slave has not written its data I/O register. Other transmission security methods might be defined using ports for handshake lines or data bytes with command fields.

A multi-master system may also be configured by the user. An exchange of master control could be implemented using a handshake method through the I/O ports or by an exchange of code messages through the serial peripheral interface system. The major device control that plays a part in this system is the MSTR bit in the serial peripheral control register and the MODF bit in the serial peripheral status register.

Port A Tone and Simple PWM Circuitry

INTRODUCTION

When the Tone output mask option is selected on PA7-PA4 a fixed frequency will appear on the output pin whenever the appropriate DDRA and PORTA bits are set to 1. Each of the port pins A4 - A7 provides a different frequency. The frequency is dependent on the oscillator input frequency and on the values selected for SCP1 and SCP0 in the SCI Baud Rate Register (see Table 7). An example of frequencies generated with a 4MHz oscillator and SCP1=SCP0=1 is shown in Figure 32.

Even when the tone output mask option is selected the PA7-PA4 pins still function as CMOS inputs when the appropriate bits in DDRA are set to 0. No signal will appear on the port pin when that pin is configured as an input. When a tone pin is in the output mode (i.e. for pin PAx, DDRAx is set to "1") writing a 1 to the respective PA7-PA4 bit in the PORTA register enables the frequency to appear on the pin output. Writing a 0 to this location disconnects this signal from the pin output. When the bits of PORTA are in output mode (DDRAx=1) reading the port reads the state of the PORTA bit in register location \$00, not the tone signal.

Note that the Port A tone option is individually selectable via mask option for PA7, PA6, PA5 and PA4. For example, you may decide to configure PA7 and PA4 as tone outputs and keep PA6 and PA5 as regular port I/O pins.

Standard Tone Option

When the standard tone option is chosen, those Port A pins with the tone outputs enabled will output a fixed frequency, square wave signal. The output driver for this signal will be the standard CMOS push-pull circuitry of the Port A output pin. The frequency of the square wave depends on which Port A pin is being used and the value of the SCI baud rate prescaler bits SCP1 and SCP0. Table 6 shows output frequencies for different combinations of oscillator frequencies and baud rate prescalers.

The standard tone option is ideal for applications that need a fixed frequency that does not require CPU intervention (as does the TCMP function). One example would be an LCD backplane driver.

Simple PWM Option

When the PWM tone option is chosen, the waveforms of the tones are changed to those shown in Figure 32. Also, those Port A pins chosen as tone outputs have their low side output driver disabled. This open drain configuration (see Figure 6D) allows wire ORing of the pins to produce various duty cycle outputs creating a simple PWM. An example of a composite PWM waveform is shown as the last waveform in Figure 32. In this case the signal shown is the result of wire-ORing all four pins together (with a pull-down resistor), setting DDRA7-DDRA4=1 and PA7, PA5 and PA4=1 and PA6=0. The number in parentheses beside the port designations in the diagram is the duty cycle of the associated output signal.

