

# 1

## PRODUCT OVERVIEW

### SAM8 PRODUCT FAMILY

Samsung's new SAM8 family of 8-bit single-chip CMOS microcontrollers offers a fast and efficient CPU, a wide range of integrated peripherals, and various mask-programmable ROM sizes.

A dual address/data bus architecture and a large number of bit- or nibble-configurable I/O ports provide a flexible programming environment for applications with varied memory and I/O requirements. Timer/counters with selectable operating modes are included to support real-time operations. Many SAM8 microcontrollers have an external interface that provides access to external memory and other peripheral devices.

A sophisticated interrupt structure recognizes up to eight interrupt levels. Each level can have one or more interrupt sources and vectors. Fast interrupt processing (within a minimum six CPU clocks) can be assigned to one interrupt level at a time.

### KS88C4616/C4632 MICROCONTROLLER

The KS88C4616/C4632 single-chip 8-bit microcontroller is designed for useful 10-bit resolution A/D converter, UART, SIO, ZCD extended PWM application field. Its powerful SAM87 CPU architecture includes. The internal register file is logically expanded to increase the on-chip register space.

The KS88C4616/C4632 has 16/32 K bytes of on-chip program ROM. A sophisticated bus interface enables access to external memory and other peripherals when you use the chip in ROM-less mode. Following Samsung's modular design approach, the following peripherals are integrated with the SAM87 core:

- Large number of programmable I/O ports (total 56 pins)
- One asynchronous UART module
- One synchronous SIO module
- Analog-to-digital converter with eight input channels and 10-bit resolution
- One 8-bit basic timer for watchdog function
- One 8-bit timer/counter with three operating modes (timer 0)
- One 8-bit timer for zero-cross detection circuit (timer 2)
- Two general-purpose 16-bit timer/counters with four operating modes (timer module 1)
- PWM block with one capture module, 16-bit timer/counter, PWM extension mode, and two PWM outputs
- One zero cross detection module

The KS88C4616/C4632 is a versatile general-purpose microcontroller that is ideal for use in a wide range of electronics applications requiring complex timer/counter, PWM, capture, SIO, UART and ZCD functions. It is available in a 64-pin SDIP or 64-pin QFP package.

### OTP

The KS88P4632 is an OTP (One Time Programmable) version of the KS88C4616/C4632 microcontroller. The KS88P4632 microcontroller has an on-chip 32-Kbyte one-time-programmable EPROM instead of a masked ROM. The KS88P4632 is comparable to the KS88C4616/C4632, both in function and in pin configuration.

## FEATURES

### CPU

- SAM87 CPU core

### Memory

- 528-byte general purpose register area
- 16/32-Kbyte internal program memory
- ROM-less operating mode

### External Interface

- 64-Kbyte external data memory area
- 64-Kbyte external program memory area (ROM-less mode)

### Instruction Set

- 79 instructions
- IDLE and STOP instructions added for power-down modes

### Instruction Execution Time

- 500 ns at 12 MHz  $f_{OSC}$  (minimum)

### Interrupts

- 21 interrupt sources and 21 vectors
- Eight interrupt levels
- Fast interrupt processing

### General I/O

- Seven I/O ports (total 56 pins)
- Seven bit-programmable ports

### PWM and Capture

- Two 14-bit PWM output
- One capture

### Serial I/O

- One synchronous serial I/O module
- Selectable transmit and receive rates
- Selectable baud rate for Rx and Tx respectively

### Timer/Counters

- One 8-bit basic timer for watchdog function
- One 8-bit timer/counter with three operating modes (timer 0)
- One 8-bit timer for the zero-cross detection circuit
- Two 16-bit general-purpose timer/counters with four operating modes (timer C and D)

### UART

- One UART module
- Full duplex serial I/O interface with three UART modes

### A/D Converter

- Eight analog input pins
- 10-bit conversion resolution
- 20  $\mu$ s conversion time (10 MHz CPU clock)

### Zero Cross Detection Circuit

- Zero cross detection circuit that generates a digital signal in synchronization with an AC signal input

