

# 1

## PRODUCT OVERVIEW

### OVERVIEW

The KS57C3316 single-chip CMOS microcontroller has been designed for high performance using Samsung's newest 4-bit CPU core, SAM47 (Samsung Arrangeable Microcontrollers).

With features such as LCD direct drive capability, 4-channel A/D converter, 8-bit timer/counter, watch timer and PLL frequency synthesizer, it offers you an excellent design solution for a wide variety of applications that require LCD functions and audio applications.

Up to 56 pins of the 80-pin QFP package, it can be dedicated to I/O. Eight vectored interrupts provide fast response to internal and external events. In addition, the KS57C3316's advanced CMOS technology provides for low power consumption and a wide operating voltage range.

### OTP

The KS57C3316 microcontroller is also available in OTP (One Time Programmable) version, KS57P3316. The KS57P3316 microcontroller has an on-chip 16-Kbyte one-time-programmable EPROM instead of masked ROM. The KS57P3316 is comparable to KS57C3316, both in function and in pin configuration.

## FEATURES

### Memory

- 512-nibble RAM
- 16K-byte ROM

### I/O Pins

- Input only: 4 pins
- Output only: 28 pins
- I/O: 24 pins

### LCD Controller/Driver

- Maximum 14-digit LCD direct drive capability
- 28 segment x 4 common signals
- Display modes: Static, 1/2 duty (1/2 bias)  
1/3 duty (1/2 or 1/3 bias), 1/4 duty (1/3 bias)

### 8-Bit Basic Timer

- Programmable interval timer functions
- Watch-dog timer function

### 8-Bit Timer/Counter

- Programmable 8-bit timer
- External event counter
- Arbitrary clock frequency output
- External clock signal divider
- Serial I/O interface clock generator

### Watch Timer

- Time interval generation  
: 0.5 s, 3.9 ms at 32.768 kHz
- Frequency outputs to BUZ pin
- Clock source generation for LCD

### 8-Bit Serial I/O Interface

- 8-bit transmit/receive mode
- 8-bit receive mode
- Data direction selectable (LSB-first or MSB-first)
- Internal or external clock source

### A/D Converter

- 4-channels with 8-bit resolution

### Bit Sequential Carrier Buffer

- Support 16-bit serial data transfer in arbitrary format

### PLL Frequency Synthesizer

- Level = 300 mVp-p (min)
- AMVCO range = 0.5 MHz to 30 MHz
- FMVCO range = 30 MHz to 150 MHz

### 16-Bit Intermediate Frequency (IF) Counter

- Level = 300 mVp-p (min)
- AMIF range = 100 kHz to 1 MHz
- FMIF range = 5 MHz to 15 MHz

## FEATURES (Continued)

### Interrupts

- Four internal vectored interrupts
- Four external vectored interrupts
- Two quasi-interrupts

### Memory-Mapped I/O Structure

- Data memory bank 15

### Three Power-Down Modes

- Idle: Only CPU clock stops
- Stop1: Main system or subsystem clock stops
- Stop2: Main system and subsystem clock stop
- CE low: PLL and IFC stop

### Oscillation Sources

- Crystal or ceramic oscillator for main system clock
- Crystal for subsystem clock
- Main system clock frequency: 4.5 MHz (Typ)
- Subsystem clock frequency: 32.768 kHz (Typ)
- CPU clock divider circuit (by 4, 8, or 64)

### Instruction Execution Times

- 0.9, 1.8, 14.2  $\mu$ s at 4.5 MHz
- 122  $\mu$ s at 32.768 kHz (subsystem)

### Operating Temperature

- $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$

### Operating Voltage Range

- 1.8 V to 5.5 V at 3MHz
- PLL/IFC operation: 2.5V to 3.5V or 4.0V to 5.5V

### Package Type

- 80-pin QFP

BLOCK DIAGRAM

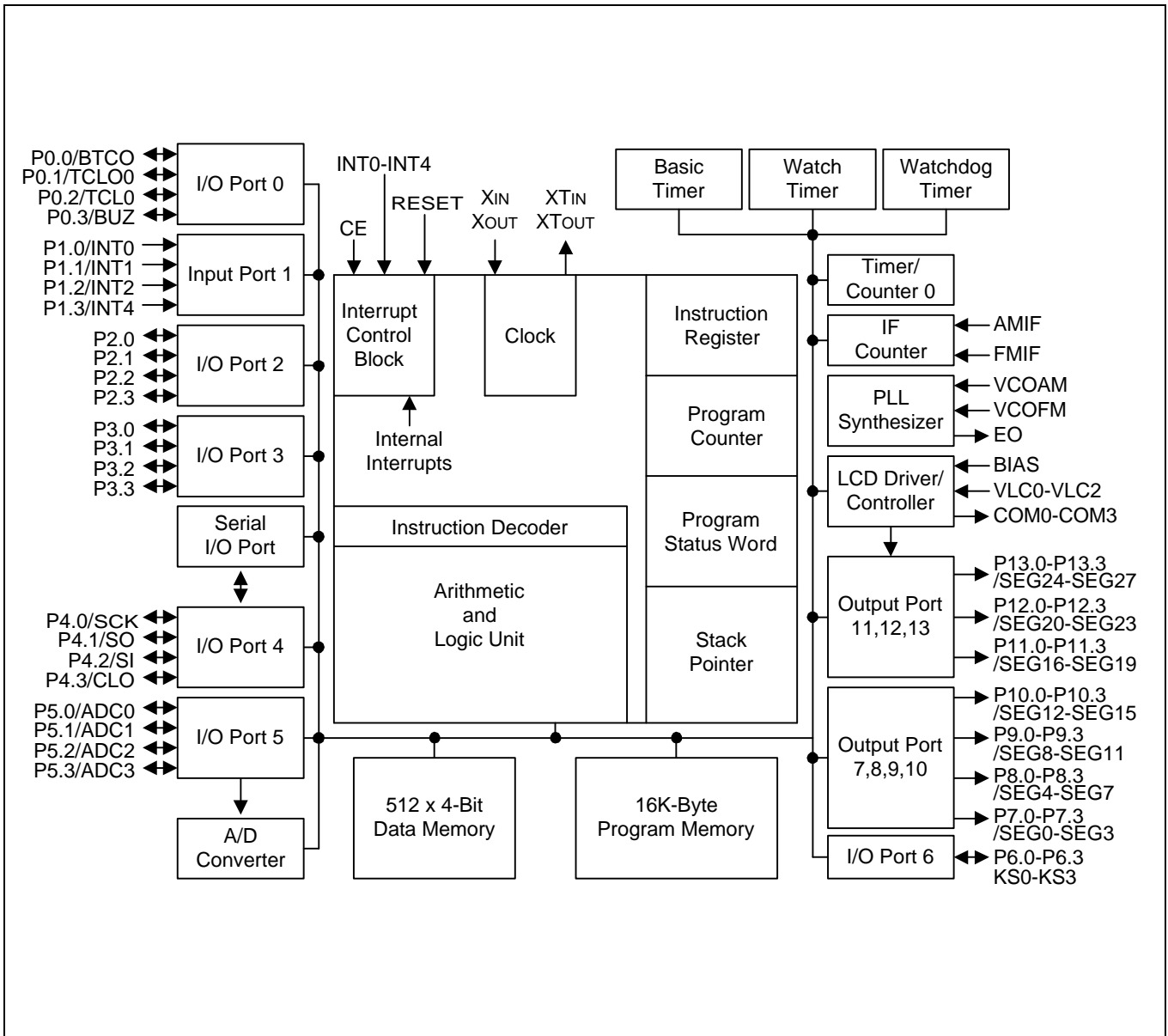


Figure 1-1. KS57C3316 Simplified Block Diagram

**PIN ASSIGNMENTS**

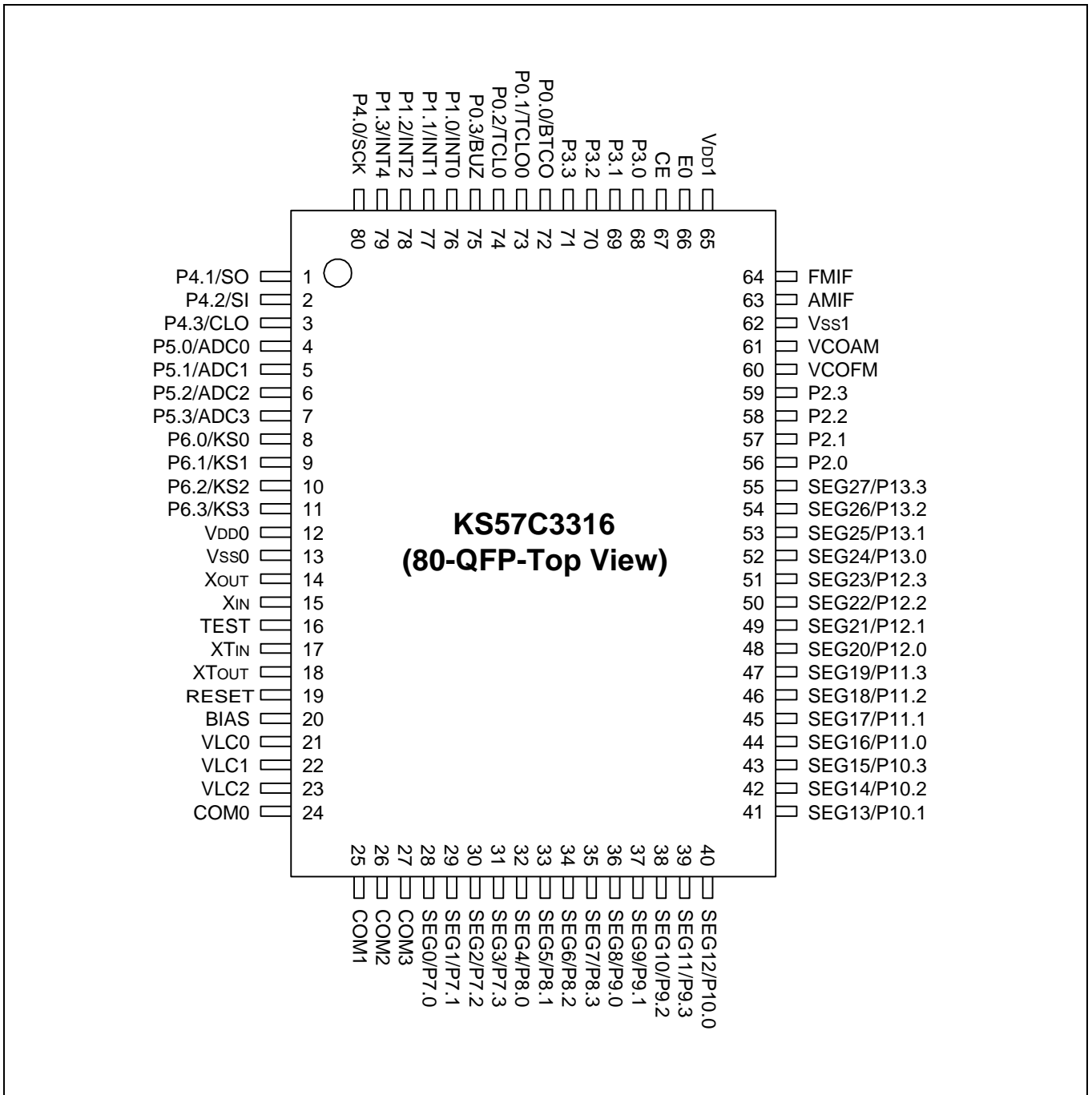


Figure 1-2. KS57C3316 80-QFP Pin Assignment

**PIN DESCRIPTIONS**

**Table 1-1. KS57C3316 Pin Descriptions**

Pin Name	Pin Type	Description	Number	Share Pin	Reset Value	Circuit Type
P0.0 P0.1 P0.2 P0.3	I/O	4-bit I/O port. 1-bit or 4-bit read, write, and test are possible. Pull-up resistors can be configured by software.	72 73 74 75	BTCO TCLO0 TCL0 BUZ	Input	D-2 D-2 D-4 D-2
P1.0 P1.1 P1.2 P1.3	I	4-bit input port. 1-bit or 4-bit read and test are possible. Pull-up resistors can be configured by software.	76 77 78 79	INT0 INT1 INT2 INT4	Input	A-4
P2.0-P2.3 P3.0-P3.3	I/O	4-bit I/O ports. 1-bit, 4-bit or 8-bit read, write and test are possible. Pull-up resistors can be configured by software. Ports 2 and 3 can be paired to support 8-bit data transfer.	56-59 68-71	–	Input	D-2
P4.0 P4.1 P4.2 P4.3	I/O	4-bit I/O ports. 1-bit, 4-bit or 8-bit read, write and test are possible. Pull-up resistors can be configured by software.	80 1 2 3	SCK SO SI CLO	Input	D-4 D-2 D-4 D-2
P5.0 P5.1 P5.2 P5.3	I/O	Ports 4 and 5 can be paired to support 8-bit data transfer.	4 5 6 7	ADC0 ADC1 ADC2 ADC3	Input	F-10
P6.0 P6.1 P6.2 P6.3	I/O	4-bit I/O port. 1-bit, 4-bit or 8-bit read, write and test are possible. Pull-up resistors can be configured by software.	8 9 10 11	KS0 KS1 KS2 KS3	Input	D-7
P7.0 P7.1 P7.2 P7.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	28 29 30 31	SEG0 SEG1 SEG2 SEG3	Output	H-28
P8.0 P8.1 P8.2 P8.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	32 33 34 35	SEG4 SEG5 SEG6 SEG7	Output	H-28
P9.0 P9.1 P9.2 P9.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	36 37 38 39	SEG8 SEG9 SEG10 SEG11	Output	H-28
P10.0 P10.1 P10.2 P10.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	40 41 42 43	SEG12 SEG13 SEG14 SEG15	Output	H-28

Table 1-1. KS57C3316 Pin Descriptions (Continued)

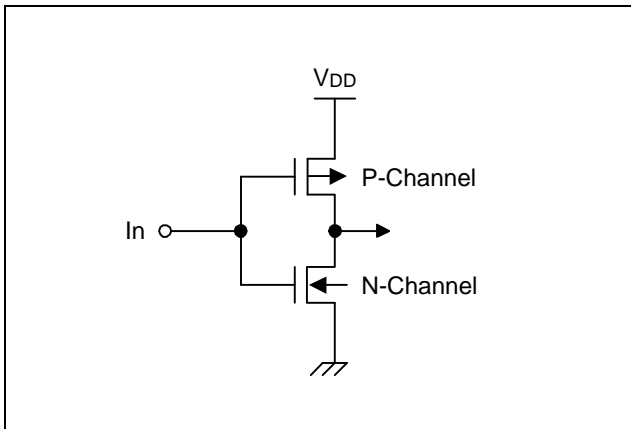
Pin Name	Pin Type	Description	Number	Share Pin	Reset Value	Circuit Type
P11.0 P11.1 P11.2 P11.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	44 45 46 47	SEG16 SEG17 SEG18 SEG19	Output	H-28
P12.0 P12.1 P12.2 P12.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	48 49 50 51	SEG20 SEG21 SEG22 SEG23	Output	H-28
P13.0 P13.1 P13.2 P13.3	O	1-bit or 4-bit output port. Alternatively used for LCD segment output.	52 53 54 55	SEG24 SEG25 SEG26 SEG27	Output	H-28
COM0- COM3	O	Common signal output for LCD display	24-27	–	Output	H
BIAS	I	LCD power control	20	–	Input	–
V <sub>LC0</sub> V <sub>LC1</sub> V <sub>LC2</sub>	I	LCD power supply. Voltage dividing resistors are assignable by software	21 22 23	–	Input	–
V <sub>DD0</sub>	–	Main power supply	12	–	–	–
V <sub>SS0</sub>	–	Main Ground	13	–	–	–
RESET	I	System reset pin	19	–	Input	B
X <sub>OUT</sub> X <sub>IN</sub>	–	Crystal, or ceramic oscillator pin for main system clock. (For external clock input, use X <sub>IN</sub> and input X <sub>IN</sub> 's reverse phase to X <sub>OUT</sub> )	14 15	–	–	–
XT <sub>OUT</sub> XT <sub>IN</sub>	–	Crystal oscillator pin for subsystem clock. (For external clock input, use XT <sub>IN</sub> and input XT <sub>IN</sub> 's reverse phase to XT <sub>OUT</sub> )	18 17	–	–	–
TEST	I	Test signal input (must be connected to V <sub>SS</sub> for normal operation)	16	–	–	–
CE	I	Input pin for checking device power. Normal operation is high level and PLL/IFC operation is stopped at low level.	67	–	Input	B-5
VCOFM VCOAM	I	External VCOFM/AM signal inputs.	60 61	–	Input	B-4
EO	O	PLL's phase error output	66	–	Output	A-2
FMIF AMIF	I	FM/AM intermediate frequency signal inputs.	64 63	Input	–	B-4
V <sub>DD1</sub>	–	PLL/IFC power supply	65	–	–	–
V <sub>SS1</sub>	–	PLL/IFC ground	62	–	–	–