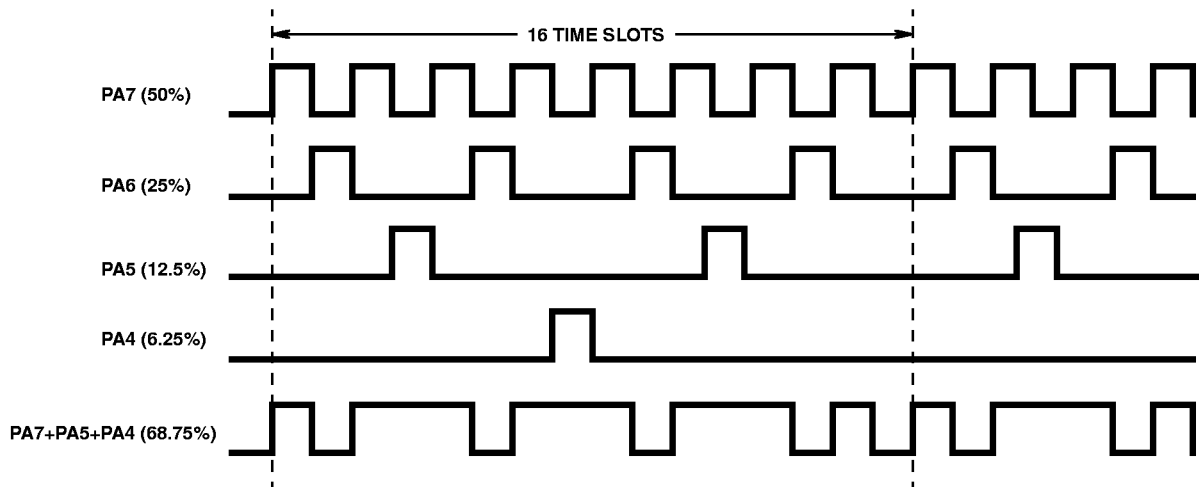


FIGURE 32. PORT A TONE GENERATOR/SIMPLE PWM OUTPUT WAVEFORMS

TABLE 7. PORT A TONES WITH 4MHz OSCILLATOR

PIN	FREQUENCY DIVISOR OF BAUD RATE PRESCALE	FREQUENCY WITH $SCP1=SCP0=1$ IN SCI BAUD RATE REGISTER
PA4	Divide By 64	150Hz
PA5	Divide By 32	300Hz
PA6	Divide By 16	600Hz
PA7	Divide By 8	1200Hz

NOTE: Frequency is dependent on the Baud Rate Prescaler value set in the Baud Rate Register. See *Serial Communications Interface (SCI)* for details on the Baud Rate Register

The port A tone output options are not available on the MC68CH05C4A or the MC68CH05C8A devices. When designing CDP68HC05C4B/C8B systems which must maintain backward compatibility with the MC68CH05C4A or the MC68CH05C8A avoid use of the port A tone option.

Effects of Stop and Wait Modes on the Timer and Serial Systems

STOP MODE

When the processor executes the STOP instruction, the internal oscillator is turned off. This halts all internal CPU processing including the operation of the programmable timer, serial communications interface, serial peripheral interface, and COP. The only way for the MCU to “wake up” from the stop mode is by receipt of an external interrupt ($\overline{IRQ} = 0$) or by a hardware reset (logic low on \overline{RESET} pin or a power-on reset).

Timer During Stop Mode

When the MCU enters the stop mode, the timer counter stops counting (the internal processor is stopped) and remains at that particular count value until the stop mode is exited by an interrupt (if exited by reset the counter is forced to \$FFFC). If the stop mode is exited by an external low on the \overline{IRQ} pin, then the counter resumes from its stopped value as if nothing had happened. If at least one valid input capture edge occurs

at the ICAP pin while in the stop mode, the input capture detect circuitry is armed. This action does not set any timer flags or “wake up” the MCU, but when the MCU does “wake up” there will be an active input capture flag (and data) from that first valid edge which occurred during the stop mode. If the stop mode is exited by an external reset (logic low on \overline{RESET} pin), then no such input capture flag or data action takes place even if there was a valid input capture edge (at the TCAP pin) during the MCU stop mode.

SCI During Stop Mode

When the MCU enters the stop mode, the baud rate generator which drives the receiver and transmitter is shut down. This essentially stops all SCI activity. The receiver is unable to receive and transmitter is unable to transmit. If the STOP instruction is executed during a transmitter transfer, that transfer is halted. When the stop mode is exited, that particular transmission resumes (if the exit is the result of a low input to the \overline{IRQ} pin). Since the previous transmission resumes after an \overline{IRQ} interrupt stop mode exit, the user should ensure that the SCI transmitter is in the idle state when the STOP instruction is executed. If the receiver is receiving data when the STOP instruction is executed, received data sampling is stopped (baud rate generator stops) and the rest of the data is lost. For the above reasons, all SCI transactions should be in the idle state when the STOP instruction is executed.

SPI During Stop Mode

When the MCU enters the stop mode, the baud rate generator which drives the SPI shuts down. This essentially stops all master mode SPI operation, thus the master SPI is unable to transmit or receive any data. If the STOP instruction is executed during an SPI transfer, that transfer is halted until the MCU exits the stop mode (provided it is an exit resulting from a logic low on the \overline{IRQ} pin). If the stop mode is exited by a reset, then the appropriate control/status bits are cleared and the SPI is disabled. If the device is in the slave mode when the STOP instruction is executed, the slave SPI will still operate. It can still accept data and clock information in addition to transmitting its own data back to a master device.