### Buzzer Frequency Output

- 200 Hz to 20 kHz signal can be generated

### Oscillator Frequency

- 1 MHz to 12 MHz external crystal oscillator
- Maximum 12 MHz CPU clock

### Operating Temperature Range

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

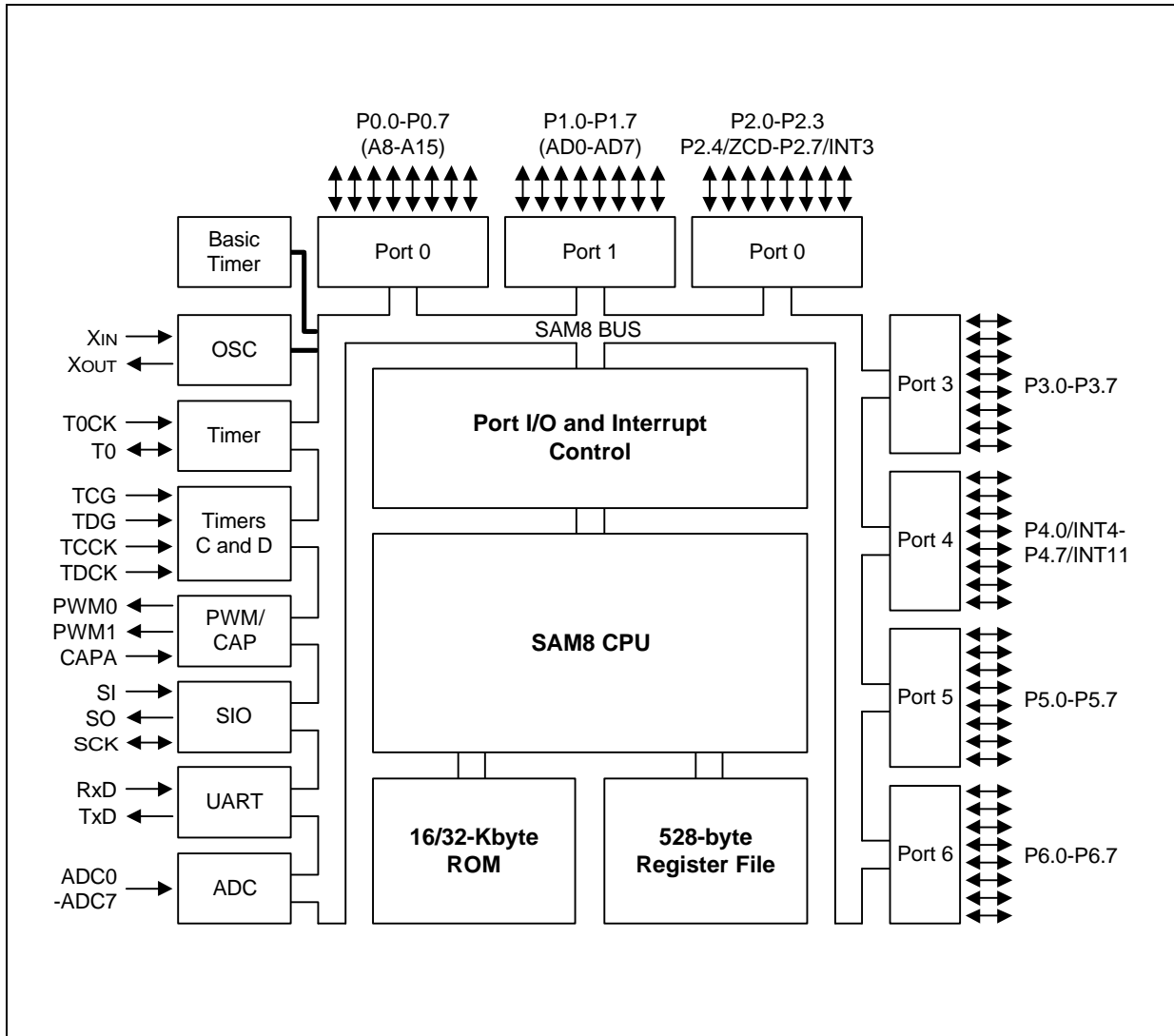
### Operating Voltage Range

- 2.7 V to 5.5 V