**Table 1-1. KS57C3316 Pin Descriptions (Concluded)**

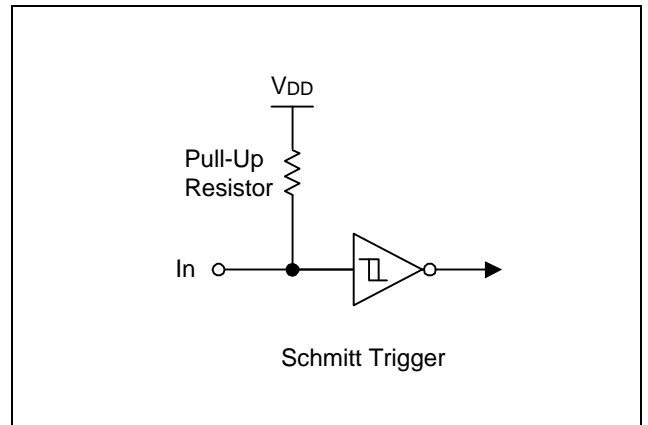
Pin Name	Pin Type	Description	Number	Share Pin	Reset Value	Circuit Type
BTCO	I/O	Basic timer overflow output signal	72	P0.0	Input	D-2
TCL00	I/O	Timer/counter 0 clock output signal	73	P0.1	Input	D-2
TCL0	I/O	External clock input for timer/counter 0	74	P0.2	Input	D-4
BUZ	I/O	2,4,8 or 16 kHz frequency output for buzzer sound for 4.19 MHz main system clock or 32.768 kHz subsystem clock	75	P0.3	Input	D-2
INT0 INT1	I	External interrupt. The triggering edges (rising/falling) are selectable. Only INT0 is synchronized with system clock.	76 77	P1.0 P1.1	Input	A-4
INT2	I	Quasi-interrupt with detection of rising edge signal.	78	P1.2		
INT4	I	External interrupt input with detection of rising or falling edges.	79	P1.3		
SCK	I/O	SIO interface clock signal	80	P4.0		
SI	I/O	SIO interface data input signal	1	P4.2	Input	D-4
SO	I/O	SIO interface data output signal	2	P4.1		
CLO	I/O	CPU clock output	3	P4.3		
KS0-KS3	I/O	Quasi-interrupt input with falling edge detection	8-11	P6.0- P6.3		
ADC0- ADC3	I/O	ADC input ports.	4-7	P5.0- P5.3	Input	F-10
SEG0- SEG3	O	LCD segment signal output.	28-31	P7.0- P7.3	Output	H-28
SEG4- SEG27	O	LCD segment signal output.	32-55	P8-P13	Output	H-28



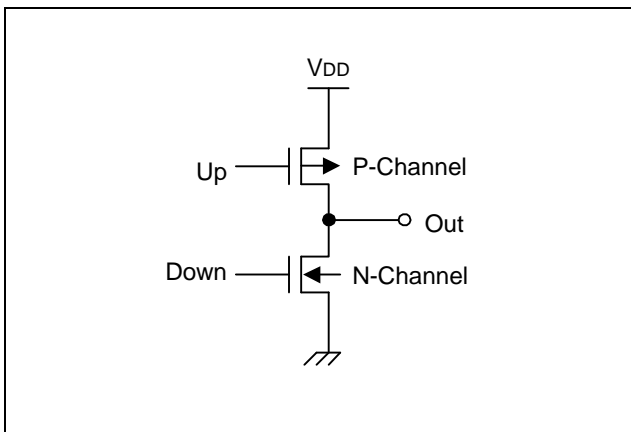
**PIN CIRCUIT DIAGRAMS**



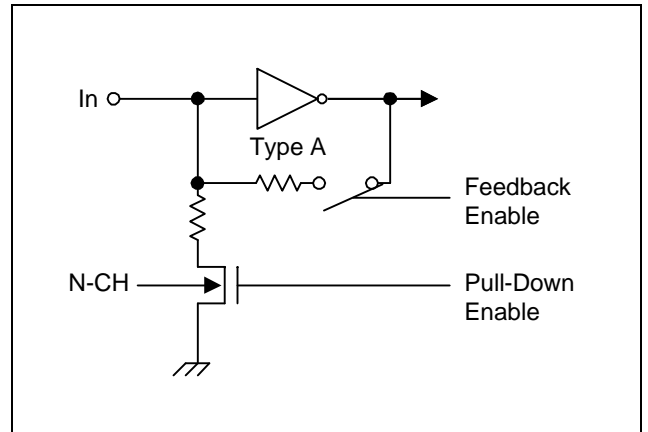
**Figure 1-3. Pin Circuit Type A**



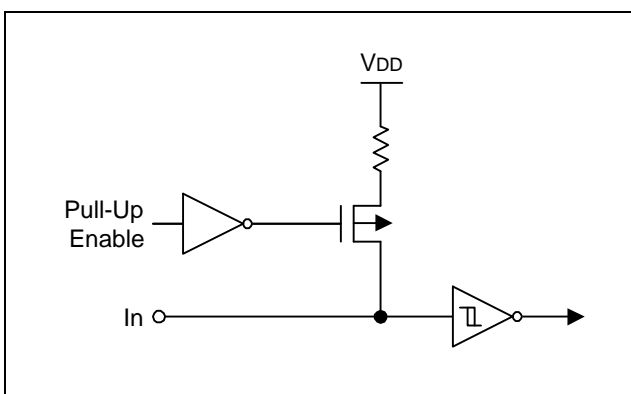
**Figure 1-6. Pin Circuit Type B (RESET)**



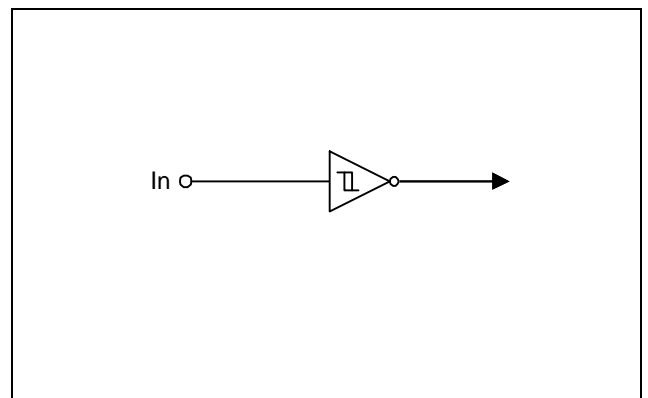
**Figure 1-4. Pin Circuit Type A-2(E0)**



**Figure 1-7. Pin Circuit Type B-4**



**Figure 1-5. Pin Circuit Type A-4 (P1)**



**Figure 1-8. Pin Circuit Type B-5(CE)**

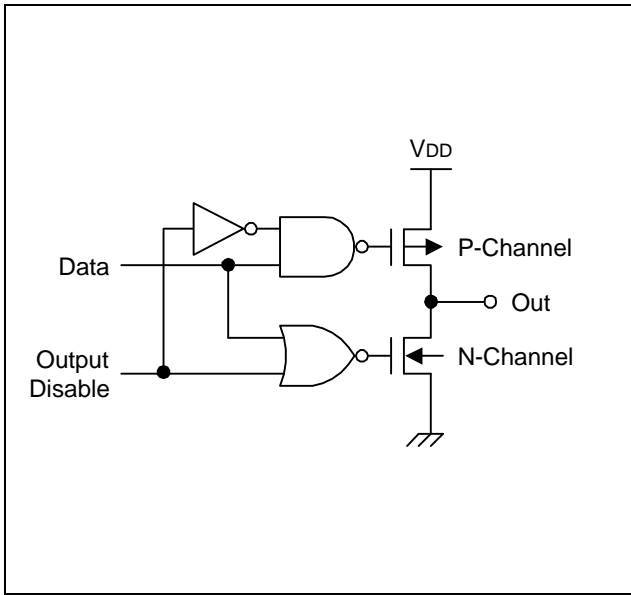


Figure 1-9. Pin Circuit Type C

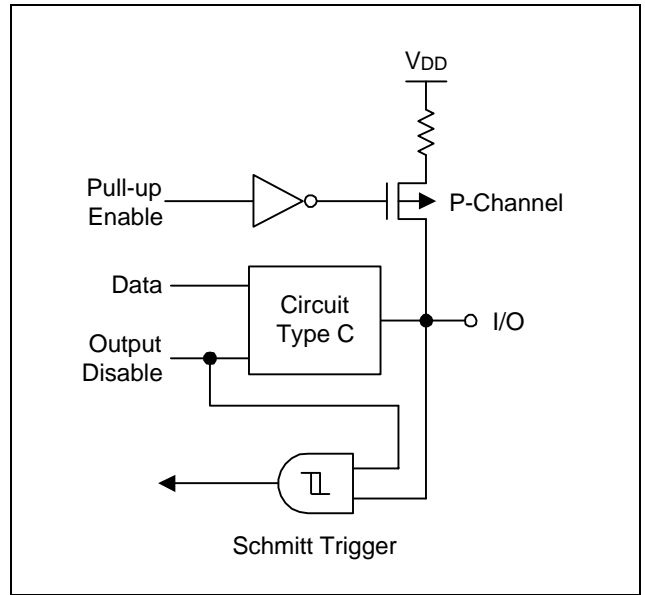


Figure 1-11. Pin Circuit Type D-4

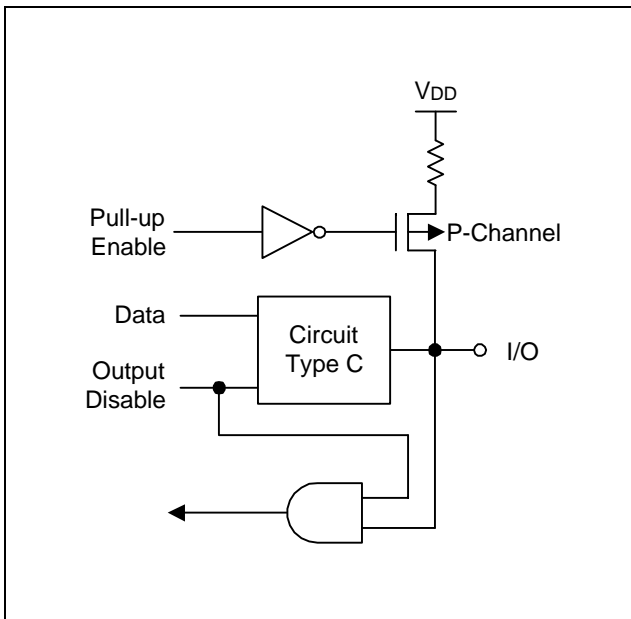


Figure 1-10. Pin Circuit Type D-2

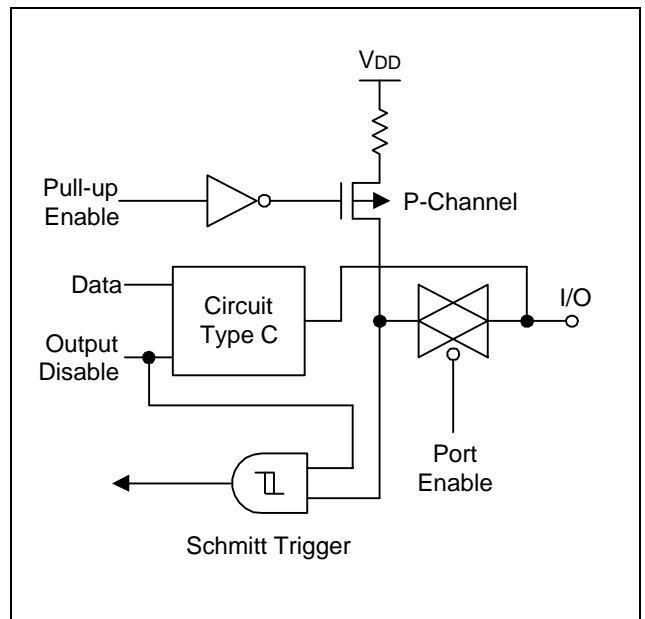
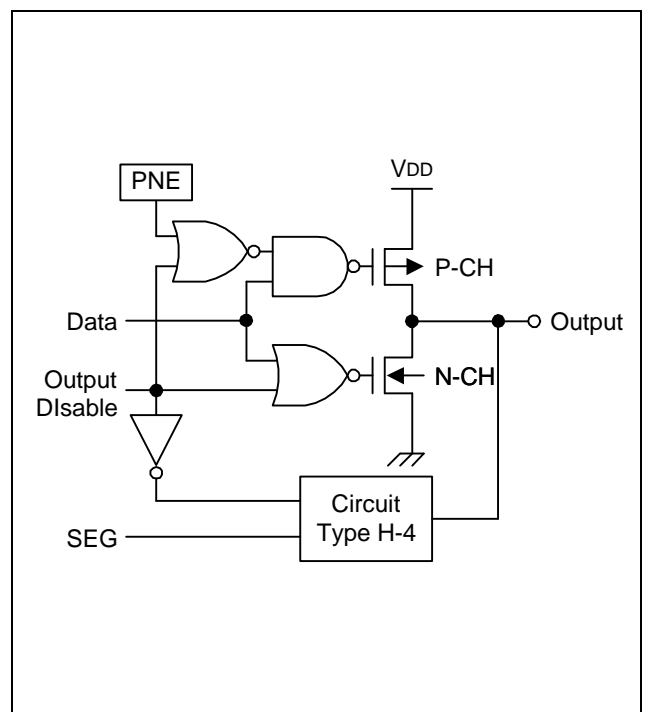
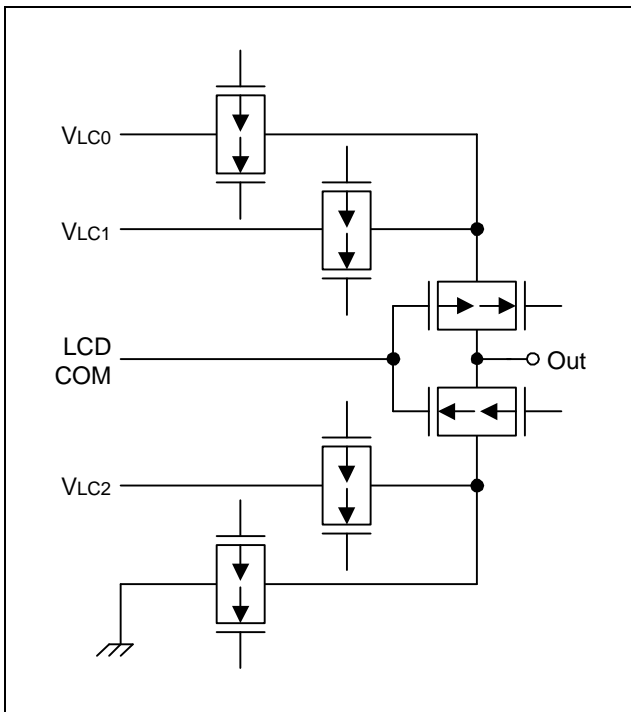
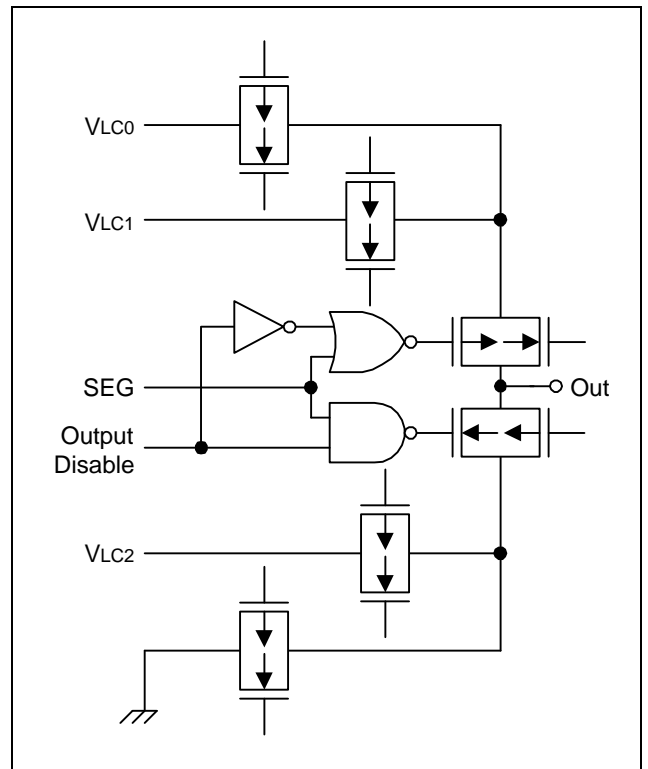
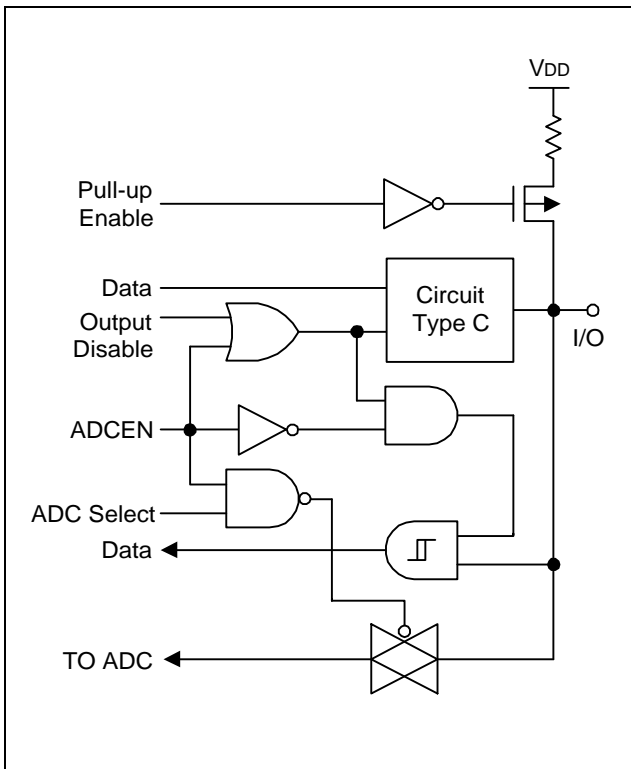


Figure 1-12. Pin Circuit Type D-7 (P6)



# 17

## ELECTRICAL DATA

### OVERVIEW

In this section, information on KS57C3316 electrical characteristics is presented as tables and graphics. The information is arranged in the following order:

#### Standard Electrical Characteristics

- Absolute maximum ratings
- D.C. electrical characteristics
- System clock oscillator characteristics
- I/O capacitance
- A.C. electrical characteristics
- Operating voltage range

#### Miscellaneous Timing Waveforms

- A.C timing measurement point
- Clock timing measurement at  $X_{IN}$
- Clock timing measurement at  $XT_{IN}$
- Input timing for RESET
- Input timing for external interrupts and Quasi-Interrupts

#### Stop Mode Characteristics and Timing Waveforms

- RAM data retention supply voltage in stop mode
- Stop mode release timing when initiated by RESET
- Stop mode release timing when initiated by an interrupt request

# 18

## KS57P3316 OTP

### OVERVIEW

The KS57P3316 single-chip CMOS microcontroller is the OTP (One Time Programmable) version of the KS57C3316 microcontroller. It has an on-chip EPROM instead of masked ROM. The EPROM is accessed by a serial data format.