At the end of a possible transmission with a slave SPI in the stop mode, no flags are set until a logic low IRQ input results in an MCU “wake up”. Caution should be observed when operating the SPI (as a slave) during the stop mode because none of the protection circuitry (write collision, mode fault, etc.) is active.

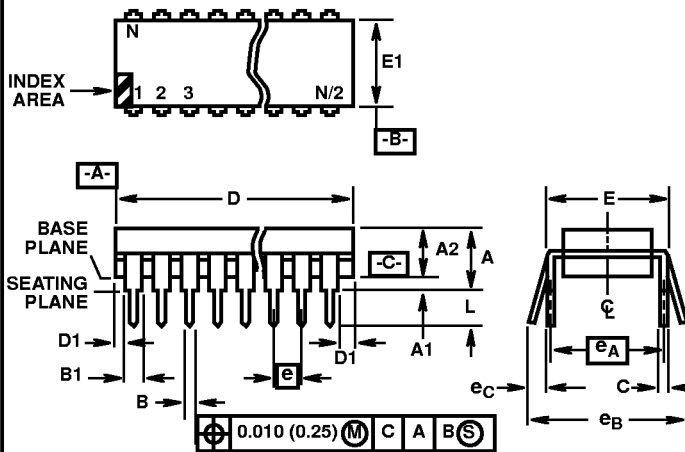
It should also be noted that when the MCU enters the stop mode all enabled output drivers (TDO, TCMP, MISO, MOSI, and SCK ports) remain active and any sourcing currents from these outputs will be part of the total supply current required by the device.

WAIT MODE

When the MCU enters the wait mode, the CPU clock is halted. All CPU action is suspended; however, the timer, SCI, SPI, and COP systems remain active. In fact, any interrupt from the timer, SCI, SPI, or $\overline{\text{IRQ}}$ pin or a reset from the COP or $\overline{\text{RESET}}$ pin will cause the processor to exit the wait mode. Since the timer and serial systems operate as they do in the normal “run” mode, only a general discussion of the wait mode is provided below.

The wait mode power consumption depends on how many systems are active. The power consumption will be highest when all the systems (timer, TCMP, SCI, and SPI) are active. The power consumption will be the least when the SCI and SPI systems are disabled (timer operation cannot be disabled in the wait mode). If a non-reset exit from the wait mode is performed (i.e., timer overflow interrupt exit), the state of the remaining systems will be unchanged. If a reset exit from the wait mode is performed all the systems revert to the disabled reset state. See previous discussion of COP.

Dual-In-Line Plastic Packages (PDIP)



NOTES:

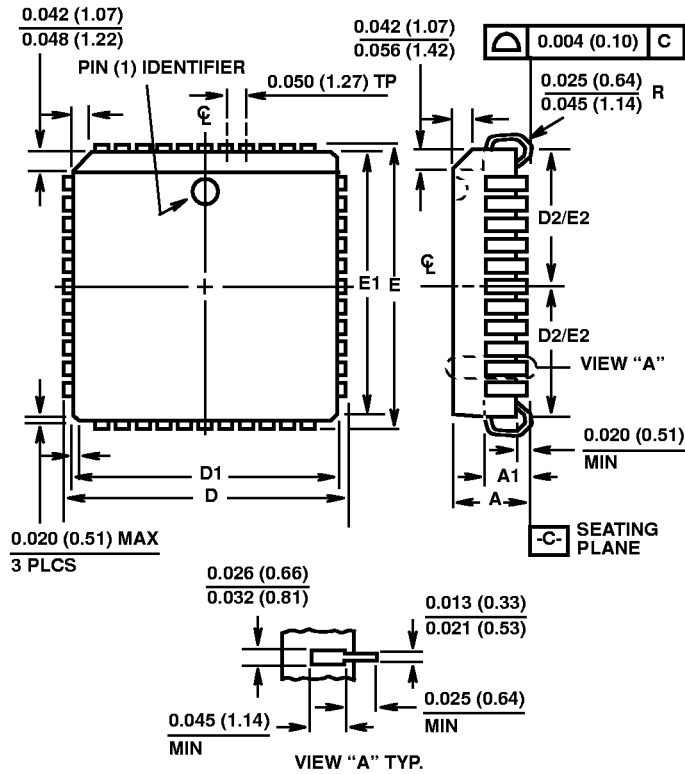
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured 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).