### Package Types

- 64-pin SDIP, 64-pin QFP

**BLOCK DIAGRAM**



**Figure 1-1. Block Diagram**

PIN ASSIGNMENTS

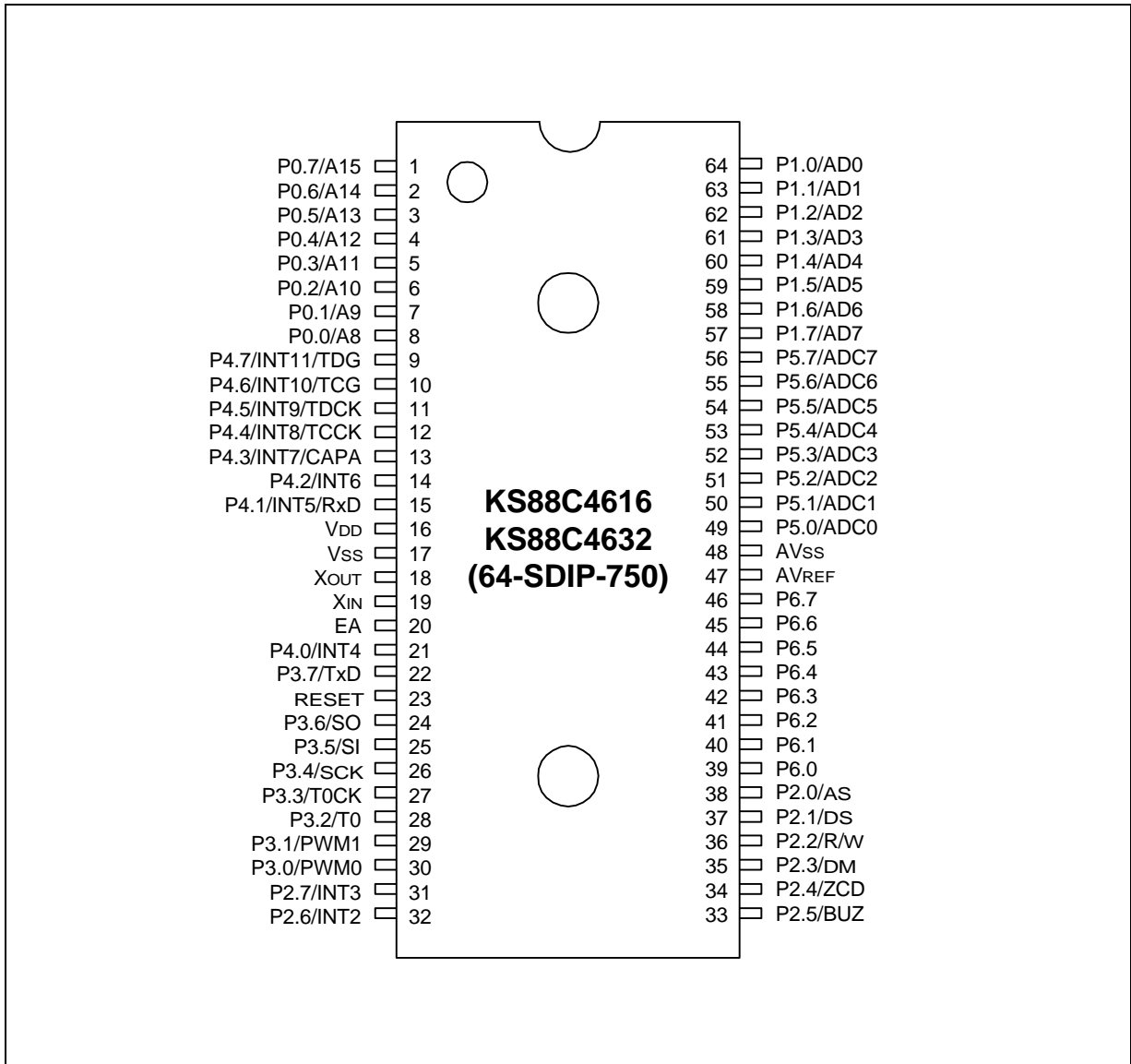


Figure 1-2. Pin Assignment Diagram (64-Pin SDIP Package)

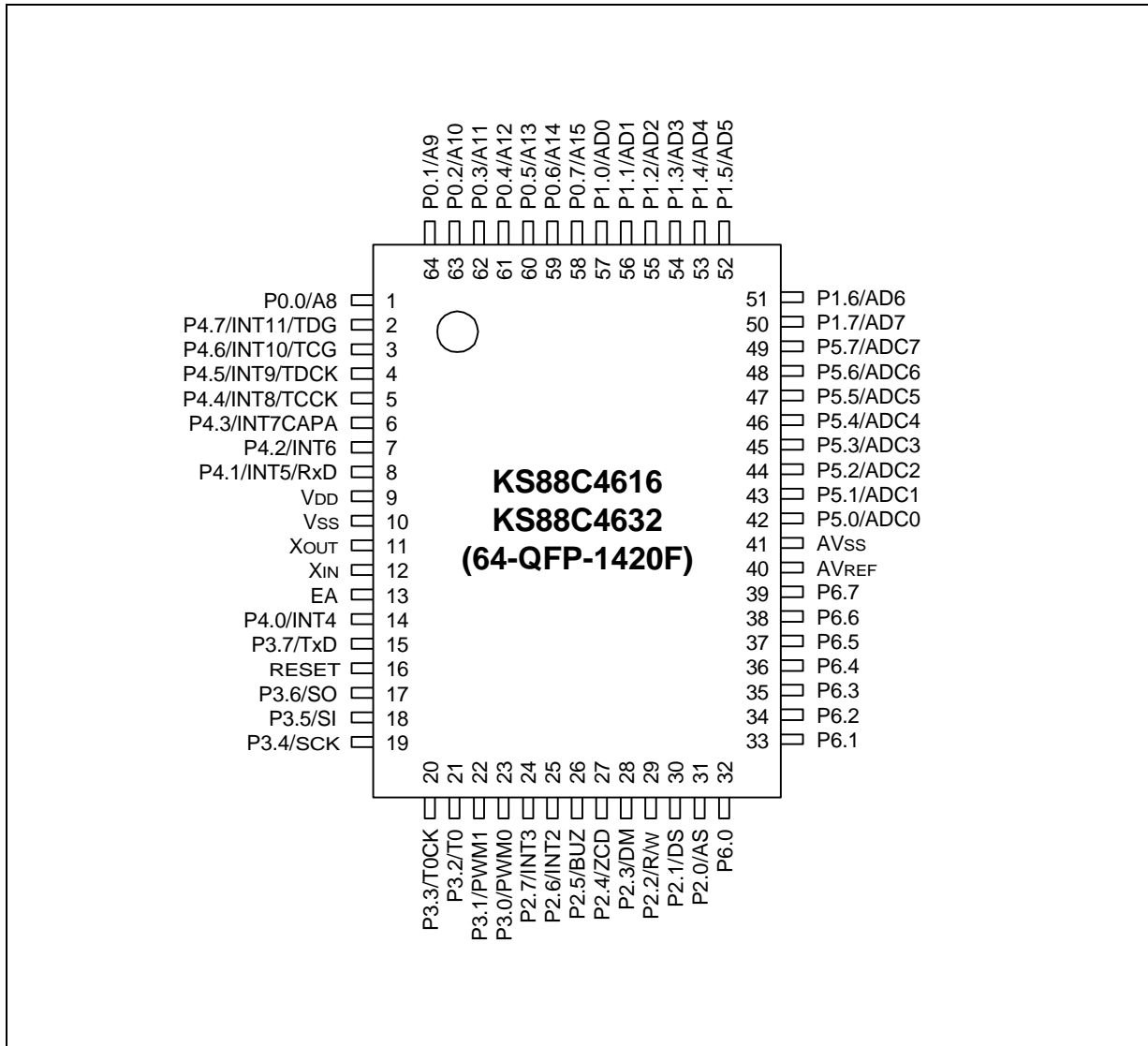


Figure 1-3. Pin Assignment Diagram (64-Pin QFP Package)