The KS57P3316 is fully compatible with the KS57C3316, both in function and in pin configuration. Because of its simple programming requirements, the KS57P3316 is ideal for use as an evaluation chip for the KS57C3316.

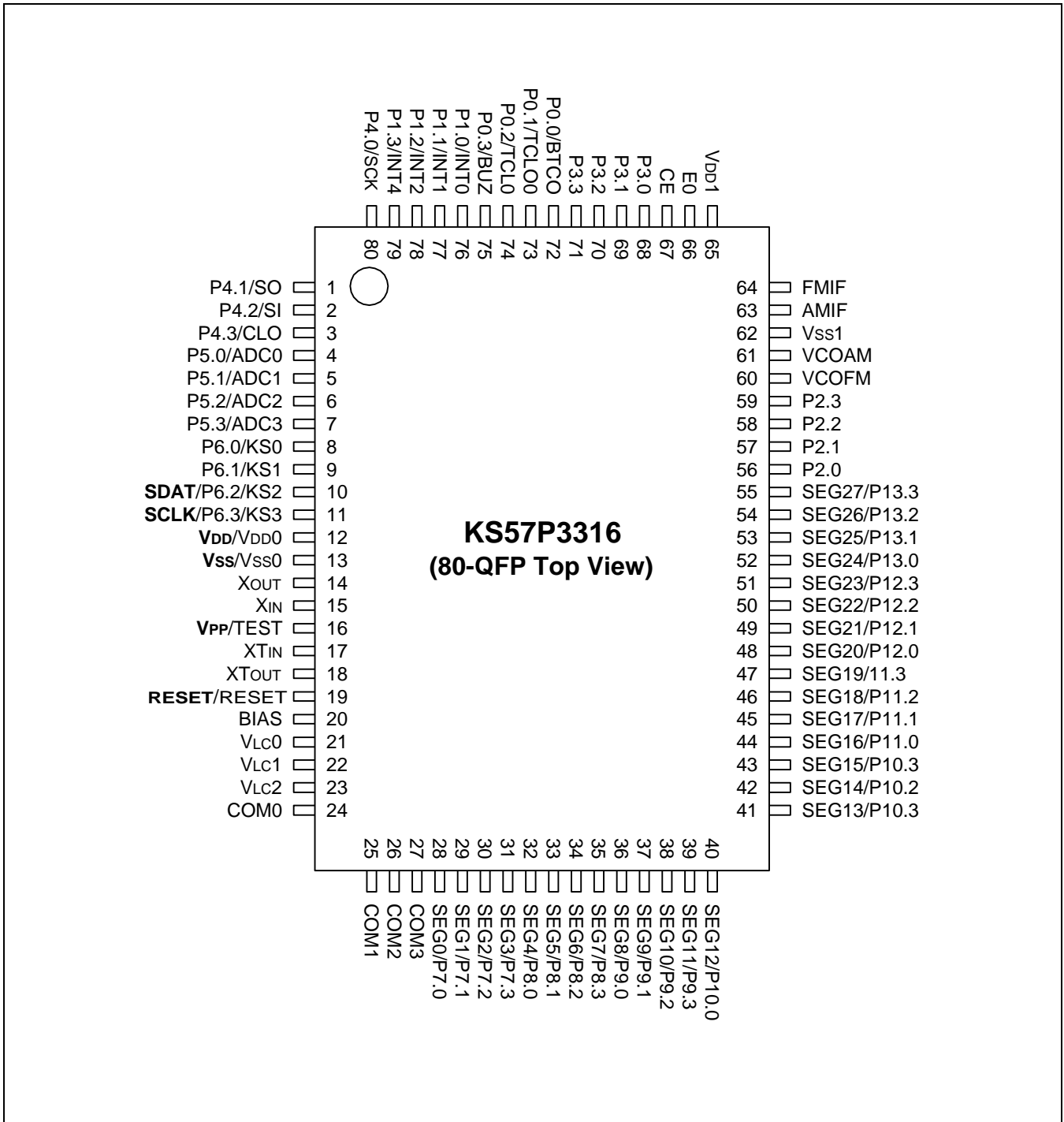


Figure 18-1. KS57P3316 Pin Assignments (80-QFP)

Table 18-1. Pin Descriptions Used to Read/Write the EPROM

Main Chip	During Programming			
Pin Name	Pin Name	Pin No.	I/O	Function
P6.2	SDAT	10	I/O	Serial data pin. Output port when reading and input port when writing. Can be assigned as a Input or push-pull output port.
P6.3	SCLK	11	I/O	Serial clock pin. Input only pin.
TEST	V <sub>PP</sub> (TEST)	16	I	Power supply pin for EPROM cell writing (indicates that OTP enters into the writing mode). When 12.5 V is applied, OTP is in writing mode and when 5 V is applied, OTP is in reading mode.
RESET	RESET	19	I	Chip initialization
V <sub>DD</sub> / V <sub>SS</sub>	V <sub>DD</sub> / V <sub>SS</sub>	12/13	I	Logic power supply pin. V <sub>DD</sub> should be tied to +5 V during programming.

Table 18-2. Comparison of KS57P3316 and KS57C3316 Features

Characteristic	KS57P3316	KS57C3316
Program Memory	16K bytes EPROM	16K bytes mask ROM
Operating Voltage (V <sub>DD</sub> )	1.8 V to 5.5 V 2.5 V to 3.5 V or 4.0 V to 5.5 V at PLL/IFC operation	1.8 V to 5.5 V 2.5 V to 3.5 V or 4.0 V to 5.5 V at PLL/IFC operation
OTP Programming Mode	V <sub>DD</sub> = 5 V, V <sub>PP</sub> (TEST) = 12.5 V	–
Pin Configuration	80 QFP	80 QFP
EPROM Programmability	User Program 1 time	Programmed at the factory

## OPERATING MODE CHARACTERISTICS

When 12.5 V is supplied to the V<sub>pp</sub> (TEST) pin of the KS57P3316, the EPROM programming mode is entered. The operating mode (read, write, or read protection) is selected according to the input signals to the pins listed in Table 17-3 below.

Table 18-3. Operating Mode Selection Criteria

V <sub>DD</sub>	V <sub>pp</sub> (TEST)	REG/MEM	Address(A15-A0)	R/W	Mode
5 V	5 V	0	0000H	1	EPROM read
	12.5 V	0	0000H	0	EPROM program
	12.5 V	0	0000H	1	EPROM verify
	12.5 V	1	0E3FH	0	EPROM read protection

**NOTE:** "0" means low level; "1" means high level.

Table 18-4. D.C. Electrical Characteristics

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input high voltage	V <sub>IH1</sub>	All input pins except those specified below	0.7 V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IH2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET	0.8 V <sub>DD</sub>		V <sub>DD</sub>	
	V <sub>IH3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>	V <sub>DD</sub> -0.1		V <sub>DD</sub>	
Input low voltage	V <sub>IL1</sub>	All input pins except those specified below	-	-	0.3 V <sub>DD</sub>	
	V <sub>IL2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET			0.2 V <sub>DD</sub>	
	V <sub>IL3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>			0.1	
Output high voltage	V <sub>OH1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -2.0	-	V <sub>DD</sub>	
	V <sub>OH2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V; Other output ports; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -1.0		V <sub>DD</sub>	
Output low voltage	V <sub>OL1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OL</sub> = 1 mA,	-	-	2.0	
	V <sub>OL2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V Other output ports; I <sub>OL</sub> = 10 mA	-		2	
Input high leakage current <sup>(note)</sup>	I <sub>LIH</sub>	V <sub>IN</sub> = V <sub>DD</sub> All input pins	-	-	3	μA
Input low leakage current <sup>(note)</sup>	I <sub>LIL</sub>	V <sub>IN</sub> = 0 V All input pins	-	-	-3	
Output high leakage current <sup>(note)</sup>	I <sub>LOH</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins	-	-	3	
Output low leakage current <sup>(note)</sup>	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V All output pins	-	-	-3	

**NOTE:** Except for X<sub>IN</sub>, X<sub>OUT</sub>, XT<sub>IN</sub>, and XT<sub>OUT</sub>



Table 18-4. D.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
V <sub>LC0</sub> output voltage	V <sub>LC0</sub>	T <sub>A</sub> = 25 °C	0.6 V <sub>DD</sub> - 0.2	0.6 V <sub>DD</sub>	0.6 V <sub>DD</sub> + 0.2	V
V <sub>LC1</sub> output voltage	V <sub>LC1</sub>	T <sub>A</sub> = 25 °C	0.4 V <sub>DD</sub> - 0.2	0.4 V <sub>DD</sub>	0.4 V <sub>DD</sub> + 0.2	
V <sub>LC2</sub> output voltage	V <sub>LC2</sub>	T <sub>A</sub> = 25 °C	0.2 V <sub>DD</sub> - 0.2	0.2 V <sub>DD</sub>	0.2 V <sub>DD</sub> + 0.2	
COM output voltage deviation	V <sub>DC</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3) I <sub>O</sub> = ± 15 μA (I = 0 - 3)	-	± 45	± 120	mV
SEG output voltage deviation	V <sub>DS</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3) I <sub>O</sub> = ± 15 μA (I = 0 - 3)		± 45	± 120	
LCD output voltage deviation	R <sub>LCD</sub>	T <sub>A</sub> = 25 °C	70	100	150	kΩ
Oscillator feed back resistors	R <sub>OSC1</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C X <sub>IN</sub> = V <sub>DD</sub> , X <sub>OUT</sub> = 0 V	300	600	1500	
	R <sub>OSC2</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C X <sub>TIN</sub> = V <sub>DD</sub> , X <sub>TOUT</sub> = 0 V	1500	3000	4500	
Pull-down resistor	R <sub>D</sub>	V <sub>DD</sub> = 5.0 V, V <sub>IN</sub> = V <sub>DD</sub> ; VCOFM, VCOAM, AMIF, and FMIF	15	30	45	
Pull-up resistor	R <sub>L1</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V Ports 1, 2, 3, 4, 5, and 6	25	47	100	
		V <sub>DD</sub> = 3 V	50	95	200	
	R <sub>L2</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V RESET	100	220	400	
		V <sub>DD</sub> = 3 V	200	450	800	

Table 18-4. D.C. Electrical Characteristics (Concluded)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

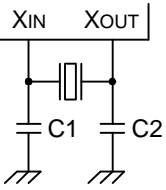
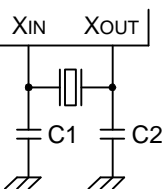
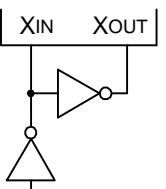
Parameter	Symbol	Conditions	Min	Typ	Max	Units		
Supply Current <sup>(1)</sup>	I <sub>DD1</sub> <sup>(2)</sup>	Main operating: PCON = 0011B, SCMOD = 0000B CE = V <sub>DD</sub> ; Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	4.5 MHz	-	5.5	27	mA	
			6.0 MHz		3.5	8		
	I <sub>DD2</sub> <sup>(2)</sup>	CE Low mate: PCON = 0011B, SCMOD = 0000B CE = 0 V Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	4.5 MHz	-	2.5	5.5		
			V <sub>DD</sub> = 3 V ± 10%		6.0 MHz	1.6		4
					4.5 MHz	1.2		3
					6.0 MHz	1.0		2.5
	I <sub>DD3</sub> <sup>(2)</sup>	Main idle mode: PCON = 0111B, SCMOD = 0000B Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	6.0 MHz	-	0.9	2.0		
			4.5 MHz		0.5	1.0		
			V <sub>DD</sub> = 3 V ± 10%		6.0 MHz	0.4		0.8
					4.5 MHz			
I <sub>DD4</sub> <sup>(2)</sup>	Sub operating mode: PCON = 0011B, SCMOD = 1001B CE = 0 V; V <sub>DD</sub> = 3 V ± 10% 32 kHz crystal oscillator		-	15	30	uA		
I <sub>DD5</sub> <sup>(2)</sup>	Sub idle mode: PCON = 0111B, SCMOD = 1001B CE = 0 V; V <sub>DD</sub> = 3 V ± 10% 32 kHz crystal oscillator		-	6	15			
I <sub>DD6</sub> <sup>(2)</sup>	Stop mode: CPU = fxt/4, SCMOD = 1101B CE = 0 V; V <sub>DD</sub> = 5 V ± 10%		-	0.5	3			
I <sub>DD7</sub> <sup>(2)</sup>	Stop mode: CPU = fx/4, SCMOD = 0100B V <sub>DD</sub> = 5 V ± 10%		-					

**NOTES:**

- Supply current does not include current drawn through internal pull-up resistors and LCD voltage dividing resistors.
- Data includes the power consumption for sub-system clock oscillation.

Table 18-5. Main System Clock Oscillator Characteristics

(T<sub>A</sub> = -40 °C + 85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

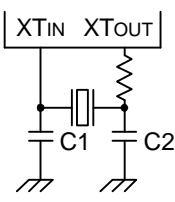
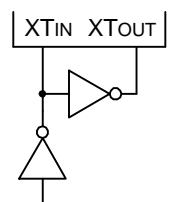
Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Ceramic Oscillator		Oscillation frequency (1)	V <sub>DD</sub> = 2.7 V to 5.5 V	0.4	–	6	MHz
		Stabilization time (2)	Stabilization occurs when V <sub>DD</sub> is equal to the minimum oscillator voltage range.	–	–	4	ms
Crystal Oscillator		Oscillation frequency (1)	V <sub>DD</sub> = 2.7 V to 5.5 V	0.4	–	6	MHz
		Stabilization time (2)	V <sub>DD</sub> = 4.5 V to 5.5 V	–	–	10	ms
			V <sub>DD</sub> = 1.8 V to 4.5 V	–	–	30	
External Clock		X <sub>IN</sub> input frequency (1)	–	0.4	–	6	MHz
		X <sub>IN</sub> input high and low level width (t <sub>XH</sub> , t <sub>XL</sub> )	–	83.3	–	–	ns

**NOTES:**

- Oscillation frequency and X<sub>IN</sub> input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs, or when stop mode is terminated.

Table 18-6. Subsystem Clock Oscillator Characteristics

(T<sub>A</sub> = -40 °C + 85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Crystal Oscillator		Oscillation frequency (1)	–	32	32.768	35	kHz
		Stabilization time (2)	V <sub>DD</sub> = 2.7 V to 5.5 V	–	1.0	2	s
			V <sub>DD</sub> = 1.8 V to 4.5 V	–	–	10	
External Clock		XT <sub>IN</sub> input frequency (1)	–	32	–	100	kHz
		XT <sub>IN</sub> input high and low level width (t <sub>XTL</sub> , t <sub>XTH</sub> )	–	5	–	15	μs

**NOTES:**

- Oscillation frequency and XT<sub>IN</sub> input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs.

Table 18-7. Input/Output Capacitance

(T<sub>A</sub> = 25 °C, V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input capacitance	C <sub>IN</sub>	f <sub>CLK</sub> = 1 MHz; Unmeasured pins are returned to V <sub>SS</sub>	–	–	15	pF
Output capacitance	C <sub>OUT</sub>		–	–	15	pF
I/O capacitance	C <sub>IO</sub>		–	–	15	pF

Table 18-8. A.C. Electrical Characteristics

(T<sub>A</sub> = –40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time (1)	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3		64	
Interrupt input high, low width	t <sub>INTH</sub> , t <sub>INTL</sub>	INT0	(2)	–	–	μs
		INT1, INT2, INT4, KS0–KS2	10			
RESET and CE Input Low Width	t <sub>RSL</sub>	Input	10	1	–	μs

**NOTES:**

- Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.
- Minimum value for INT0 is based on a clock of 2t<sub>CY</sub> or 128/fxx as assigned by the IMOD0 register setting.