E40.6 (JEDEC MS-011-AC ISSUE B) 40 LEAD 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	1.980	2.095	50.3	53.2	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	40		40		9

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Plastic Leaded Chip Carrier Packages (PLCC)



N44.65 (JEDEC MS-018AC ISSUE A) 44 LEAD PLASTIC LEADED CHIP CARRIER PACKAGE

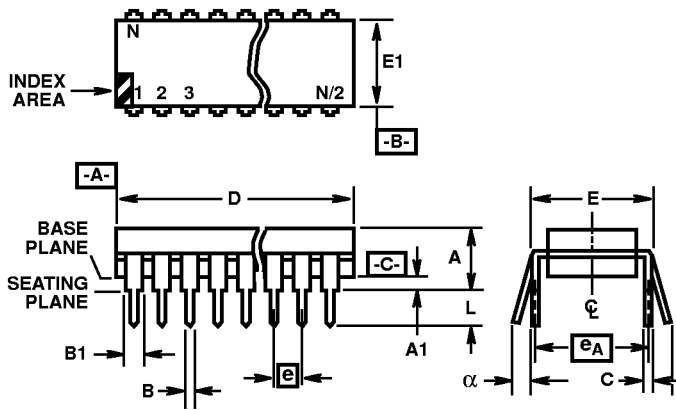
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.165	0.180	4.20	4.57	-
A1	0.090	0.120	2.29	3.04	-
D	0.685	0.695	17.40	17.65	-
D1	0.650	0.656	16.51	16.66	3
D2	0.291	0.319	7.40	8.10	4, 5
E	0.685	0.695	17.40	17.65	-
E1	0.650	0.656	16.51	16.66	3
E2	0.291	0.319	7.40	8.10	4, 5
N	44		44		6

Rev. 1 3/95

NOTES:

1. Controlling dimension: INCH. Converted millimeter dimensions are not necessarily exact.
2. Dimensions and tolerancing per ANSI Y14.5M-1982.
3. Dimensions D1 and E1 do not include mold protrusions. Allowable mold protrusion is 0.010 inch (0.25mm) per side.
4. To be measured at seating plane -C- contact point.
5. Centerline to be determined where center leads exit plastic body.
6. "N" is the number of terminal positions.

Shrink Dual-In-Line Plastic Packages (SPDIP)



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. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
4. D and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
5. E and eA are measured with the leads constrained to be perpendicular to datum -C-.
6. N is the maximum number of terminal positions.