Table 1-1. KS88C4616/C4632 Pin Descriptions

Pin Name	Pin Type	Pin Description	Circuit Number	Pin Number	Share Pins
P0.0–P0.7	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull, open-drain, output. Pull-up resistors are assignable by software. Port 0 can also be configured as external interface address line A8–A15	1	8–1 (1, 64–58)	– A8–A15
P1.0–P1.7	I/O	Same general characteristics as port 0. Port 1 can also be configured as external interface address/data lines AD0–AD7	1	64–57 (57–50)	– AD0–AD7
P2.0–P2.3 P2.4–P2.7	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull output. P2.0–P2.3 can be configured for external bus control signals. P2.4–P2.7 are used for general I/O or for the ZCD, BUZ, INT2 and INT3	2 3	38–35 (31–28) 34–31 (27–24)	– AS, DS DM, R/W ZCD, BUZ INT2, INT3
P3.0–P3.7	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull output. Each port 3 pin has an alternative function: P3.0: PWM0 (PWM0 module output) P3.1: PWM1 (PWM1 module output) P3.2: T0 (T0 capture input or PWM output) P3.3: T0CK (timer 0 external clock input) P3.4: SCK (SIO module input) P3.5: SI (SIO module clock I/O) P3.6: SO (SIO module output) P3.7: TxD: SO1 (The T0 function for P3.2 is selected using the T0CON register.)	4	30–22 (23–15)	(See pin description)
P4.0–P4.7	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull output. Port 4 pins are used external interrupts INT4–INT11 or for the following share functions: P4.1: RxD (UART module input) P4.3: CAPA (capture input) P4.4: TCCK (timer/counter C clock input) P4.5: TDCK (timer/counter D clock input) P4.6: TCG (timer C gate input) P4.7: TDG (timer D gate input)	5	21, 15–9 (14–2)	(See pin description)

Table 1-1. KS88C4616/C4632 Pin Descriptions (Continued)

Pin Name	Pin Type	Pin Description	Circuit Number	Pin Number	Share Pins
P5.0–P5.7	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull, output. Pull-up resistors are assignable by software. Port 5 pins can also be used as A/D converter inputs.	6	49–56 (42–49)	ADC0– ADC7
P6.0–P6.7	I/O	Individual pins are software configurable as input or push-pull, open-drain, output. Pull-up resistors are assignable by software.	1	39–46 (32–39)	–
AD0–AD7	I/O	External interface address/data line	6	64–57 (57–50)	P1.0–P1.7
AS DS R/W DM	I/O	External bus control signals	2	38–35 (31–28)	P2.0–P2.3
ZCD	I/O	Zero cross detector input	2	34 (27)	P2.4
BUZ	I/O	200 Hz–20 kHz frequency output for buzzer sound	2	33 (26)	P2.5
PWM0 PWM1	I/O	PWM output	3	30, 29 (23, 22)	P3.0–P3.1
T0 (CAP)	I/O	T0 capture input or PWM output	3	28 (21)	P3.2
T0CK	I/O	External clock input for Timer 0	3	27 (20)	P3.3
SCK	I/O	SIO clock signal	3	26 (19)	P3.4
SI, SO	I/O	SIO data input/output	3	25, 24 (18, 17)	P3.5–P3.6
TxD	I/O	UART data output	3	22 (15)	P3.7
INT2–INT3	I/O	External interrupts: the triggering edge is selectable.	2	32, 31 (25, 24)	P2.6–P2.7
INT4	I/O	External interrupts: the triggering edge is selectable.	4	21 (14)	P4.0
RxD/INT5	I/O	UART data input or external interrupt: the triggering edge is selectable.	4	15 (8)	P4.1
INT6 CAPA/INT7	I/O	Capture module input or external interrupt: the triggering edge is selectable.	4	14, 13 (7, 6)	P4.2–P4.3

Table 1-1. KS88C4616/C4632 Pin Descriptions (Concluded)

Pin Name	Pin Type	Pin Description	Circuit Number	Pin Number	Share Pins
TCKK/INT8 TCDK/INT9	I/O	Timer/counter C and D clock input or external interrupts: the triggering edge is selectable.	4	12, 11 (5, 4)	P4.4–P4.5
TCG/INT10 TDG/INT11	I/O	Timer/counter C and D clock input or external interrupts: the triggering edge is selectable.	4	10, 9 (3, 2)	P4.6–P4.7
ADC0– ADC7	I/O	A/D converter inputs	5	49–56 (42–49)	P5.0–P5.7
X <sub>IN</sub> , X <sub>OUT</sub>	–	System clock input and output pins	–	19, 18 (12, 11)	–
RESET	I	System reset pin	7	23 (16)	–
EA	I	External access (EA) pin with three modes: 0 V: Normal operation (internal ROM) 5 V: ROM-less operation (external interface) 12.5 V: OTP read/write mode	–	20 (13)	–
AV <sub>REF</sub> , AV <sub>SS</sub>	–	A/D converter reference voltage input and ground	–	47, 48 (40, 41)	–
V <sub>DD</sub> , V <sub>SS</sub>	–	Voltage input pin and ground	–	16, 17 (9, 10)	–