Table 18-8. A.C. Electrical Characteristics (continued)

(T<sub>A</sub> = –10 °C to +70 °C, V<sub>DD</sub> = 3.5 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
A/D converting Resolution	–	–	–	8	–	bits
Absolute accuracy	–	–	–	–	± 2	LSB
AD conversion time	t <sub>CON</sub>	–	17	34/fxx (note)	–	μs
Analog input voltage	V <sub>IAN</sub>	–	V <sub>SS</sub>	–	V <sub>DD</sub>	V
Analog input impedance	R <sub>AN</sub>	V <sub>DD</sub> = 5 V	2	1000	–	MΩ

**NOTE:** fxx stands for the system clock (fx or fxt).

**Table 18-8. A.C. Electrical Characteristics (Continued)**(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 2.5 V to 3.5 V or V<sub>DD</sub> = 4.0 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
VCOFM, VCOAM, FMIF and AMIF Input Voltage (Peak to Peak)	V <sub>IN</sub>	Sine wave input	0.3	–	V <sub>DD</sub>	V
Frequency	f <sub>VCOAM</sub>	VCOAM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.5	–	30	MHz
	f <sub>VCOFM</sub>	VCOFM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	30		150	
	f <sub>AMIF</sub>	AMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.1		1.0	
	f <sub>FMIF</sub>	FMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	5		15	

Table 18-8. A.C. Electrical Characteristics (continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time <sup>(1)</sup>	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3	–	64	
		With subsystem clock (fxt)	114	122	125	
TCL0 input frequency	f <sub>TI</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0	–	1.5	MHz
		V <sub>DD</sub> = 1.8 V to 5.5 V			1	
TCL0 input high, low width	t <sub>TIH</sub> , t <sub>TIL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.48	–	–	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.8			
SCK cycle time	t <sub>KCY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	800	–	–	ns
		Internal SCK source	650			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	3200			
		Internal SCK source	3800			
SCK high, low width	t <sub>KH</sub> , t <sub>KL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	400	–	–	
		Internal SCK source	t <sub>KCY</sub> /2- 50			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	1600			
		Internal SCK source	t <sub>KCY</sub> /2-150			
SI setup time to SCK high	t <sub>SIK</sub>	External SCK source	100	–	–	
		Internal SCK source	150			
SI hold time to SCK high	t <sub>KSI</sub>	External SCK source	400	–	–	
		Internal SCK source	400			
Output delay for SCK to SO	t <sub>KSO</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	–	–	300	
		Internal SCK source			250	
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source			1000	
		Internal SCK source			1000	

**NOTE:** Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.

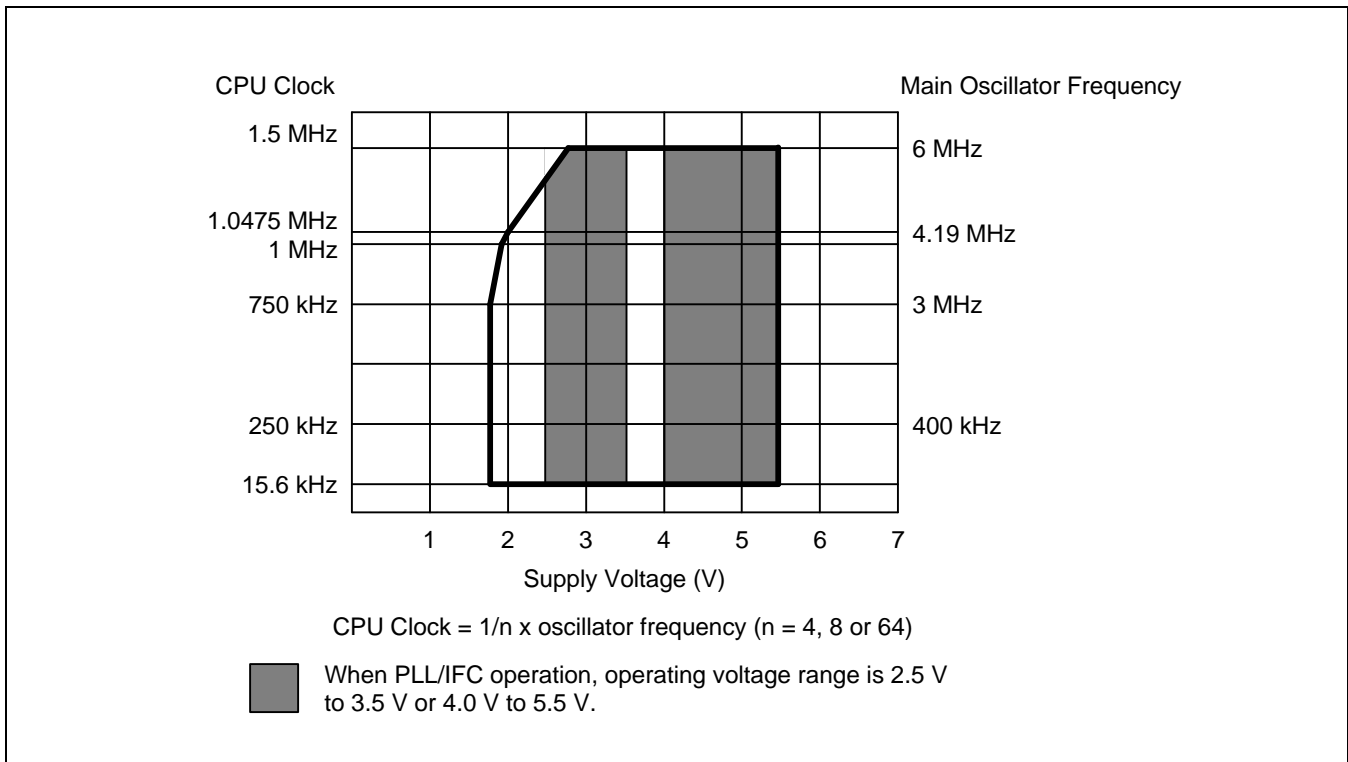


Figure 18-2. Standard Operating Voltage Range

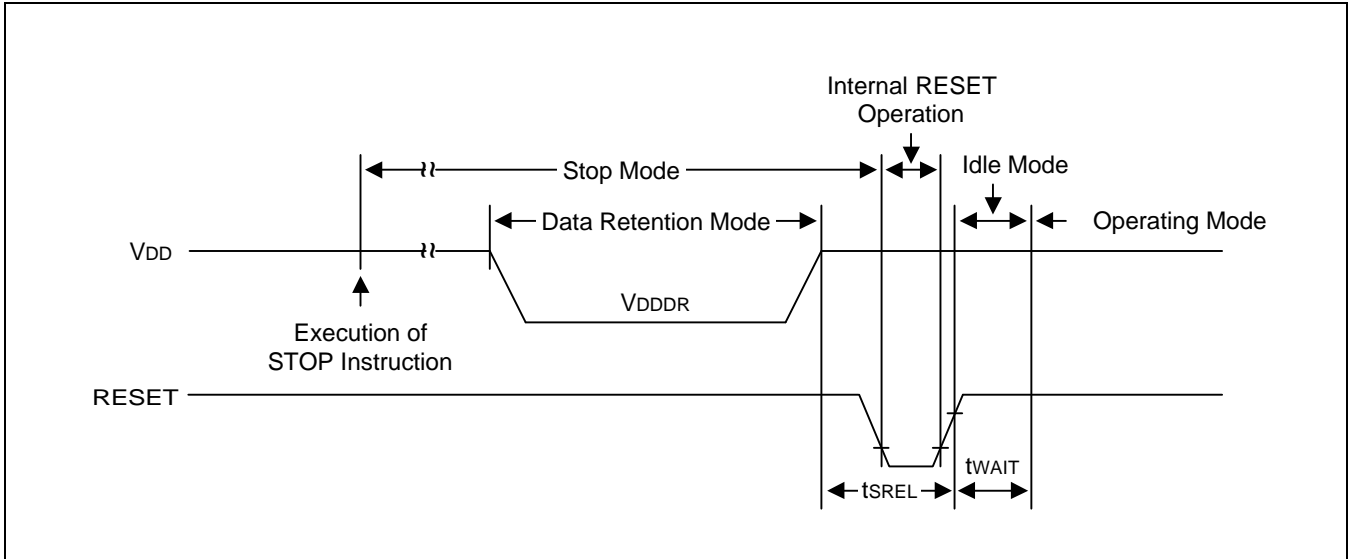
Table 18-9. RAM Data Retention Supply Voltage in Stop Mode

(T<sub>A</sub> = -40 °C to + 85 °C)

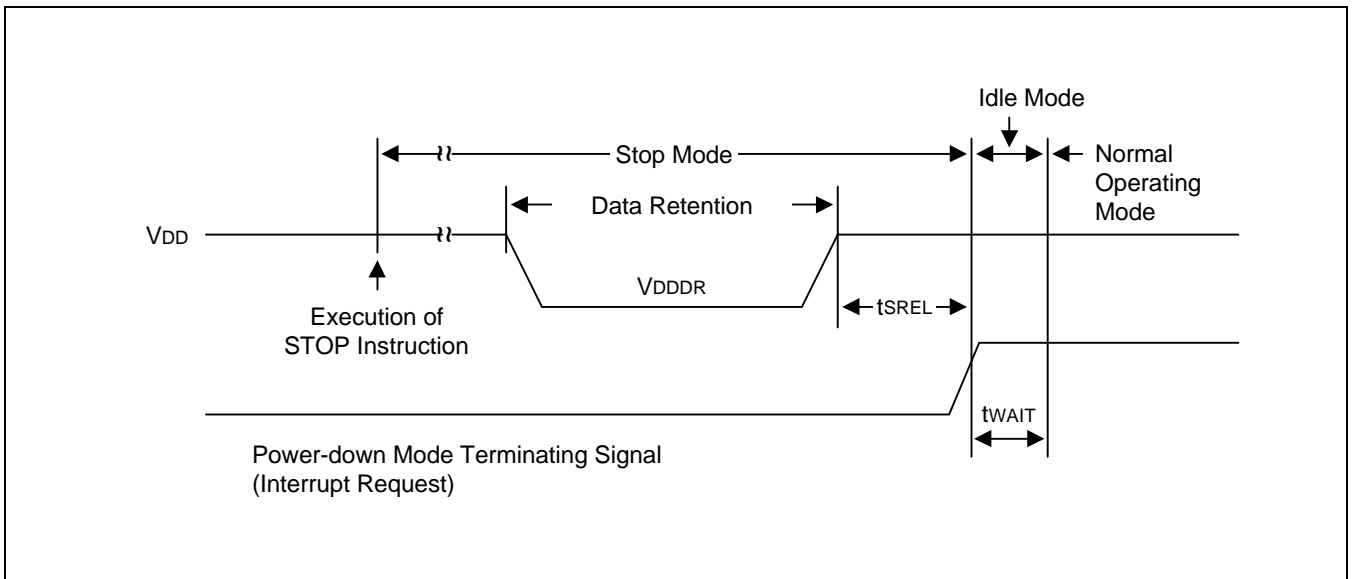
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data retention supply voltage	V <sub>DDDR</sub>	Normal operation	1.8	-	5.5	V
Data retention supply current	I <sub>DDDR</sub>	V <sub>DDDR</sub> = 1.8 V	-	0.1	1	μA



**TIMING WAVEFORMS**



**Figure 18-3. Stop Mode Release Timing When Initiated by RESET**



**Figure 18-4. Stop Mode Release Timing When Initiated by an Interrupt Request**

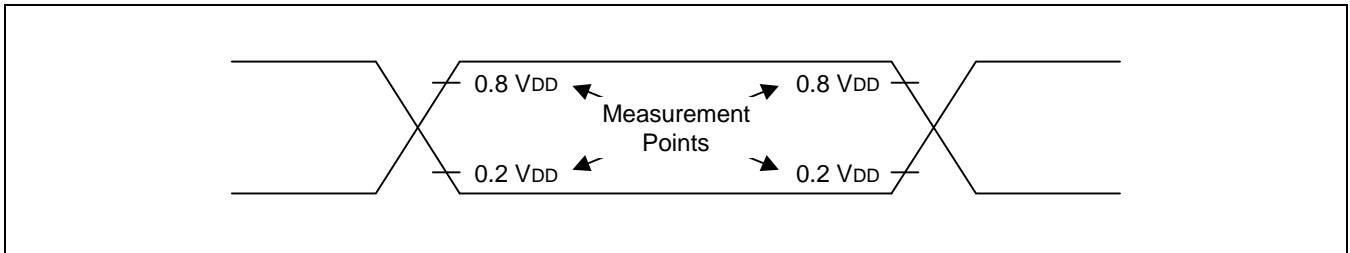


Figure 18-5. A.C. Timing Measurement Points (Except for  $X_{IN}$  and  $XT_{IN}$ )

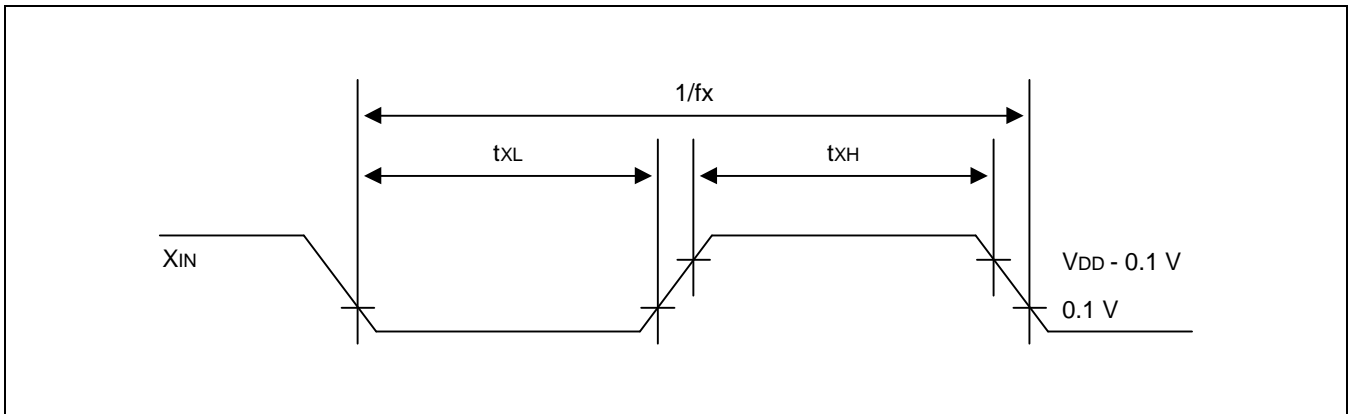


Figure 18-6. Clock Timing Measurement at  $X_{IN}$

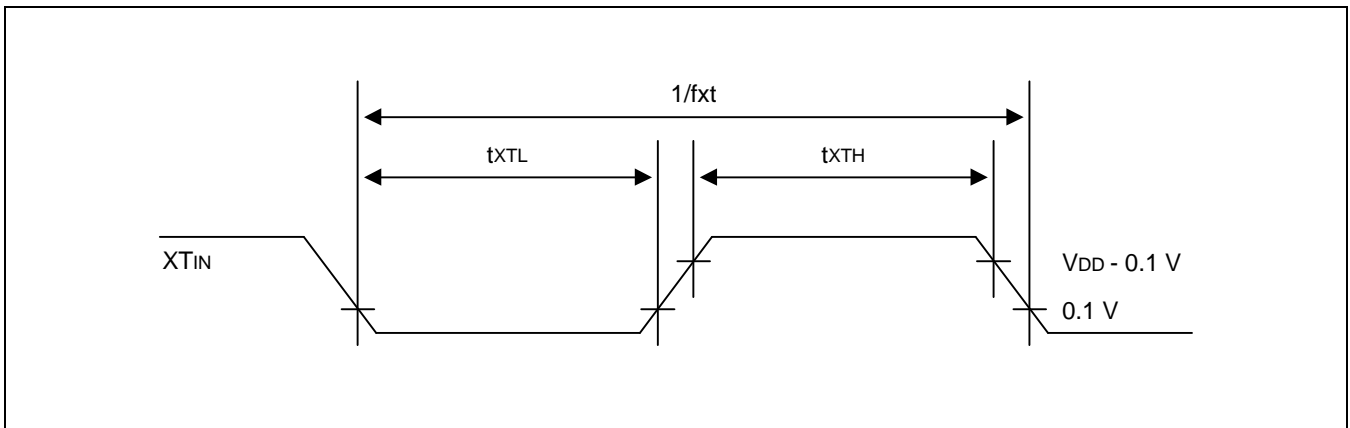


Figure 18-7. Clock Timing Measurement at  $XT_{IN}$

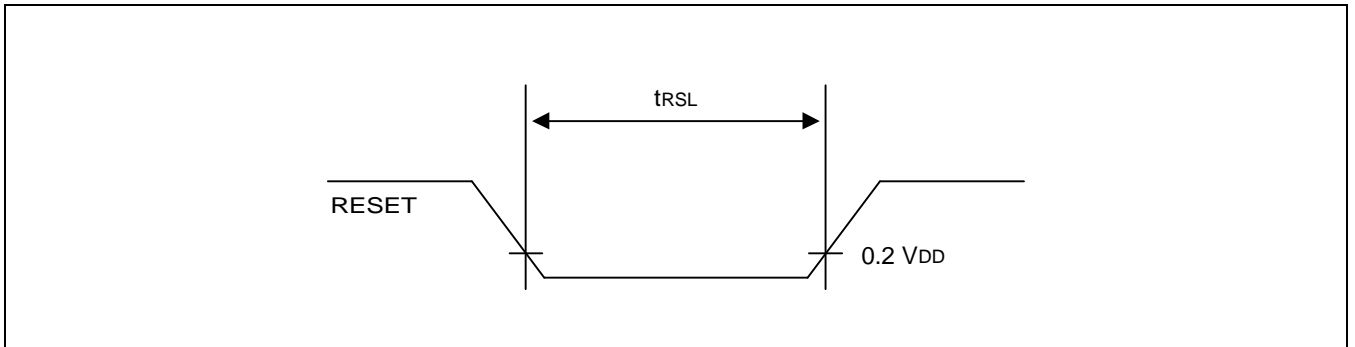


Figure 18-8. Input Timing for RESET Signal

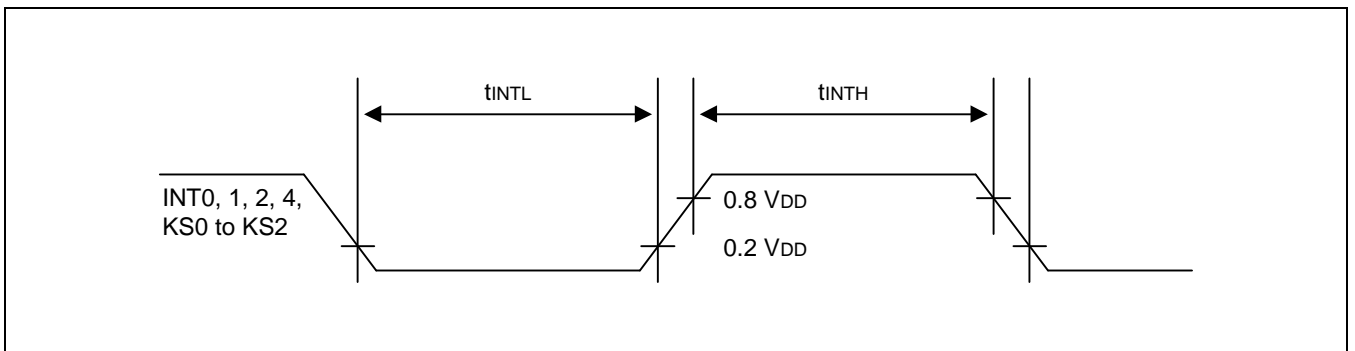


Figure 18-9. Input Timing for External Interrupts and Quasi-Interrupts

## NOTES

Table 17-1. Absolute Maximum Ratings

 $(T_A = 25\text{ }^\circ\text{C})$ 

Parameter	Symbol	Conditions	Rating	Units
Supply voltage	$V_{DD}$	–	- 0.3 to + 6.5	V
Input voltage	$V_{IN}$	Applies to all I/O ports	- 0.3 to $V_{DD} + 0.3$	
Output voltage	$V_O$	–	- 0.3 to $V_{DD} + 0.3$	
Output current high	$I_{OH}$	One I/O port active	- 15	mA
		All I/O ports active	-30	
Output current low	$I_{OL}$	One I/O port active	+ 30 (peak value)	
			+ 15 (note)	
		Total value for output ports	+ 100 (peak value)	
			+ 60 *	
Operating temperature	$T_A$		- 40 to + 85	$^\circ\text{C}$
Storage temperature	$T_{STG}$		- 65 to + 150	