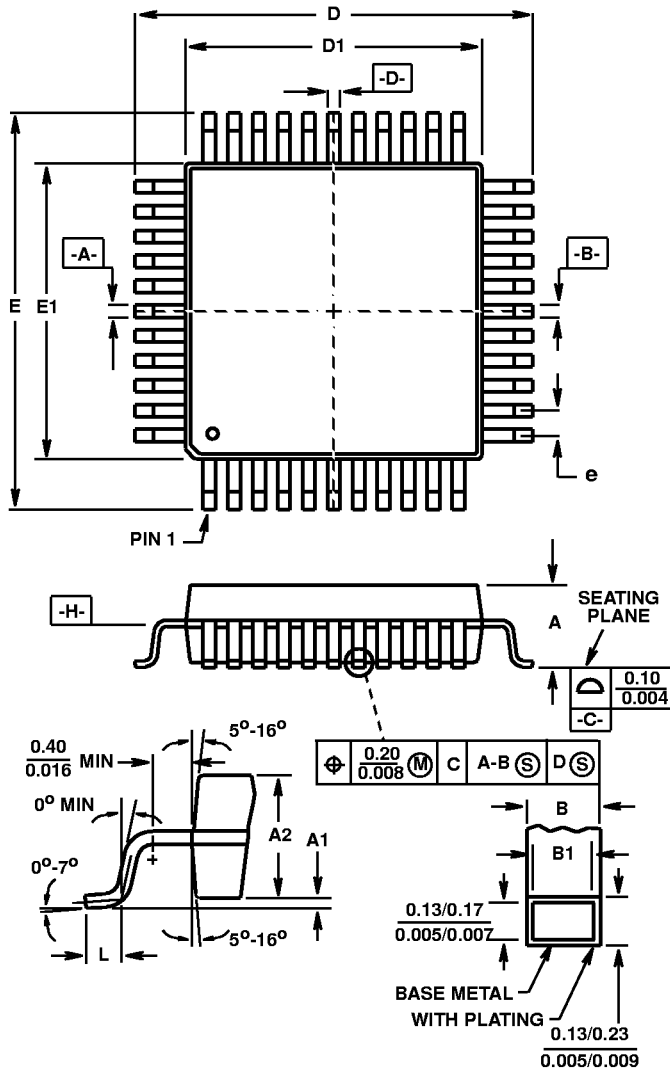
E42.6C

42 LEAD SHRINK DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.190	-	4.83	3
A1	0.020	-	0.51	-	3
B	0.015	0.022	0.38	0.56	-
B1	0.030	0.050	0.76	1.27	-
C	0.008	0.012	0.20	0.30	-
D	1.445	1.455	36.70	36.96	4
E	0.600	0.625	15.24	15.88	5
E1	0.530	0.550	13.46	13.97	4
e	0.070 BSC		1.78 BSC		-
eA	0.600 BSC		15.24 BSC		5
α	0°	15°	0°	15°	-
L	0.120	0.135	3.05	3.43	3
N	42		42		6

Rev. 0 2/97

Metric Plastic Quad Flatpack Packages (MQFP)



**Q44.10x10 (JEDEC MO-108AA-2 ISSUE A)
44 LEAD METRIC PLASTIC QUAD FLATPACK PACKAGE**

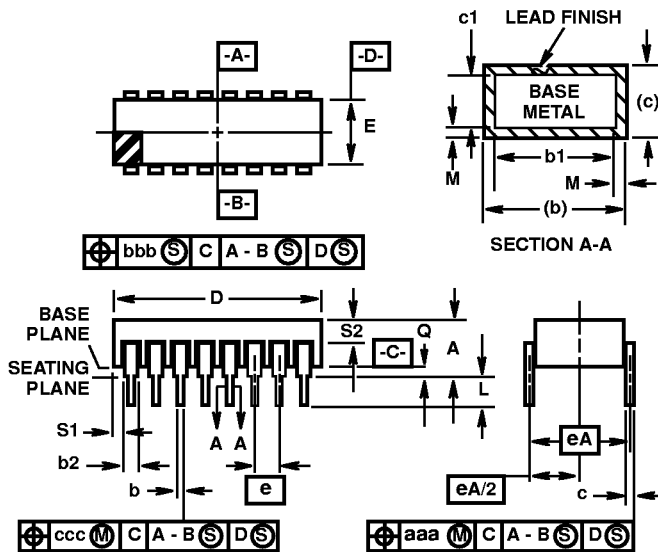
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.093	-	2.35	-
A1	0.004	0.010	0.10	0.25	-
A2	0.077	0.083	1.95	2.10	-
B	0.012	0.018	0.30	0.45	6
B1	0.012	0.016	0.30	0.40	-
D	0.510	0.530	12.95	13.45	3
D1	0.390	0.398	9.90	10.10	4, 5
E	0.510	0.530	12.95	13.45	3
E1	0.390	0.398	9.90	10.10	4, 5
L	0.026	0.037	0.65	0.95	-
N	44		44		7
e	0.032 BSC		0.80 BSC		-

Rev. 1 1/94

NOTES:

1. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.
2. All dimensions and tolerances per ANSI Y14.5M-1982.
3. Dimensions D and E to be determined at seating plane **-C-**.
4. Dimensions D1 and E1 to be determined at datum plane **-H-**.
5. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm (0.010 inch) per side.
6. Dimension B does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm (0.003 inch) total.
7. "N" is the number of terminal positions.

Ceramic Dual-In-Line Metal Seal Packages (SBDIP)



NOTES:

1. Index area: A notch or a pin one identification mark shall be located adjacent to pin one and shall be located within the shaded area shown. The manufacturer's identification shall not be used as a pin one identification mark.
2. The maximum limits of lead dimensions b and c or M shall be measured at the centroid of the finished lead surfaces, when solder dip or tin plate lead finish is applied.
3. Dimensions b1 and c1 apply to lead base metal only. Dimension M applies to lead plating and finish thickness.
4. Corner leads (1, N, N/2, and N/2+1) may be configured with a partial lead paddle. For this configuration dimension b3 replaces dimension b2.
5. Dimension Q shall be measured from the seating plane to the base plane.
6. Measure dimension S1 at all four corners.
7. Measure dimension S2 from the top of the ceramic body to the nearest metallization or lead.
8. N is the maximum number of terminal positions.
9. Braze fillets shall be concave.
10. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
11. Controlling dimension: INCH.