**NOTE:** Pin numbers shown in parentheses "( )" are for the 64-pin QFP package.



## PIN CIRCUITS

Table 1-2. Pin Circuit Assignments for the KS88C4616/C4632

Circuit Number	Circuit Type	KS88C4616/C4632 Assignments
1	I/O	Port 0,1 and port 6
2	I/O	Port 2 (P2.0–P2.3 only)
3	I/O	Port 2 (P2.4–P2.7 only)
4	I/O	Port 3
5	I/O	Port 4
6	I/O	Port 5
7	I	RESET

**NOTE:** Diagrams of circuit types 1–7 are presented below.

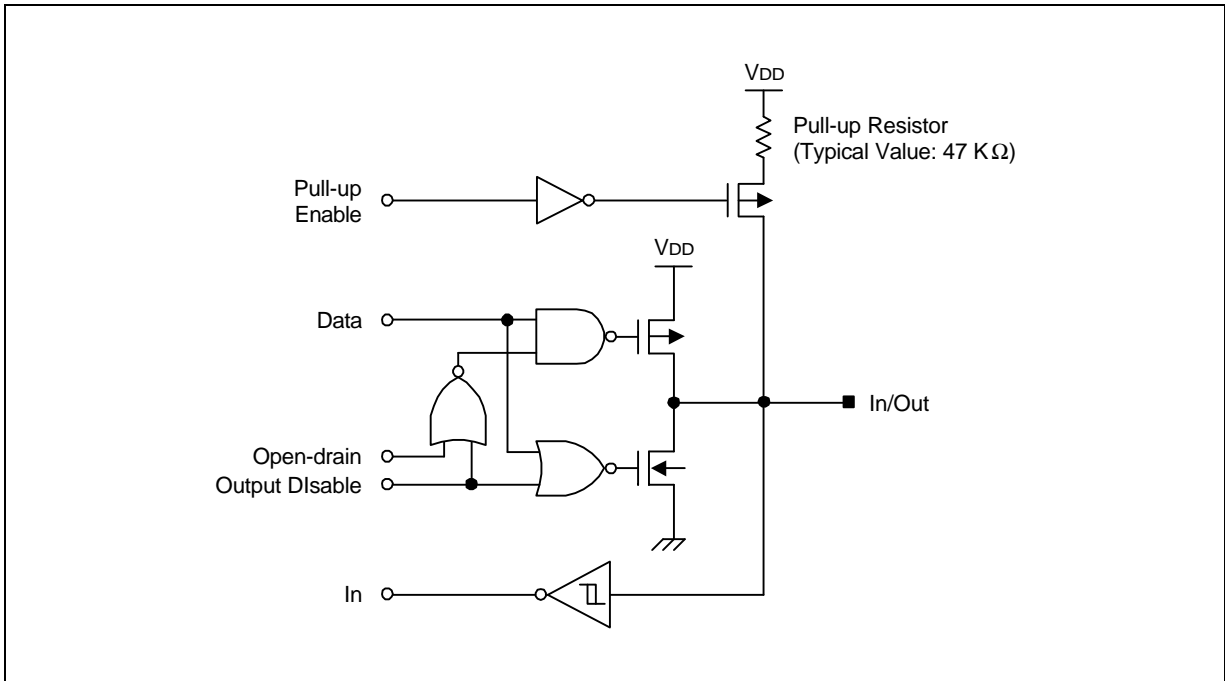


Figure 1-4. Pin Circuit Type 1 (Port 0,1 and Port 6)