**NOTE:** The values for output current low ( $I_{OL}$ ) are calculated as Peak Value  $\times \sqrt{\text{Duty}}$  .

Table 17-2. D.C. Electrical Characteristics

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input high voltage	V <sub>IH1</sub>	All input pins except those specified below	0.7 V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IH2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET	0.8 V <sub>DD</sub>		V <sub>DD</sub>	
	V <sub>IH3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>	V <sub>DD</sub> -0.1		V <sub>DD</sub>	
Input low voltage	V <sub>IL1</sub>	All input pins except those specified below	-	-	0.3 V <sub>DD</sub>	
	V <sub>IL2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET			0.2 V <sub>DD</sub>	
	V <sub>IL3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>			0.1	
Output high voltage	V <sub>OH1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -2.0	-	V <sub>DD</sub>	
	V <sub>OH2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V; Other output ports; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -1.0		V <sub>DD</sub>	
Output low voltage	V <sub>OL1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OL</sub> = 1 mA,	-	-	2.0	
	V <sub>OL2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V Other output ports; I <sub>OL</sub> = 10 mA	-		2	
Input high leakage current <sup>(note)</sup>	I <sub>LIH</sub>	V <sub>IN</sub> = V <sub>DD</sub> All input pins	-	-	3	μA
Input low leakage current <sup>(note)</sup>	I <sub>LIL</sub>	V <sub>IN</sub> = 0 V All input pins	-	-	-3	
Output high leakage current <sup>(note)</sup>	I <sub>LOH</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins	-	-	3	

**NOTE:** Except for X<sub>IN</sub>, X<sub>OUT</sub>, XT<sub>IN</sub> and XT<sub>OUT</sub>.

Table 17-2. D.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
V <sub>LC0</sub> output voltage	V <sub>LC0</sub>	T <sub>A</sub> = 25 °C	0.6 V <sub>DD</sub> - 0.2	0.6 V <sub>DD</sub>	0.6 V <sub>DD</sub> + 0.2	V
V <sub>LC1</sub> output voltage	V <sub>LC1</sub>	T <sub>A</sub> = 25 °C	0.4 V <sub>DD</sub> - 0.2	0.4 V <sub>DD</sub>	0.4 V <sub>DD</sub> + 0.2	
V <sub>LC2</sub> output voltage	V <sub>LC2</sub>	T <sub>A</sub> = 25 °C	0.2 V <sub>DD</sub> - 0.2	0.2 V <sub>DD</sub>	0.2 V <sub>DD</sub> + 0.2	
COM output voltage deviation	V <sub>DC</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3) I <sub>O</sub> = ± 15 μA (I = 0 - 3)	-	± 45	± 120	mV
SEG output voltage deviation	V <sub>DS</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3) I <sub>O</sub> = ± 15 μA (I = 0 - 3)		± 45	± 120	
LCD output voltage deviation	R <sub>LCD</sub>	T <sub>A</sub> = 25 °C	70	100	150	KΩ
Oscillator feed back resistors	R <sub>OSC1</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C X <sub>IN</sub> = V <sub>DD</sub> , X <sub>OUT</sub> = 0 V	300	600	1500	
	R <sub>OSC2</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C X <sub>TIN</sub> = V <sub>DD</sub> , X <sub>TOUT</sub> = 0 V	1500	3000	4500	
Pull-down resistor	R <sub>D</sub>	V <sub>DD</sub> = 5.0 V, V <sub>IN</sub> = V <sub>DD</sub> ; VCOFM, VCOAM, AMIF, and FMIF	15	30	45	
Pll-up Resistor	R <sub>L1</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V Ports 1, 2, 3, 4, 5, and 6	25	47	100	
		V <sub>DD</sub> = 3 V	50	95	200	
	R <sub>L2</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V RESET	100	220	400	
		V <sub>DD</sub> = 3 V	200	450	800	

Table 17-2. D.C. Electrical Characteristics (Concluded)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units			
Supply Current <sup>(1)</sup>	I <sub>DD1</sub> <sup>(2)</sup>	Main operating, PLL operating: PCON = 0011B, SCMOD = 0000B CE = V <sub>DD</sub> ; Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	4.5 MHz	-	5.5	27	mA		
	I <sub>DD2</sub> <sup>(2)</sup>	CE Low, PCON = 0011B, SCMOD = 0000B CE = 0 V Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	6.0 MHz		3.5	8			
			4.5 MHz		2.5	5.5			
			V <sub>DD</sub> = 3 V ± 10%		6.0 MHz	1.6		4	
			4.5 MHz		1.2	3			
	I <sub>DD3</sub> <sup>(2)</sup>	Main idle mode, PCON = 0111B, SCMOD = 0000B Crystal oscillator C1 = C2 = 22 pF V <sub>DD</sub> = 5 V ± 10%	6.0 MHz		-	1.0		2.5	
			4.5 MHz			0.9		2.0	
			V <sub>DD</sub> = 3 V ± 10%			6.0 MHz		0.5	1.0
			4.5 MHz			0.4		0.8	
I <sub>DD4</sub> <sup>(2)</sup>	Sub operating mode: PCON = 0011B, SCMOD = 1001B CE = 0 V; V <sub>DD</sub> = 3 V ± 10% 32 kHz crystal oscillator		-	15	30	uA			
I <sub>DD5</sub> <sup>(2)</sup>	Sub idle mode: PCON = 0111B, SCMOD = 1001B CE = 0 V; V <sub>DD</sub> = 3 V ± 10% 32 kHz crystal oscillator		-	6	15				
I <sub>DD6</sub> <sup>(2)</sup>	Stop mode: CPU = fxt/4, SCMOD = 1101B CE = 0 V; V <sub>DD</sub> = 5 V ± 10%		-	0.5	3				
I <sub>DD7</sub> <sup>(2)</sup>	Stop mode: CPU = fx/4, SCMOD = 0100B V <sub>DD</sub> = 5 V ± 10%		-						

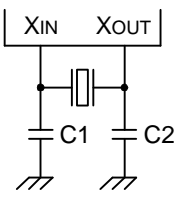
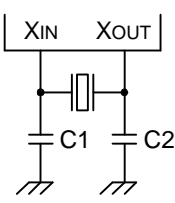
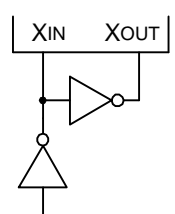
**NOTES:**

- Supply current does not include current drawn through internal pull-up resistors and LCD voltage dividing resistors.
- Data includes the power consumption for sub-system clock oscillation.



Table 17-3. Main System Clock Oscillator Characteristics

 $(T_A = -40\text{ }^\circ\text{C} + 85\text{ }^\circ\text{C}, V_{DD} = 1.8\text{ V to } 5.5\text{ V})$ 

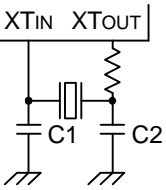
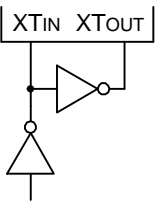
Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Ceramic Oscillator		Oscillation frequency (1)	$V_{DD} = 2.7\text{ V to } 5.5\text{ V}$	0.4	–	6	MHz
		Stabilization time (2)	Stabilization occurs when $V_{DD}$ is equal to the minimum oscillator voltage range.	–	–	4	ms
Crystal Oscillator		Oscillation frequency (1)	$V_{DD} = 2.7\text{ V to } 5.5\text{ V}$	0.4	–	6	MHz
		Stabilization time (2)	$V_{DD} = 4.5\text{ V to } 5.5\text{ V}$	–	–	10	ms
			$V_{DD} = 1.8\text{ V to } 4.5\text{ V}$	–	–	30	
External Clock		$X_{IN}$ input frequency (1)	–	0.4	–	6	MHz
		$X_{IN}$ input high and low level width ( $t_{XH}$ , $t_{XL}$ )	–	83.3	–	–	ns

**NOTES:**

- Oscillation frequency and  $X_{IN}$  input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs, or when stop mode is terminated.

Table 17-4. Subsystem Clock Oscillator Characteristics

(T<sub>A</sub> = -40 °C + 85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Crystal Oscillator		Oscillation frequency <sup>(1)</sup>	–	32	32.768	35	kHz
		Stabilization time <sup>(2)</sup>	V <sub>DD</sub> = 2.7 V to 5.5 V	–	1.0	2	s
			V <sub>DD</sub> = 1.8 V to 4.5 V	–	–	10	
External Clock		XT <sub>IN</sub> input frequency <sup>(1)</sup>	–	32	–	100	kHz
		XT <sub>IN</sub> input high and low level width (t <sub>X<sub>TL</sub></sub> , t <sub>X<sub>TH</sub></sub> )	–	5	–	15	μs

**NOTES:**

- Oscillation frequency and XT<sub>IN</sub> input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs.

Table 17-5. Input/Output Capacitance

(T<sub>A</sub> = 25 °C, V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input capacitance	C <sub>IN</sub>	f <sub>CLK</sub> = 1 MHz; Unmeasured pins are returned to V <sub>SS</sub>	–	–	15	pF
Output capacitance	C <sub>OUT</sub>		–	–	15	pF
I/O capacitance	C <sub>IO</sub>		–	–	15	pF

Table 17-6. A.C. Electrical Characteristics

(T<sub>A</sub> = –40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time (1)	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3		64	
Interrupt input high, low width	t <sub>INTH</sub> , t <sub>INTL</sub>	INT0	(2)	–	–	μs
		INT1, INT2, INT4, KS0–KS2	10			
RESET and CE Input Low Width	t <sub>RSL</sub>	Input	10	1	–	μs

**NOTES:**

1. Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.
2. Minimum value for INT0 is based on a clock of 2t<sub>CY</sub> or 128/fxx as assigned by the IMOD0 register setting.

Table 17-6. A.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = –10 °C to +70 °C, V<sub>DD</sub> = 3.5 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
A/D converting Resolution	–	–	–	8	–	bits
Absolute accuracy	–	–	–	–	±2	LSB
AD conversion time	t <sub>CON</sub>	–	17	34/fxx (note)	–	μs
Analog input voltage	V <sub>IAN</sub>	–	V <sub>SS</sub>	–	V <sub>DD</sub>	V
Analog input impedance	R <sub>AN</sub>	V <sub>DD</sub> = 5 V	2	1000	–	MΩ

**NOTE:** fxx stands for the system clock (fx or fxt).

Table 17-6. A.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 2.5 V to 3.5 V or V<sub>DD</sub> = 4.0 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
VCOFM, VCOAM, FMIF and AMIF Input Voltage (Peak to Peak)	V <sub>IN</sub>	Sine wave input	0.3	–	V <sub>DD</sub>	V
Frequency	f <sub>VCOAM</sub>	VCOAM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.5	–	30	MHz
	f <sub>VCOFM</sub>	VCOFM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	30		150	
	f <sub>AMIF</sub>	AMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.1		1.0	
	f <sub>FMIF</sub>	FMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	5		15	

Table 17-6. A.C. Electrical Characteristics (Concluded)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time <sup>(1)</sup>	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3	–	64	
		With subsystem clock (fxt)	114	122	125	
TCL0 input frequency	f <sub>TI</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0	–	1.5	MHz
		V <sub>DD</sub> = 1.8 V to 5.5 V			1	
TCL0 input high, low width	t <sub>TIH</sub> , t <sub>TIL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.48	–	–	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.8			
SCK cycle time	t <sub>KCY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	800	–	–	ns
		Internal SCK source	650			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	3200			
		Internal SCK source	3800			
SCK high, low width	t <sub>KH</sub> , t <sub>KL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	400	–	–	
		Internal SCK source	t <sub>KCY</sub> /2- 50			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	1600			
		Internal SCK source	t <sub>KCY</sub> /2-150			
SI setup time to SCK high	t <sub>SIK</sub>	External SCK source	100	–	–	
		Internal SCK source	150			
SI hold time to SCK high	t <sub>KSI</sub>	External SCK source	400	–	–	
		Internal SCK source	400			
Output delay for SCK to SO	t <sub>KSO</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	–	–	300	
		Internal SCK source			250	
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source			1000	
		Internal SCK source			1000	

**NOTE:** Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.

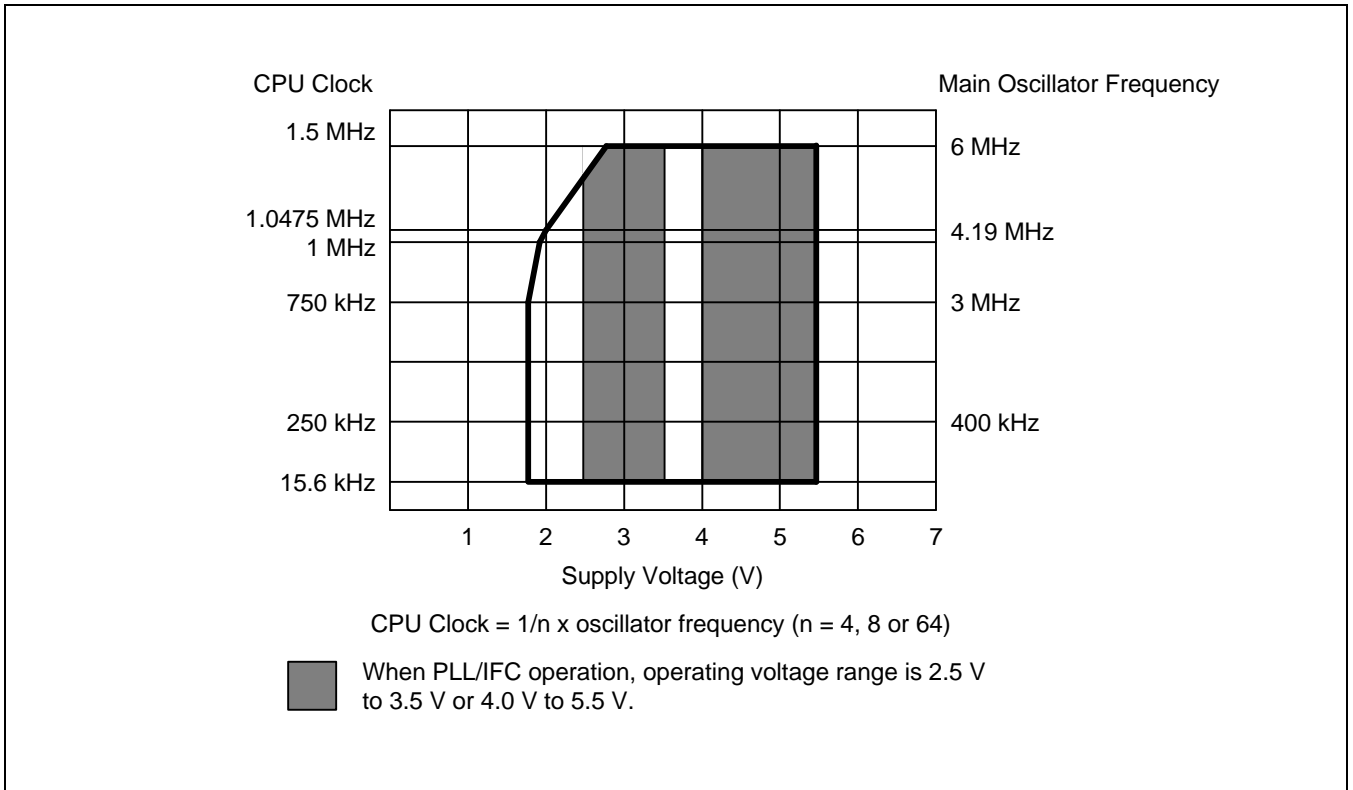


Figure 17-1. Standard Operating Voltage Range

Table 17-7. RAM Data Retention Supply Voltage in Stop Mode

(T<sub>A</sub> = -40 °C to +85 °C)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data retention supply voltage	V <sub>DDDR</sub>	Normal operation	1.8	-	5.5	V
Data retention supply current	I <sub>DDDR</sub>	V <sub>DDDR</sub> = 1.8 V	-	0.1	1	μA