D40.6 MIL-STD-1835 CDIP2-T40 (D-5, CONFIGURATION C) 40 LEAD CERAMIC DUAL-IN-LINE METAL SEAL PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.225	-	5.72	-
b	0.014	0.026	0.36	0.66	2
b1	0.014	0.023	0.36	0.58	3
b2	0.045	0.065	1.14	1.65	-
b3	0.023	0.045	0.58	1.14	4
c	0.008	0.018	0.20	0.46	2
c1	0.008	0.015	0.20	0.38	3
D	-	2.096	-	53.24	4
E	0.510	0.620	12.95	15.75	4
e	0.100 BSC		2.54 BSC		-
eA	0.600 BSC		15.24 BSC		-
eA/2	0.300 BSC		7.62 BSC		-
L	0.125	0.200	3.18	5.08	-
Q	0.015	0.070	0.38	1.78	5
S1	0.005	-	0.13	-	6
S2	0.005	-	0.13	-	7
α	90°	105°	90°	105°	-
aaa	-	0.015	-	0.38	-
bbb	-	0.030	-	0.76	-
ccc	-	0.010	-	0.25	-
M	-	0.0015	-	0.038	2
N	40		40		8

Rev. 0 4/94

TABLE 1. INSTRUCTION SET OP CODE MAP

HI LOW	BIT MANIPULATION		BRANCH		READ/MODIFY/WRITE				CONTROL		REGISTER/MEMORY					
	BTB	BSC	REL		DIR	INH	INH	IX1	IX	INH	IMM	DIR	EXT	IX2	IX1	IX
0	0	1	2		3	4	5	6	7	8	9	A	C	D	E	F
0	BRSET0 BTB 3	BSET0 BSC 2	BRA REL 2		5 NEG DIR 1	3 NEGA INH 1	3 NEG INH 1	6 NEG IX1 1	5 NEG IX 1	9 RTI INH 1		2 SUB IMM 2	4 SUB EXT 3	5 SUB IX2 3	4 SUB IX1 1	3 SUB IX 1
1	BRCLR0 BTB 3	BCLR0 BSC 2	BRN REL 2							6 RTS INH 1		2 CMP IMM 2	4 CMP EXT 3	5 CMP IX2 3	4 CMP IX1 1	3 CMP IX 1
2	BRSET1 BTB 3	BSET1 BSC 2	BHI REL 2			11 MUL INH 1						2 SBC IMM 2	4 SBC EXT 3	5 SBC IX2 3	4 SBC IX1 1	3 SBC IX 1
3	BRCLR1 BTB 3	BCLR1 BSC 2	BLS REL 2		5 COM DIR 1	3 COMA INH 1	3 COMX INH 1	6 COM IX1 1	5 COM IX 1	10 SWI INH 1		2 CPX IMM 2	4 CPX EXT 3	5 CPX IX2 3	4 CPX IX1 1	3 CPX IX 1
4	BRSET2 BTB 3	BSET2 BSC 2	BOC REL 2		5 LSR DIR 1	3 LSRA INH 1	3 LSRX INH 1	6 LSR IX1 1	5 LSR IX 1			2 AND IMM 2	4 AND EXT 3	5 AND IX2 3	4 AND IX1 1	3 AND IX 1
5	BRCLR2 BTB 3	BCLR2 BSC 2	BCS REL 2									2 BIT IMM 2	4 BIT EXT 3	5 BIT IX2 3	4 BIT IX1 1	3 BIT IX 1
6	BRSET3 BTB 3	BSET3 BSC 2	BNE REL 2		5 ROR DIR 1	3 RORA INH 1	3 RORX INH 1	6 ROR IX1 1	5 ROR IX 1			2 LDA IMM 2	4 LDA EXT 3	5 LDA IX2 3	4 LDA IX1 1	3 LDA IX 1
7	BRCLR3 BTB 3	BCLR3 BSC 2	BEQ REL 2		5 ASR DIR 1	3 ASRA INH 1	3 ASRX INH 1	6 ASR IX1 1	5 ASR IX 1	2 TAX INH 1			4 STA EXT 3	5 STA IX2 3	4 STA IX1 1	3 STA IX 1
8	BRSET4 BTB 3	BSET4 BSC 2	BHCC REL 2		5 LSL DIR 1	3 LSLA INH 1	3 LSLX INH 1	6 LSL IX1 1	5 LSL IX 1	2 CLC INH 1		2 EOR IMM 2	4 EOR EXT 3	5 EOR IX2 3	4 EOR IX1 1	3 EOR IX 1
9	BRCLR4 BTB 3	BCLR4 BSC 2	BHCS REL 2		5 ROL DIR 1	3 ROLA INH 1	3 ROLX INH 1	6 ROL IX1 1	5 ROL IX 1	2 SEC INH 1		2 ADC IMM 2	4 ADC EXT 3	5 ADC IX2 3	4 ADC IX1 1	3 ADC IX 1
A	BRSET5 BTB 3	BSET5 BSC 2	BPL REL 2		5 DEC DIR 1	3 DECA INH 1	3 DECX INH 1	6 DEC IX1 1	5 DEC IX 1			2 ORA IMM 2	4 ORA EXT 3	5 ORA IX2 3	4 ORA IX1 1	3 ORA IX 1
B	BRCLR5 BTB 3	BCLR5 BSC 2	BMI REL 2							2 SEI INH 1		2 ADD IMM 2	4 ADD EXT 3	5 ADD IX2 3	4 ADD IX1 1	3 ADD IX 1
C	BRSET6 BTB 3	BSET6 BSC 2	BMC REL 2		5 INC DIR 1	3 INCA INH 1	3 INCX INH 1	6 INC IX1 1	5 INC IX 1	2 RSP INH 1			2 JMP EXT 3	4 JMP IX2 3	3 JMP IX1 1	2 JMP IX 1
D	BRCLR6 BTB 3	BCLR6 BSC 2	BMS REL 2		5 TST DIR 1	3 TSTA INH 1	3 TSTX INH 1	6 TST IX1 1	5 TST IX 1	2 NOP INH 1		6 BSR REL 2	5 JSR EXT 3	7 JSR IX2 3	6 JSR IX1 1	5 JSR IX 1
E	BRSET7 BTB 3	BSET7 BSC 2	BIL REL 2							2 STOP INH 1		2 LDX IMM 2	4 LDX EXT 3	5 LDX IX2 3	4 LDX IX1 1	3 LDX IX 1
F	BRCLR7 BTB 3	BCLR7 BSC 2	BIH REL 2		5 CLR DIR 1	3 CLRA INH 1	3 CLR INH 1	6 CLR IX1 1	5 CLR IX 1	2 TXA INH 1			4 STX EXT 3	5 STX IX2 3	4 STX IX1 1	3 STX IX 1