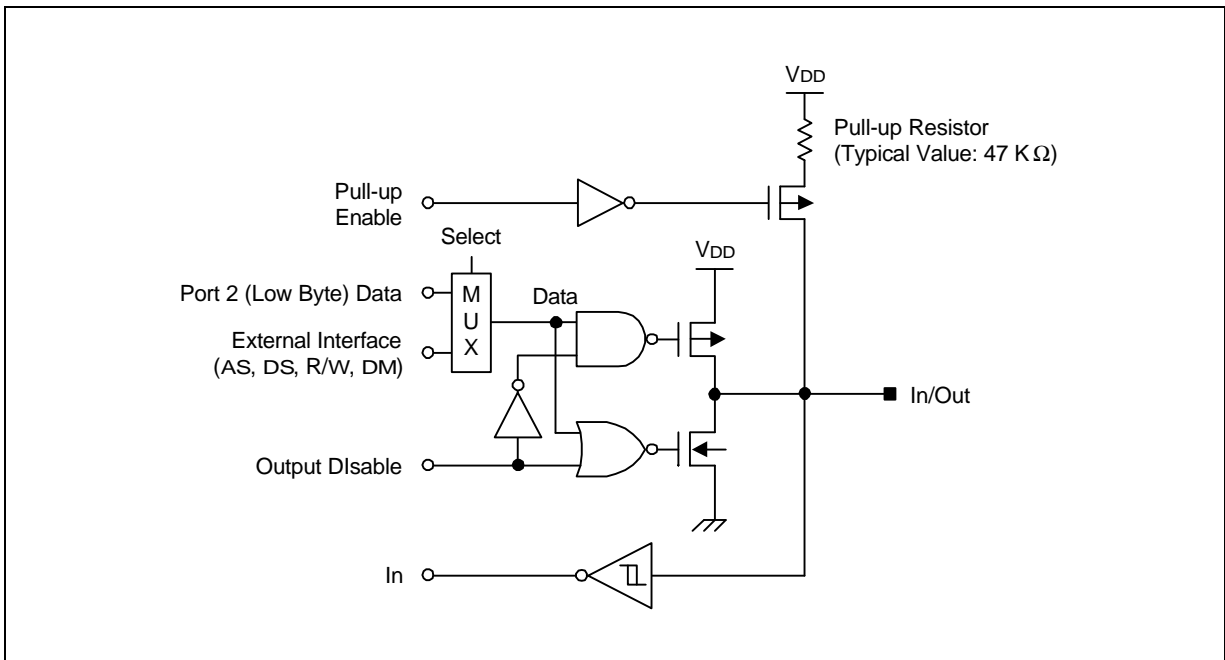


Figure 1-5. Pin Circuit Type 2 (Port 2, P2.0-P2.3 only)

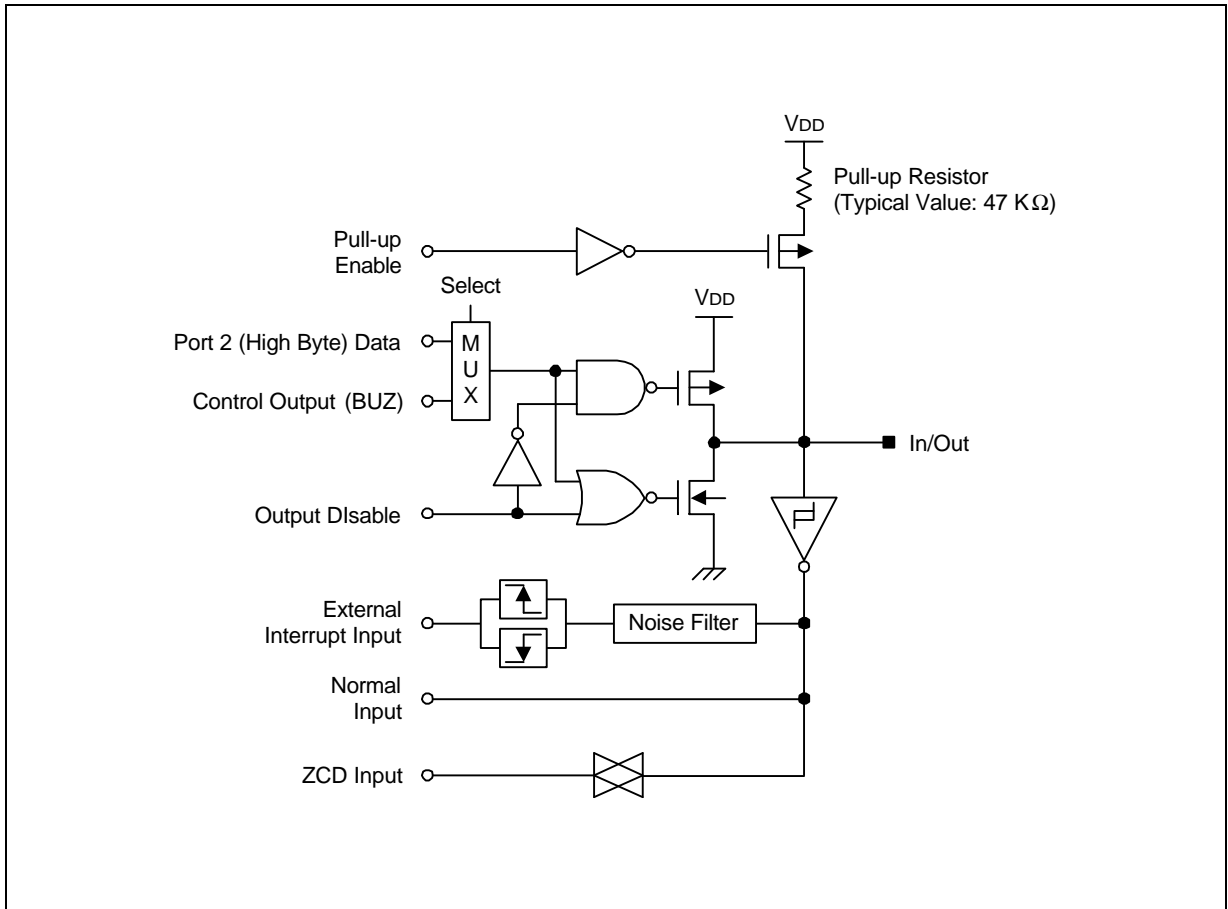


Figure 1-6. Pin Circuit Type 3 (Port 2, P2.4-P2.7 only)