TIMING WAVEFORMS

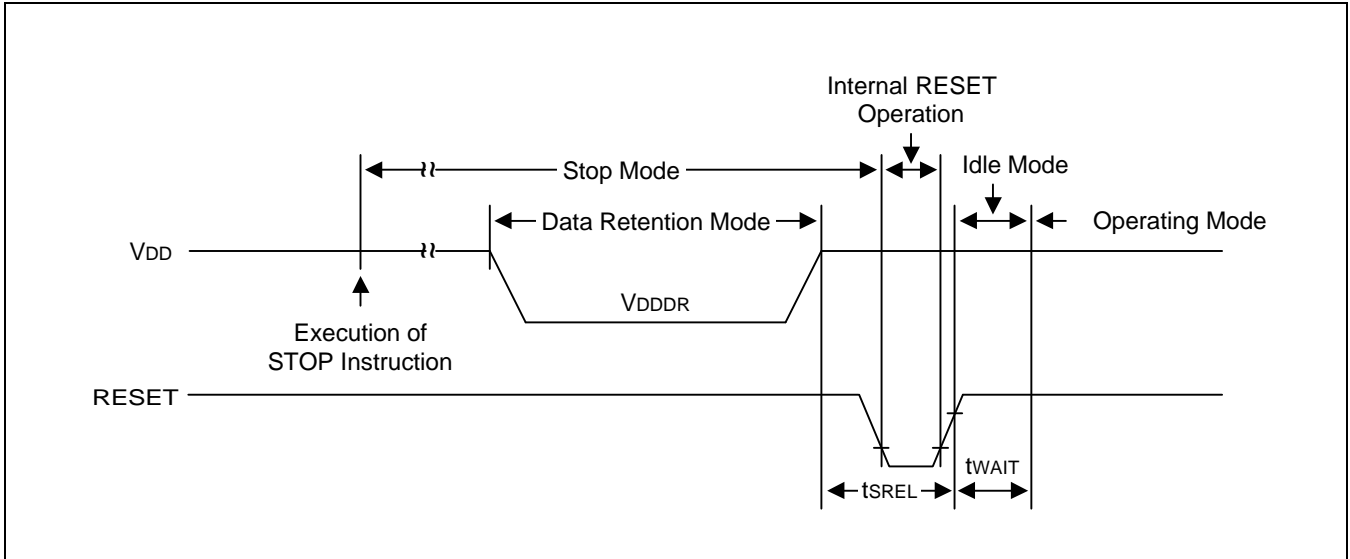


Figure 17-2. Stop Mode Release Timing When Initiated by RESET

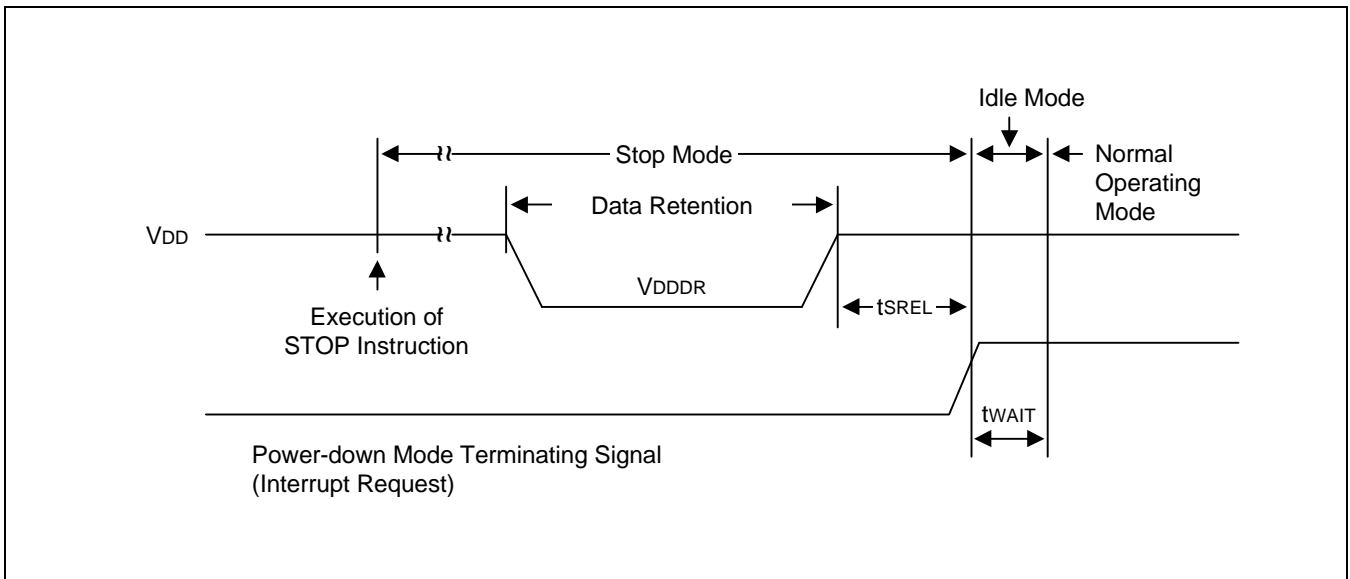


Figure 17-3. Stop Mode Release Timing When Initiated by an Interrupt Request

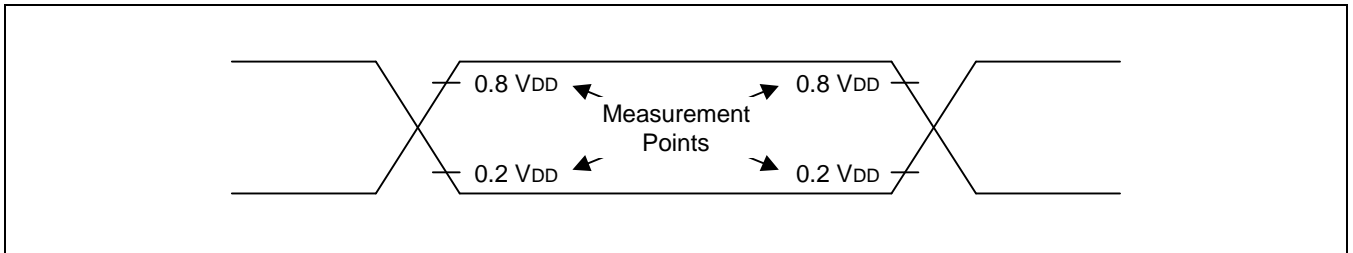


Figure 17-4. A.C. Timing Measurement Points (Except for X<sub>IN</sub> and XT<sub>IN</sub>)

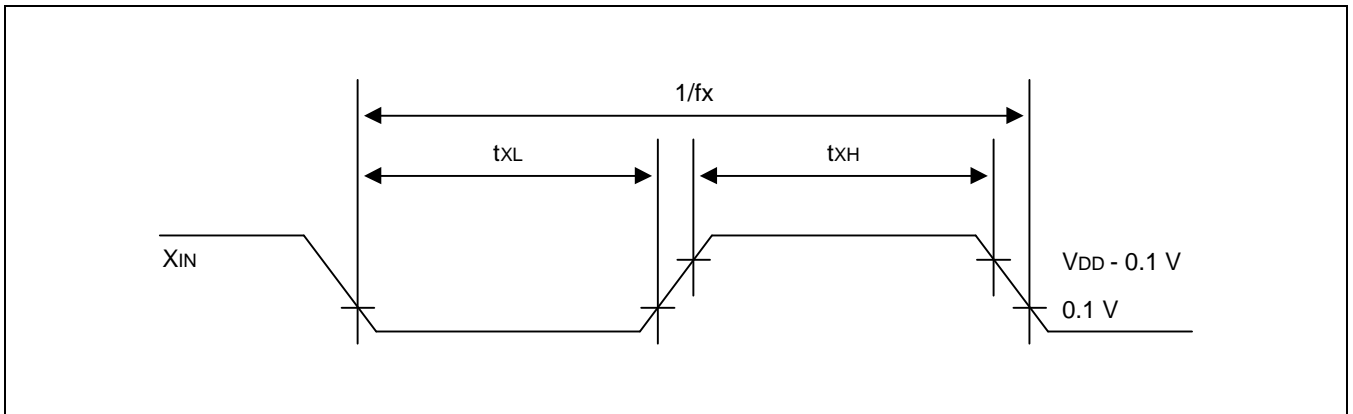


Figure 17-5. Clock Timing Measurement at X<sub>IN</sub>

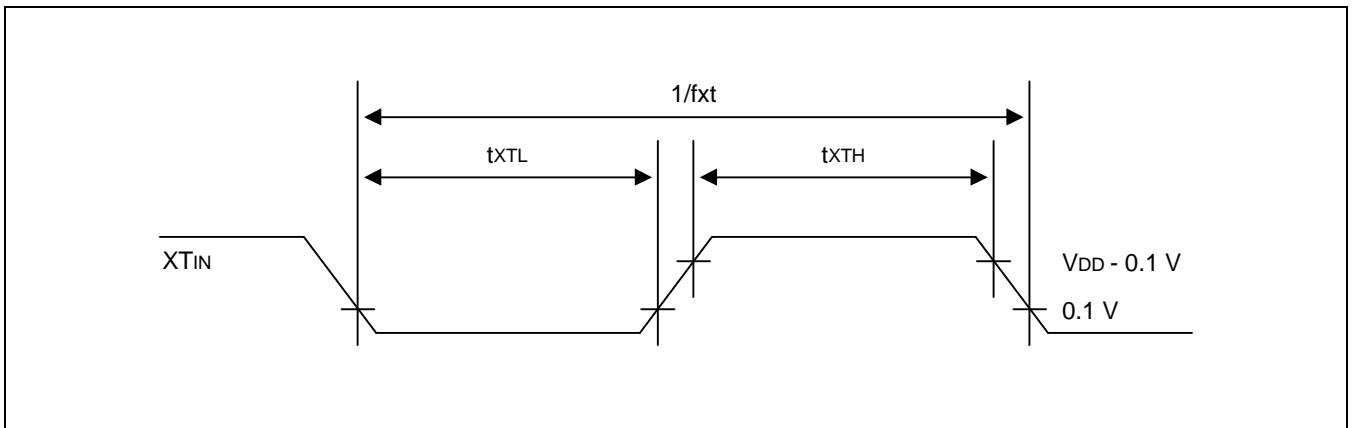
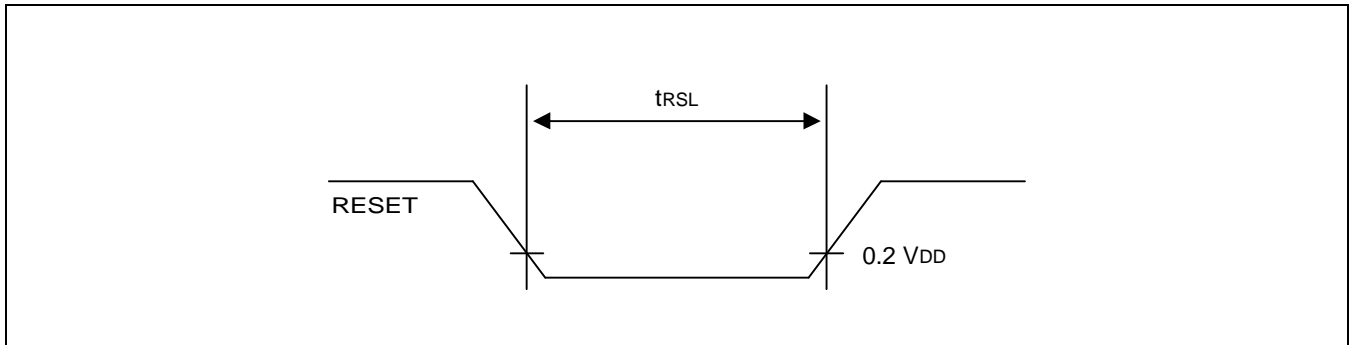
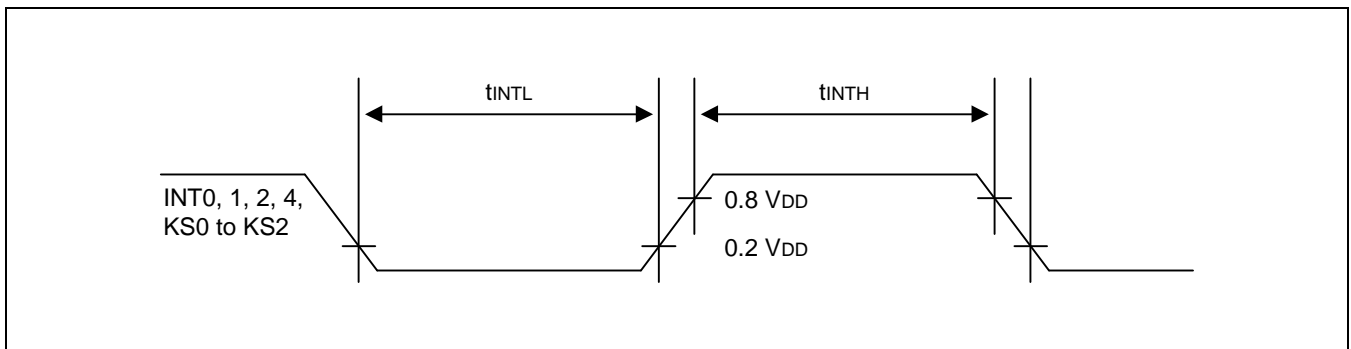


Figure 17-6. Clock Timing Measurement at XT<sub>IN</sub>



**Figure 17-7. Input Timing for RESET Signal****Figure 17-8. Input Timing for External Interrupts and Quasi-Interrupts**

# 18 MECHANICAL DATA

## OVERVIEW

This section contains the following information about the device package:

- Package dimensions in millimeters
- Pad diagram
- Pad/pin coordinate data table

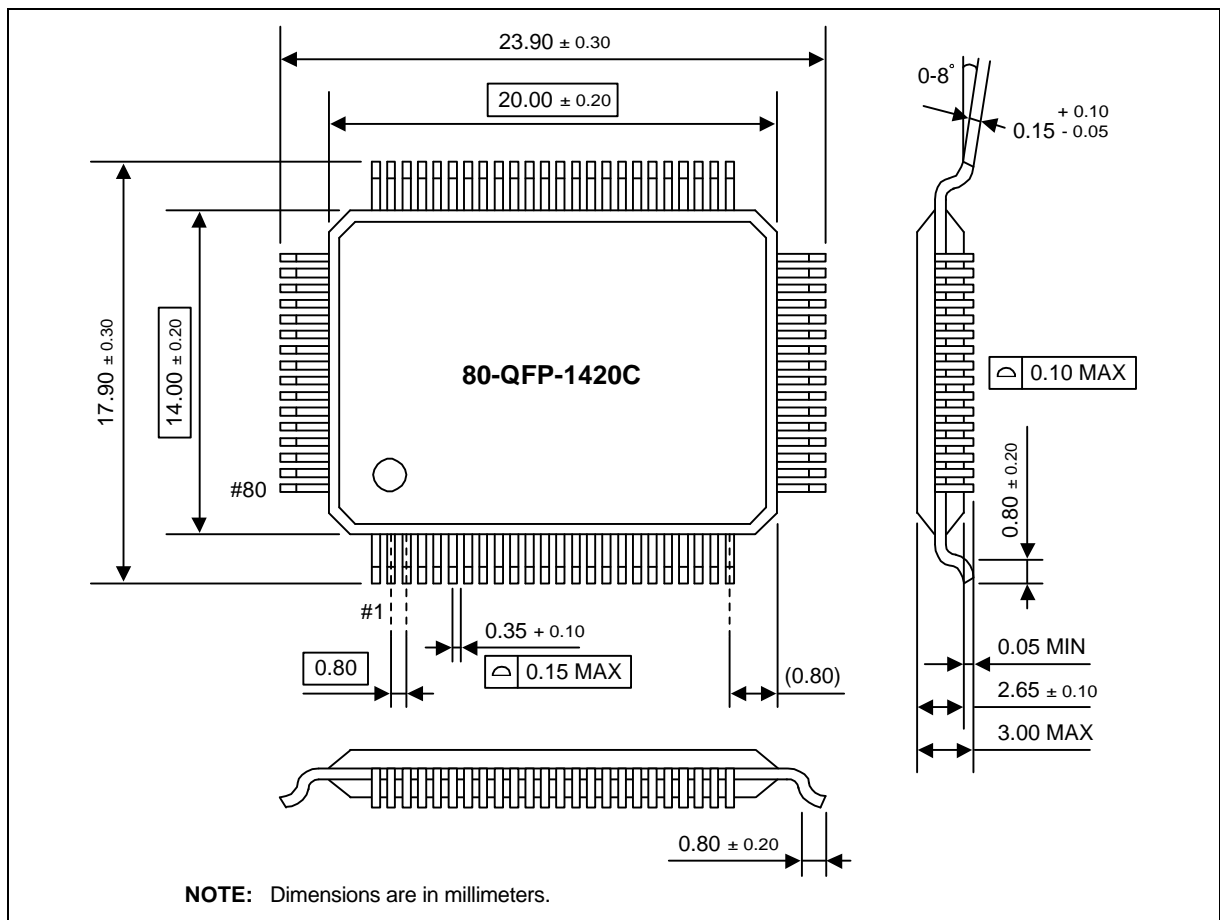


Figure 18-1. 80-QFP-1420C Package Dimensions

# 19

## KS57P3316 OTP

### OVERVIEW

The KS57P3316 single-chip CMOS microcontroller is the OTP (One Time Programmable) version of the KS57C3316 microcontroller. It has an on-chip EPROM instead of masked ROM. The EPROM is accessed by a serial data format.