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

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

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

LSB of Opcode
0

HI
LOW

MSB of Opcode
0
Number of Cycles
Instruction Mnemonic
Number of Bytes/Addressing Mode
BTB
BRSET0
3

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 KPI, 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, STOP Disable, 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
CDP68HC05J4B	4160	176	16-BIT; 1IC, 1OC	None	14 i/o	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator, Keypad Scan Interface, STOP Disable, 2 High Current Pins (15mA)	20PDIP, 20SOIC, 28PDIP, 28SOIC
CDP68HC05P1B	2320	128	16-BIT; 1IC, 1OC	None	20 i/o, 1 i	Yes	Yes	Yes	8x8 Unsigned Multiply, RC or Crystal Oscillator, Keypad Scan Interface, Wake Up Timer, 2 High Current Pins (20mA)	20SOIC, 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 Scan Interface, SIOP, Wake Up Timer, 2 High Current Pins (20mA)	20SOIC, 28PDIP, 28SOIC
CDP68HC05JC2	2110	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
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 i/o = Bidirectional Port J1850 = SAE J1850 Serial Communications Interface HSC Versions: High Speed Versions, Max $f_{osc} = 8\text{MHz}$
IC = Input Capture KPI = Keypad Interrupt SCI = Serial Communications Interface HCL Versions: Low Power Versions, Typical Run Power = 1.2mW
i = Input Only Port OC = Output Compare SPI = Serial Peripheral Interface SIOP = Simple Serial I/O Port