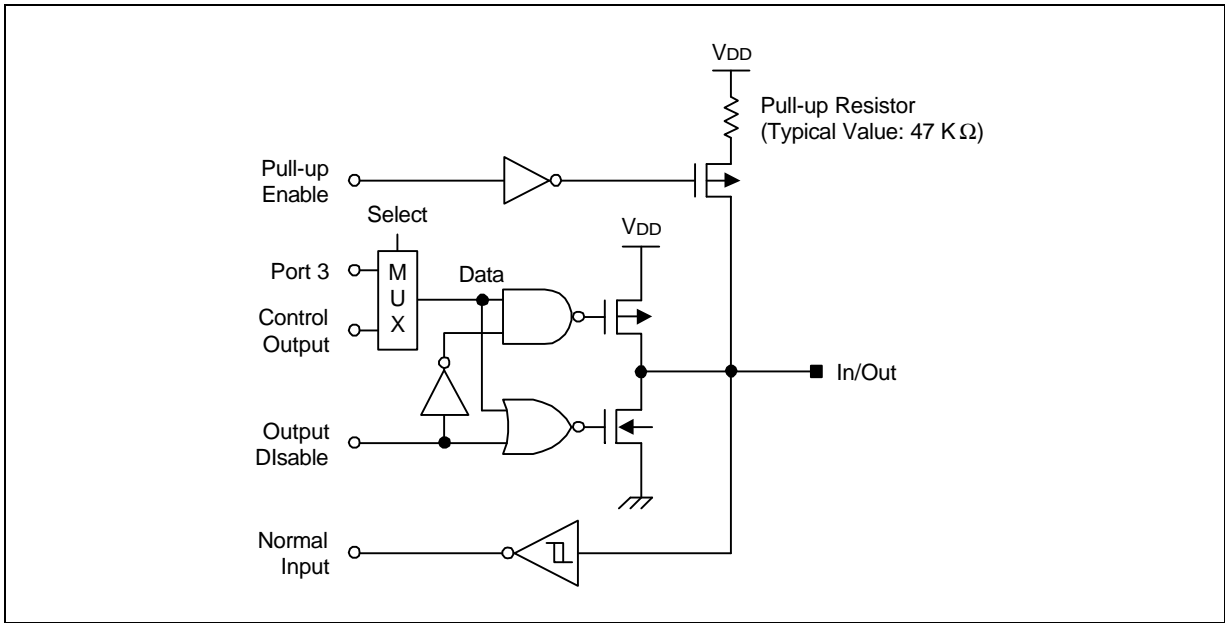


Figure 1-7. Pin Circuit Type 4 (Port 3)

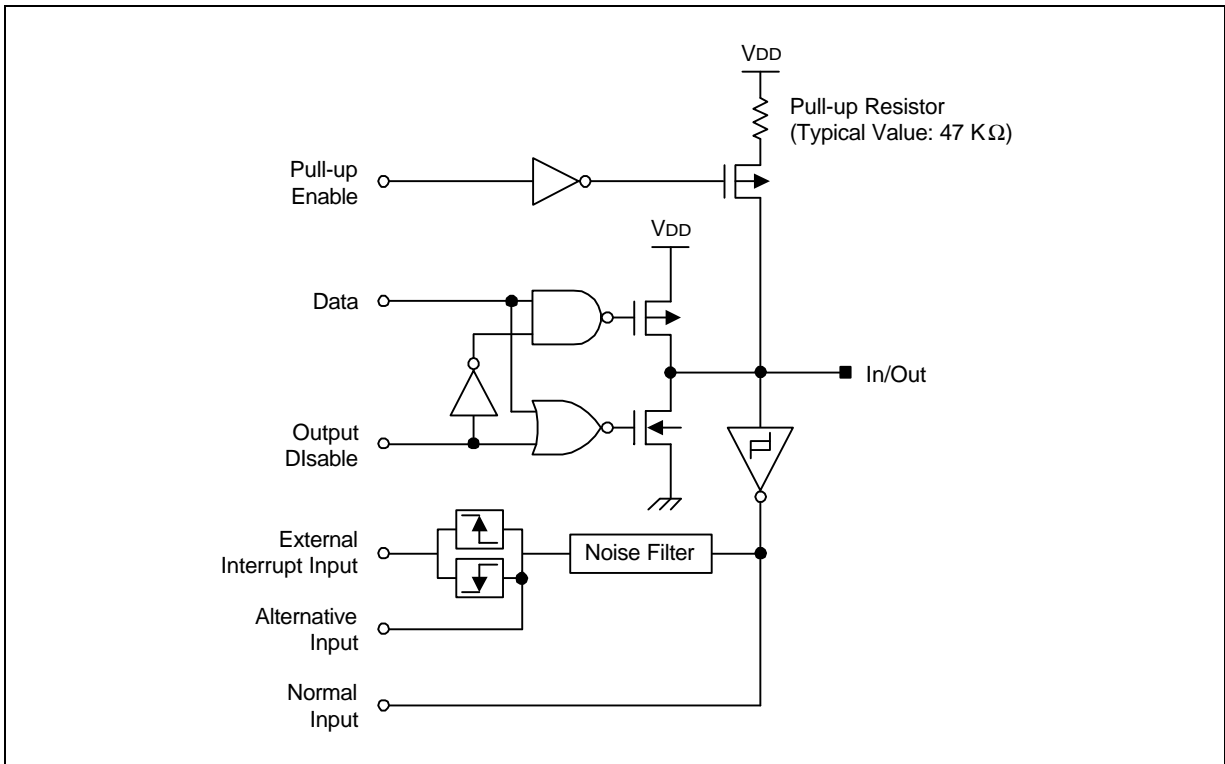


Figure 1-8. Pin Circuit Type 5 (Port 4)