The KS57P3316 is fully compatible with the KS57C3316, both in function and in pin configuration. Because of its simple programming requirements, the KS57P3316 is ideal for use as an evaluation chip for the KS57C3316.

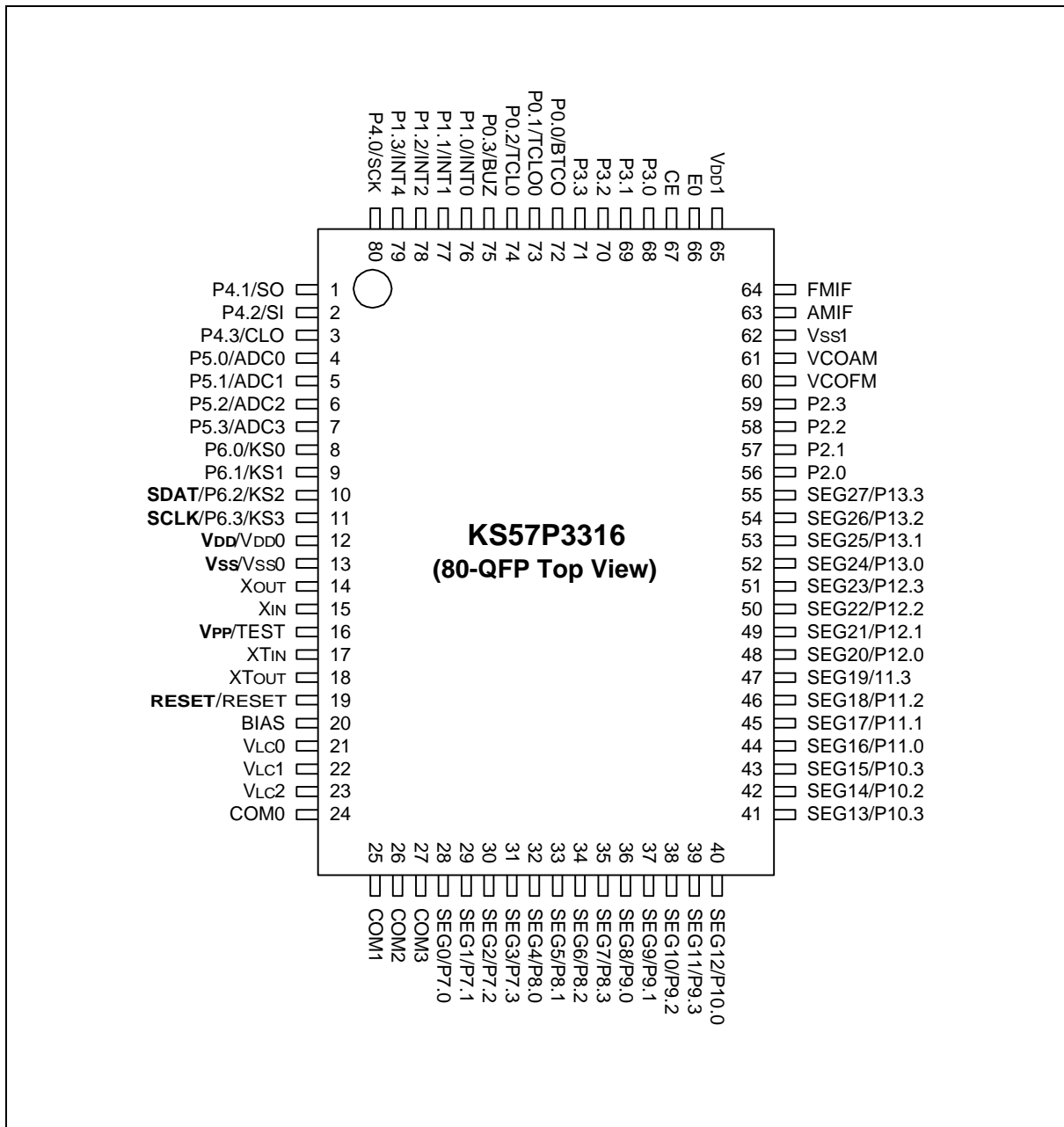


Figure 19-1. KS57P3316 Pin Assignments (80-QFP)

Table 19-1. Pin Descriptions Used to Read/Write the EPROM

Main Chip	During Programming			
Pin Name	Pin Name	Pin No.	I/O	Function
P6.2	SDAT	10	I/O	Serial data pin. Output port when reading and input port when writing. Can be assigned as a Input or push-pull output port.
P6.3	SCLK	11	I/O	Serial clock pin. Input only pin.
TEST	V <sub>PP</sub> (TEST)	16	I	Power supply pin for EPROM cell writing (indicates that OTP enters into the writing mode). When 12.5 V is applied, OTP is in writing mode and when 5 V is applied, OTP is in reading mode.
RESET	RESET	19	I	Chip initialization
V <sub>DD</sub> / V <sub>SS</sub>	V <sub>DD</sub> / V <sub>SS</sub>	12/13	I	Logic power supply pin. V <sub>DD</sub> should be tied to +5 V during programming.

Table 19-2. Comparison of KS57P3316 and KS57C3316 Features

Characteristic	KS57P3316	KS57C3316
Program Memory	16K bytes EPROM	16K bytes mask ROM
Operating Voltage (V <sub>DD</sub> )	1.8 V to 5.5 V 2.5 V to 3.5 V or 4.0 V to 5.5 V at PLL/IFC operation	1.8 V to 5.5 V 2.5 V to 3.5 V or 4.0 V to 5.5 V at PLL/IFC operation
OTP Programming Mode	V <sub>DD</sub> = 5 V, V <sub>PP</sub> (TEST) = 12.5 V	–
Pin Configuration	80 QFP	80 QFP
EPROM Programmability	User Program 1 time	Programmed at the factory

## OPERATING MODE CHARACTERISTICS

When 12.5 V is supplied to the V<sub>pp</sub> (TEST) pin of the KS57P3316, the EPROM programming mode is entered. The operating mode (read, write, or read protection) is selected according to the input signals to the pins listed in Table 17-3 below.

Table 19-3. Operating Mode Selection Criteria

V <sub>DD</sub>	V <sub>pp</sub> (TEST)	REG/MEM	Address(A15-A0)	R/W	Mode
5 V	5 V	0	0000H	1	EPROM read
	12.5 V	0	0000H	0	EPROM program
	12.5 V	0	0000H	1	EPROM verify
	12.5 V	1	0E3FH	0	EPROM read protection

**NOTE:** "0" means low level; "1" means high level.

Table 19-4. D.C. Electrical Characteristics

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input high voltage	V <sub>IH1</sub>	All input pins except those specified below	0.7 V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IH2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET	0.8 V <sub>DD</sub>		V <sub>DD</sub>	
	V <sub>IH3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>	V <sub>DD</sub> -0.1		V <sub>DD</sub>	
Input low voltage	V <sub>IL1</sub>	All input pins except those specified below	-	-	0.3 V <sub>DD</sub>	
	V <sub>IL2</sub>	P0.2, P1, P4.0, P4.2, P5, P6, CE and RESET			0.2 V <sub>DD</sub>	
	V <sub>IL3</sub>	X <sub>IN</sub> , X <sub>OUT</sub> , XT <sub>IN</sub> , and XT <sub>OUT</sub>			0.1	
Output high voltage	V <sub>OH1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -2.0	-	V <sub>DD</sub>	
	V <sub>OH2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V; Other output ports; I <sub>OH</sub> = -1 mA	V <sub>DD</sub> -1.0		V <sub>DD</sub>	
Output low voltage	V <sub>OL1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V, EO; I <sub>OL</sub> = 1 mA,	-	-	2.0	
	V <sub>OL2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V Other output ports; I <sub>OL</sub> = 10 mA	-	-	2	
Input high leakage current <sup>(note)</sup>	I <sub>LIH</sub>	V <sub>IN</sub> = V <sub>DD</sub> All input pins	-	-	3	μA
Input low leakage current <sup>(note)</sup>	I <sub>LIL</sub>	V <sub>IN</sub> = 0 V All input pins	-	-	-3	
Output high leakage current <sup>(note)</sup>	I <sub>LOH</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins	-	-	3	
Output low leakage current <sup>(note)</sup>	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V All output pins	-	-	-3	

**NOTE:** Except for X<sub>IN</sub>, X<sub>OUT</sub>, XT<sub>IN</sub>, and XT<sub>OUT</sub>

Table 19-4. D.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
V <sub>LC0</sub> output voltage	V <sub>LC0</sub>	T <sub>A</sub> = 25 °C	0.6 V <sub>DD</sub> - 0.2	0.6 V <sub>DD</sub>	0.6 V <sub>DD</sub> + 0.2	V
V <sub>LC1</sub> output voltage	V <sub>LC1</sub>	T <sub>A</sub> = 25 °C	0.4 V <sub>DD</sub> - 0.2	0.4 V <sub>DD</sub>	0.4 V <sub>DD</sub> + 0.2	
V <sub>LC2</sub> output voltage	V <sub>LC2</sub>	T <sub>A</sub> = 25 °C	0.2 V <sub>DD</sub> - 0.2	0.2 V <sub>DD</sub>	0.2 V <sub>DD</sub> + 0.2	
COM output voltage deviation	V <sub>DC</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3 ) IO = ± 15 μA (I = 0 - 3)	–	± 45	± 120	mV
SEG output voltage deviation	V <sub>DS</sub>	V <sub>DD</sub> = 5V, (V <sub>LC0</sub> - COM <sub>i</sub>   i = 0 - 3 ) IO = ± 15 μA (I = 0 - 3)		± 45	± 120	
LCD output voltage deviation	R <sub>LCD</sub>	T <sub>A</sub> = 25 °C	70	100	150	kΩ
Oscillator feed back resistors	R <sub>OSC1</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C X <sub>IN</sub> = V <sub>DD</sub> , X <sub>OUT</sub> = 0 V	300	600	1500	
	R <sub>OSC2</sub>	V <sub>DD</sub> = 5.0 V, T <sub>A</sub> = 25 °C XT <sub>IN</sub> = V <sub>DD</sub> , XT <sub>OUT</sub> = 0 V	1500	3000	4500	
Pull-down resistor	R <sub>D</sub>	V <sub>DD</sub> = 5.0 V, V <sub>IN</sub> = V <sub>DD</sub> ; VCOFM, VCOAM, AMIF, and FMIF	15	30	45	
Pull-up resistor	R <sub>L1</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V Ports 1, 2, 3, 4, 5, and 6	25	47	100	
		V <sub>DD</sub> = 3 V	50	95	200	
	R <sub>L2</sub>	V <sub>IN</sub> = 0 V; V <sub>DD</sub> = 5 V	100	220	400	
		RESET V <sub>DD</sub> = 3 V	200	450	800	

**Table 19-4. D.C. Electrical Characteristics (Concluded)** $(T_A = -40\text{ }^\circ\text{C to } +85\text{ }^\circ\text{C, } V_{DD} = 1.8\text{ V to } 5.5\text{ V})$ 

Parameter	Symbol	Conditions	Min	Typ	Max	Units	
Supply Current <sup>(1)</sup>	$I_{DD1}^{(2)}$	Main operating: PCON = 0011B, SCMOD = 0000B CE = $V_{DD}$ ; Crystal oscillator C1 = C2 = 22 pF $V_{DD} = 5\text{ V} \pm 10\%$	4.5 MHz	–	5.5	27	mA
			6.0 MHz	–	3.5	8	
	4.5 MHz	2.5	5.5				
		$V_{DD} = 3\text{ V} \pm 10\%$	6.0 MHz		1.6	4	
	$I_{DD2}^{(2)}$	CE Low mate: PCON = 0011B, SCMOD = 0000B CE = 0 V Crystal oscillator C1 = C2 = 22 pF $V_{DD} = 5\text{ V} \pm 10\%$	4.5 MHz		1.2	3	
			6.0 MHz	1.0	2.5		
			4.5 MHz	0.9	2.0		
	$I_{DD3}^{(2)}$	Main idle mode: PCON = 0111B, SCMOD = 0000B Crystal oscillator C1 = C2 = 22 pF $V_{DD} = 5\text{ V} \pm 10\%$	6.0 MHz	–	1.0	2.5	
			4.5 MHz		0.9	2.0	
			$V_{DD} = 3\text{ V} \pm 10\%$		6.0 MHz	0.5	
$I_{DD4}^{(2)}$	Sub operating mode: PCON = 0011B, SCMOD = 1001B CE = 0 V; $V_{DD} = 3\text{ V} \pm 10\%$ 32 kHz crystal oscillator	6.0 MHz	–	15	30	uA	
		4.5 MHz		0.4	0.8		
$I_{DD5}^{(2)}$	Sub idle mode: PCON = 0111B, SCMOD = 1001B CE = 0 V; $V_{DD} = 3\text{ V} \pm 10\%$ 32 kHz crystal oscillator		–	6	15		
$I_{DD6}^{(2)}$	Stop mode: CPU = $f_x/4$ , SCMOD = 1101B CE = 0 V; $V_{DD} = 5\text{ V} \pm 10\%$		–	0.5	3		
$I_{DD7}^{(2)}$	Stop mode: CPU = $f_x/4$ , SCMOD = 0100B $V_{DD} = 5\text{ V} \pm 10\%$		–				

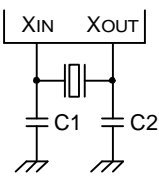
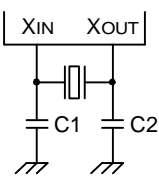
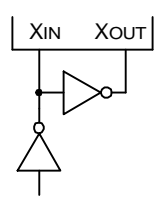
**NOTES:**

- Supply current does not include current drawn through internal pull-up resistors and LCD voltage dividing resistors.
- Data includes the power consumption for sub-system clock oscillation.



Table 19-5. Main System Clock Oscillator Characteristics

(T<sub>A</sub> = -40 °C + 85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Ceramic Oscillator		Oscillation frequency (1)	V <sub>DD</sub> = 2.7 V to 5.5 V	0.4	–	6	MHz
		Stabilization time (2)	Stabilization occurs when V <sub>DD</sub> is equal to the minimum oscillator voltage range.	–	–	4	ms
Crystal Oscillator		Oscillation frequency (1)	V <sub>DD</sub> = 2.7 V to 5.5 V	0.4	–	6	MHz
		Stabilization time (2)	V <sub>DD</sub> = 4.5 V to 5.5 V	–	–	10	ms
			V <sub>DD</sub> = 1.8 V to 4.5 V	–	–	30	
External Clock		X <sub>IN</sub> input frequency (1)	–	0.4	–	6	MHz
		X <sub>IN</sub> input high and low level width (t <sub>XH</sub> , t <sub>XL</sub> )	–	83.3	–	–	ns

**NOTES:**

- Oscillation frequency and X<sub>IN</sub> input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs, or when stop mode is terminated.

**Table 19-6. Subsystem Clock Oscillator Characteristics**

( $T_A = -40\text{ }^\circ\text{C} + 85\text{ }^\circ\text{C}$ ,  $V_{DD} = 1.8\text{ V to } 5.5\text{ V}$ )

Oscillator	Clock Configuration	Parameter	Test Condition	Min	Typ	Max	Units
Crystal Oscillator		Oscillation frequency (1)	–	32	32.768	35	kHz
		Stabilization time (2)	$V_{DD} = 2.7\text{ V to } 5.5\text{ V}$	–	1.0	2	s
			$V_{DD} = 1.8\text{ V to } 4.5\text{ V}$	–	–	10	
External Clock		$XT_{IN}$ input frequency (1)	–	32	–	100	kHz
		$XT_{IN}$ input high and low level width ( $t_{XTL}$ , $t_{XTH}$ )	–	5	–	15	$\mu\text{s}$

**NOTES:**

- Oscillation frequency and  $XT_{IN}$  input frequency data are for oscillator characteristics only.
- Stabilization time is the interval required for oscillator stabilization after a power-on occurs.

Table 19-7. Input/Output Capacitance

(T<sub>A</sub> = 25 °C, V<sub>DD</sub> = 0 V)

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input capacitance	C <sub>IN</sub>	f <sub>CLK</sub> = 1 MHz; Unmeasured pins are returned to V <sub>SS</sub>	–	–	15	pF
Output capacitance	C <sub>OUT</sub>		–	–	15	pF
I/O capacitance	C <sub>IO</sub>		–	–	15	pF

Table 19-8. A.C. Electrical Characteristics

(T<sub>A</sub> = –40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time (1)	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3		64	
Interrupt input high, low width	t <sub>INTH</sub> , t <sub>INTL</sub>	INT0	(2)	–	–	μs
		INT1, INT2, INT4, KS0–KS2	10			
RESET and CE Input Low Width	t <sub>RSL</sub>	Input	10	1	–	μs

**NOTES:**

- Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.
- Minimum value for INT0 is based on a clock of 2t<sub>CY</sub> or 128/fxx as assigned by the IMOD0 register setting.