CDP68HC05C4B/C8B, CDP68HCL05C4B/C8B, CDP68HSC05C4B/C8B

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
\$0000	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	PORT A
	4	5	6	7	8	9	10	11	Pin Numbers (Note)
	PA7/TONE7	PA6/TONE6	PA5/TONE5	PA4/TONE4	PA3	PA2	PA1	PA0	Pin Name
\$0001	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	PORT B
	19	18	17	16	15	14	13	12	Pin Numbers (Note)
	PB7	PB6	PB5	PB4	PB3	PB2	PB1	PB0	Pin Name
\$0002	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	PORT C
	21	22	23	24	25	26	27	28	Pin Numbers (Note)
	PC7	PC6	PC5	PC4	PC3	PC2	PC1	PC0	Pin Name
\$0003	I	0	I	I/O	I/O	I/O	I/O	I	PORT D
	36	-	34	33	32	31	30	29	Pin Numbers (Note)
	PD7	-	PD5/SS	PD4/SCK	PD3/MOSI	PD2/MISO	PD1/TDO	PD0/RDI	Pin Name
\$0004	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	DDRA
\$0005	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	DDRB
\$0006	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	DDRC
\$0007	UNUSED								
\$0008	UNUSED								
\$0009	UNUSED								
\$000A	SPIE	SPE	0	MSTR	CPOL	CPHA	SPR1	SPR0	SPCR
\$000B	SPIF	WCOL	0	MODF	0	0	0	0	SPSR
\$000C	SPI DATA REGISTER								SPDR
\$000D	0	0	SCP1	SCP2	0	SCR2	SCR1	SCR0	BAUD
\$000E	R8	T8	0	M	WAKE	0	0	0	SCCR1
\$000F	TIE	TCIE	RIE	ILIE	TE	RE	RWU	SBK	SCCR2
\$0010	TDRE	TC	RDRF	IDLE	OR	NF	FE	0	SCSR
\$0011	SCI DATA REGISTER								SCDR
\$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	UNUSED								
\$001D	UNUSED								
\$001E	UNUSED								
\$001F	RESERVED								RESERVED

0 = UNUSED LOCATION

FIGURE 33. I/O, CONTROL, STATUS, AND DATA REGISTER DEFINITIONS

NOTE: Pin numbers are for the 40 lead DIP package only. See page 3 for other package pinouts.

Ordering Information Sheet

A. Device Type (select one):

☐ CDP68HC05C4B ☐ CDP68HC05C8B

B. Package Type (select one):

☐ 40 Ld Dual-In-Line Plastic (E) ☐ 44 Ld MQFP (Q) ☐ Chip (H)
☐ 44 Ld PLCC (N) ☐ 42 Ld Shrink Dual-In-Line (SE)

Production Packaging (select one)

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

Pinout (select one)*

☐ Standard
☐ Low EMI

C. Select the following microcomputer options. A manufacturing mask will be generated from this information.

Operating Power/Frequency (select one)

☐ Normal (HC) ☐ High Speed (HSC) ☐ Low Power (HCL)

Internal Oscillator (select one)

☐ Crystal/Ceramic Resonator
☐ Resistor

Input Interrupt Trigger (select one)

☐ Edge Sensitive Only
☐ Level and Edge Sensitive

Watchdog (select one)

☐ Enabled
☐ Disabled

STOP Instruction (select one)

☐ Enabled
☐ Disabled

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

☐ PB7 Interrupt and Pullup ☐ PB4 Interrupt and Pullup ☐ PB1 Interrupt and Pullup
☐ PB6 Interrupt and Pullup ☐ PB3 Interrupt and Pullup ☐ PB0 Interrupt and Pullup
☐ PB5 Interrupt and Pullup ☐ PB2 Interrupt and Pullup

Port A Tone Options (select all that apply - unselected indicates normal port function)

☐ PA7 Tone Output ☐ PA5 Tone Output
☐ PA6 Tone Output ☐ PA4 Tone Output

Port A Tone Type (select only if one or more Port A Tone Options, above, are selected)

☐ Square Wave/Push-Pull Outputs ☐ Simple PWM/Open Drain Outputs

D. Customer Company _____
 Address _____
 City _____
 Phone (____) _____ Extension _____
 Contact Person _____
 Customer Part Number _____

E. 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 _____

† The C4B and C8B both require 8K of data

* Refer to Harris Tech Brief TB354 for more information on Low EMI pinouts

Date _____