Table 19-8. A.C. Electrical Characteristics (continued)

(T<sub>A</sub> = –10 °C to +70 °C, V<sub>DD</sub> = 3.5 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
A/D converting Resolution	–	–	–	8	–	bits
Absolute accuracy	–	–	–	–	± 2	LSB
AD conversion time	t <sub>CON</sub>	–	17	34/fxx (note)	–	μs
Analog input voltage	V <sub>IAN</sub>	–	V <sub>SS</sub>	–	V <sub>DD</sub>	V
Analog input impedance	R <sub>AN</sub>	V <sub>DD</sub> = 5 V	2	1000	–	MΩ

**NOTE:** fxx stands for the system clock (fx or fxt).

**Table 19-8. A.C. Electrical Characteristics (Continued)**(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 2.5 V to 3.5 V or V<sub>DD</sub> = 4.0 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
VCOFM, VCOAM, FMIF and AMIF Input Voltage (Peak to Peak)	V <sub>IN</sub>	Sine wave input	0.3	–	V <sub>DD</sub>	V
Frequency	f <sub>VCOAM</sub>	VCOAM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.5	–	30	MHz
	f <sub>VCOFM</sub>	VCOFM mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	30		150	
	f <sub>AMIF</sub>	AMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	0.1		1.0	
	f <sub>FMIF</sub>	FMIF mode, sine wave input; V <sub>IN</sub> = 0.3V <sub>P-P</sub>	5		15	

Table 19-8. A.C. Electrical Characteristics (continued)

(T<sub>A</sub> = -40 °C to +85 °C, V<sub>DD</sub> = 1.8 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Instruction cycle time <sup>(1)</sup>	t <sub>CY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.67	–	64	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.3	–	64	
		With subsystem clock (fxt)	114	122	125	
TCL0 input frequency	f <sub>TI</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0	–	1.5	MHz
		V <sub>DD</sub> = 1.8 V to 5.5 V			1	
TCL0 input high, low width	t <sub>TIH</sub> , t <sub>TIL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V	0.48	–	–	μs
		V <sub>DD</sub> = 1.8 V to 5.5 V	1.8			
SCK cycle time	t <sub>KCY</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	800	–	–	ns
		Internal SCK source	650			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	3200			
		Internal SCK source	3800			
SCK high, low width	t <sub>KH</sub> , t <sub>KL</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	400	–	–	
		Internal SCK source	t <sub>KCY</sub> /2- 50			
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source	1600			
		Internal SCK source	t <sub>KCY</sub> /2-150			
SI setup time to SCK high	t <sub>SIK</sub>	External SCK source	100	–	–	
		Internal SCK source	150			
SI hold time to SCK high	t <sub>KSI</sub>	External SCK source	400	–	–	
		Internal SCK source	400			
Output delay for SCK to SO	t <sub>KSO</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V External SCK source	–	–	300	
		Internal SCK source			250	
		V <sub>DD</sub> = 1.8 V to 5.5 V External SCK source			1000	
		Internal SCK source			1000	

**NOTE:** Unless otherwise specified, Instruction Cycle Time condition values assume a main system clock/4 (fx/4) source.

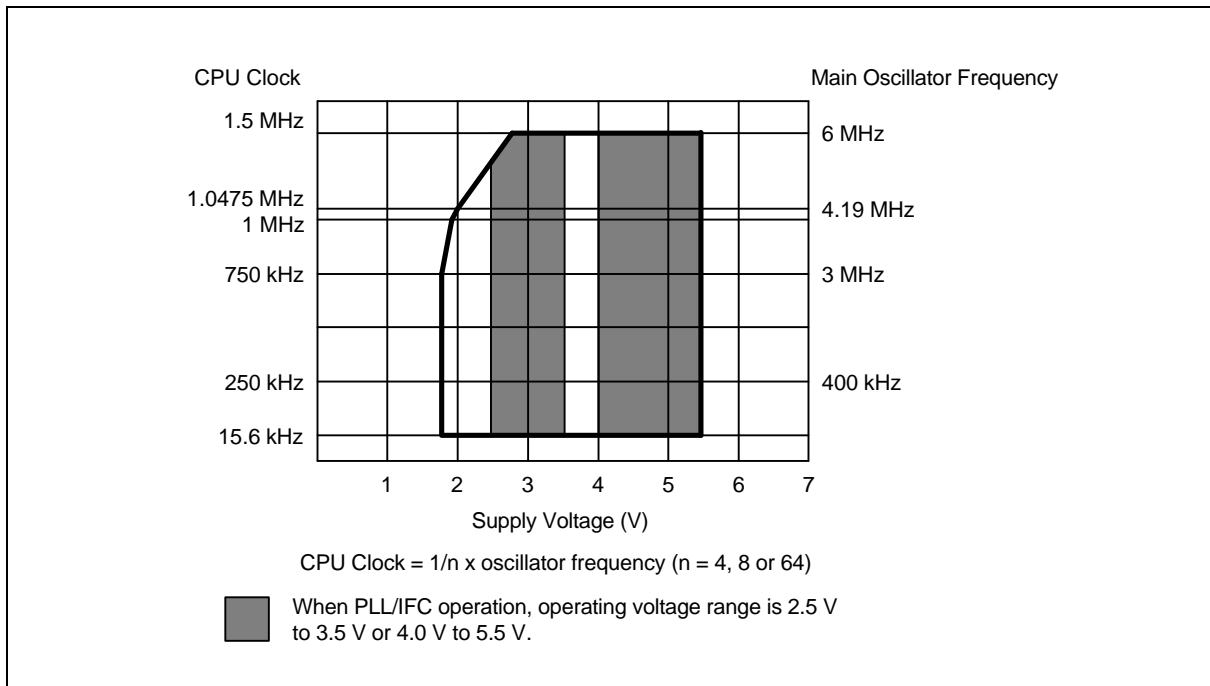


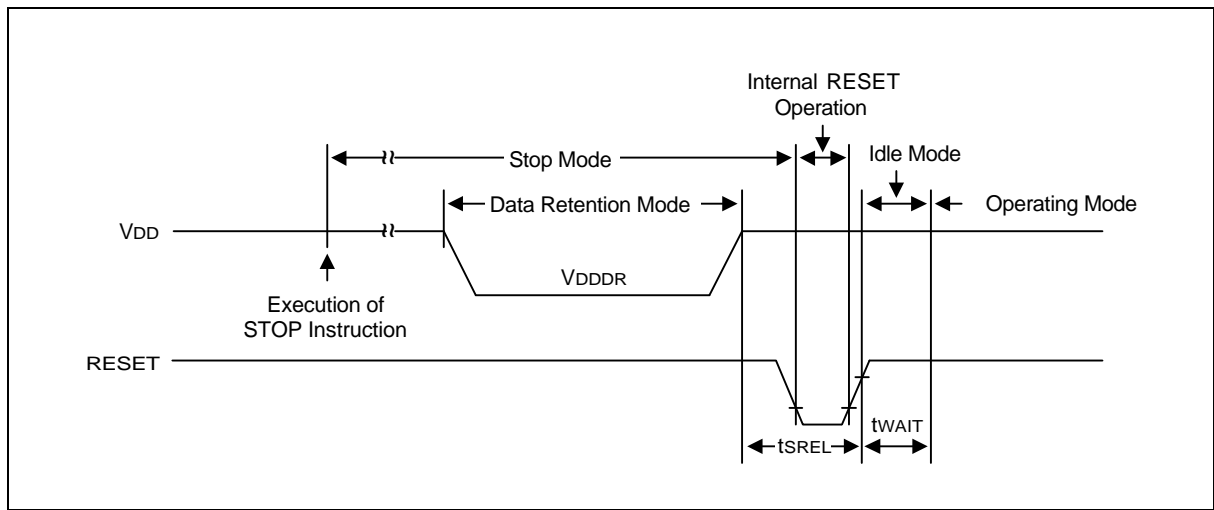
Figure 19-2. Standard Operating Voltage Range

Table 19-9. RAM Data Retention Supply Voltage in Stop Mode

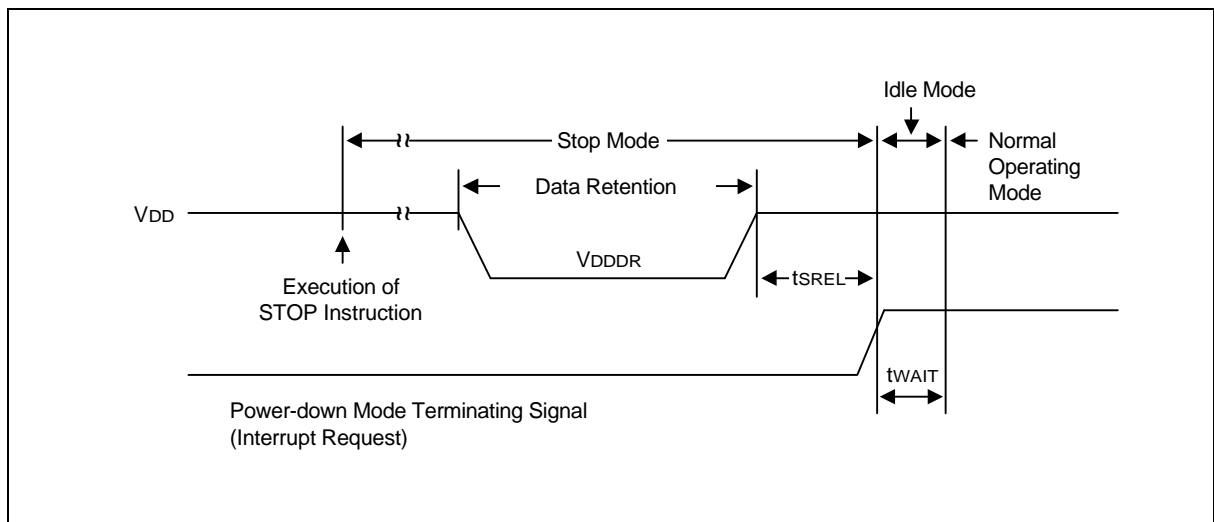
( $T_A = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data retention supply voltage	$V_{DDDR}$	Normal operation	1.8	–	5.5	V
Data retention supply current	$I_{DDDR}$	$V_{DDDR} = 1.8\text{ V}$	–	0.1	1	$\mu\text{A}$

**TIMING WAVEFORMS**



**Figure 19-3. Stop Mode Release Timing When Initiated by RESET**



**Figure 19-4. Stop Mode Release Timing When Initiated by an Interrupt Request**

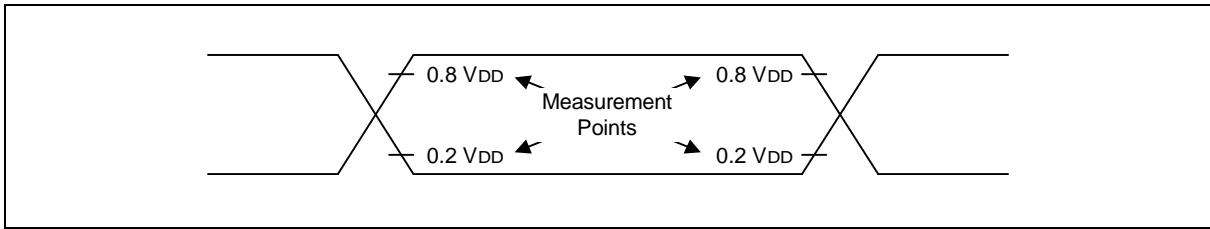


Figure 19-5. A.C. Timing Measurement Points (Except for  $X_{IN}$  and  $XT_{IN}$ )

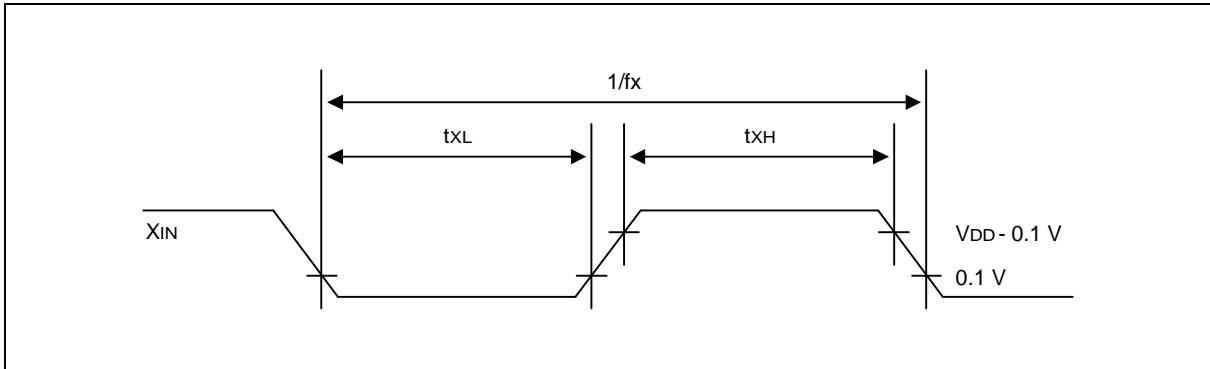


Figure 19-6. Clock Timing Measurement at  $X_{IN}$

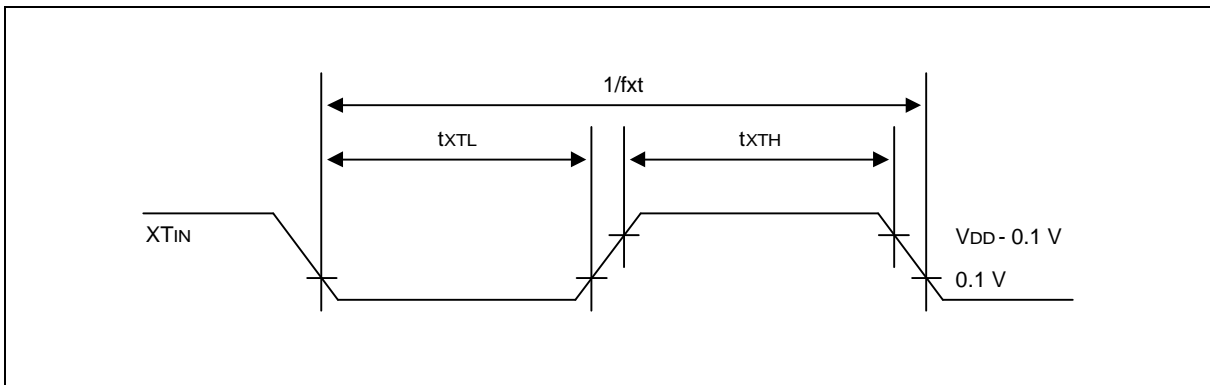


Figure 19-7. Clock Timing Measurement at  $XT_{IN}$



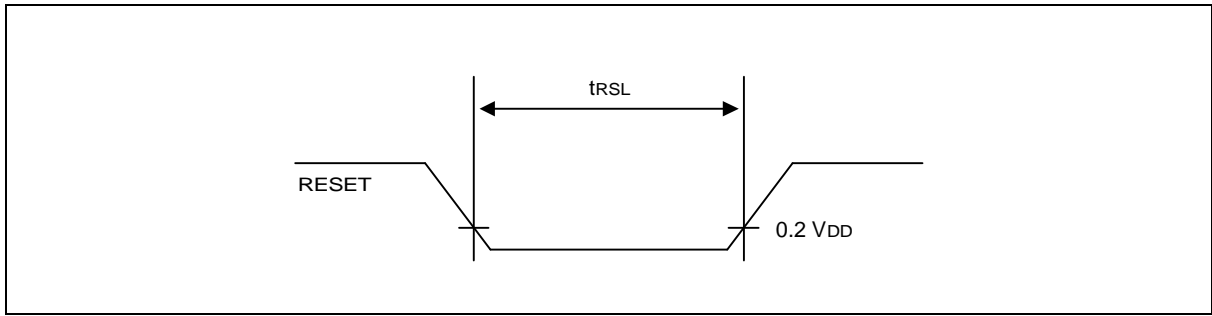


Figure 19-8. Input Timing for RESET Signal

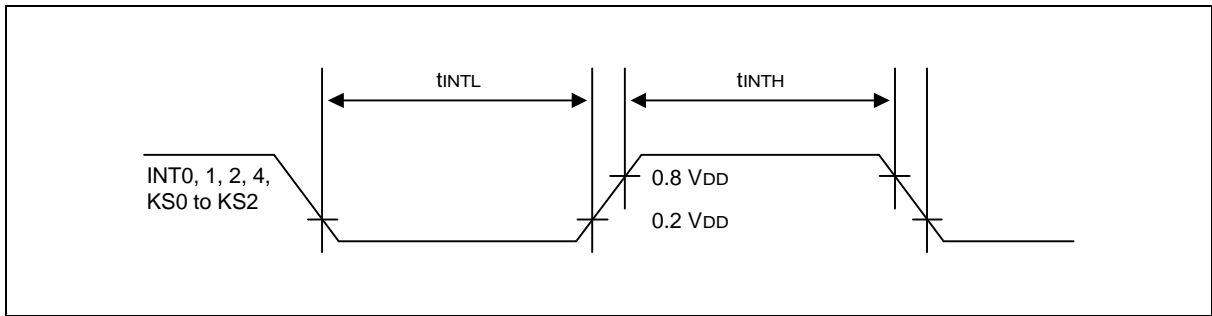


Figure 19-9. Input Timing for External Interrupts and Quasi-Interrupts

NOTES