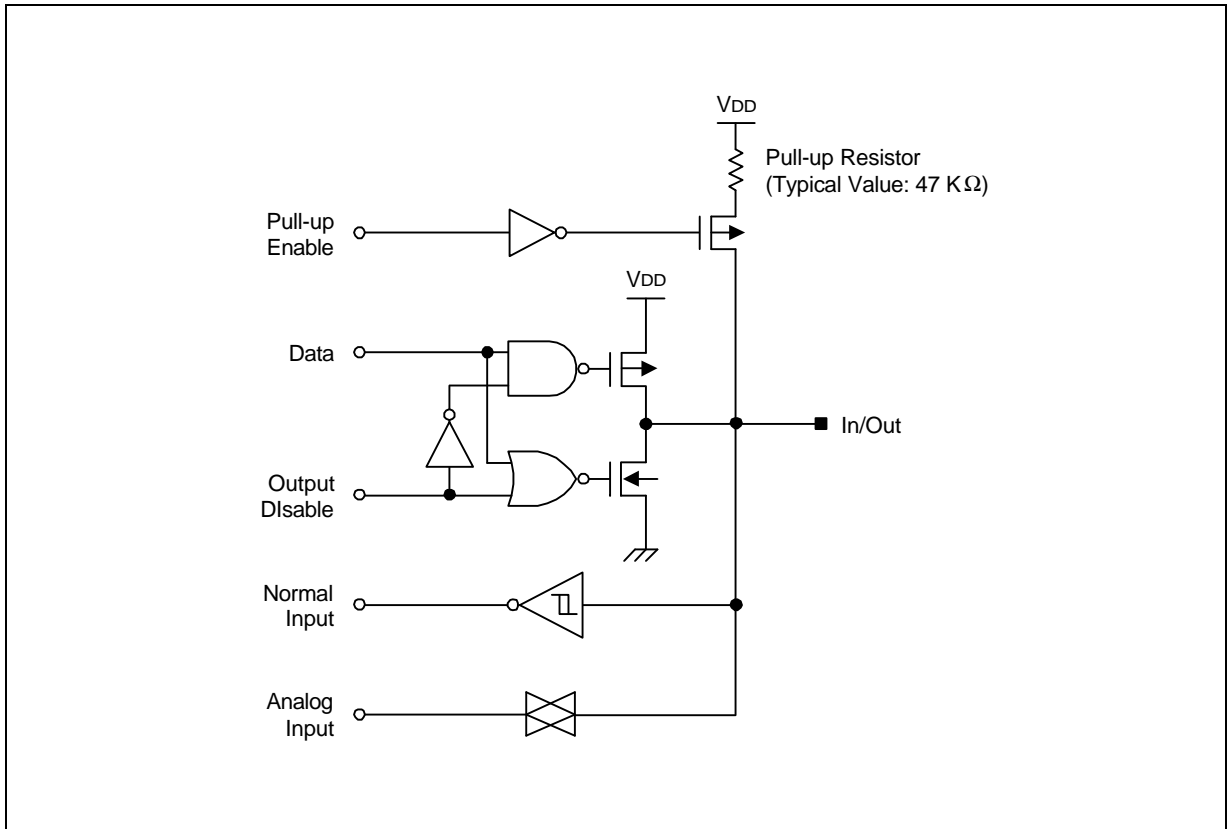


Figure 1-9. Pin Circuit Type 6 (Port 5)

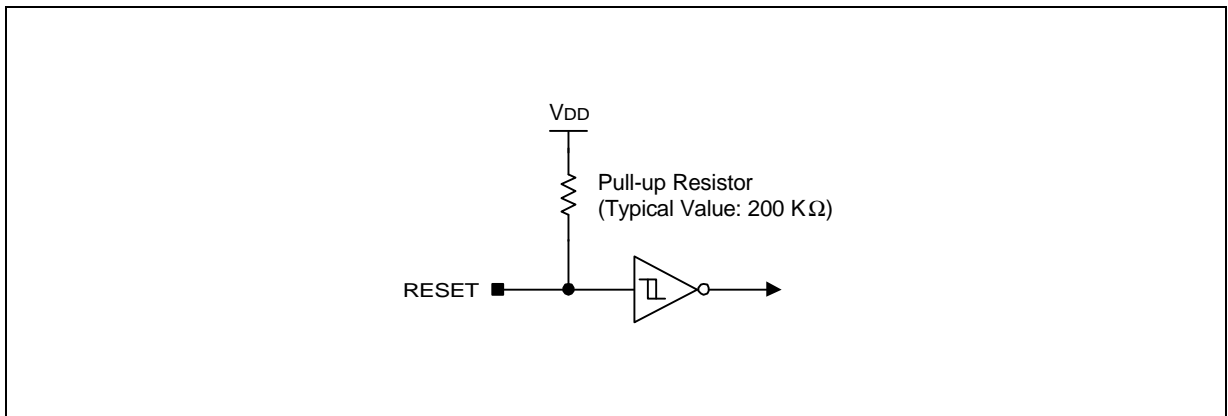


Figure 1-10. Pin Circuit Type 7 (RESET)

NOTES

# 19

## ELECTRICAL DATA

### OVERVIEW

In this chapter, KS88C4616/C4632 electrical characteristics are presented in tables and graphs. The information is arranged in the following order:

- Absolute maximum ratings
- Input/output capacitance
- D.C. electrical characteristics
- A.C. electrical characteristics
- Oscillation characteristics
- Oscillation stabilization time
- Data retention supply voltage in stop mode
- Serial I/O timing characteristics
- UART timing characteristics in mode 0
- A/D converter electrical characteristics
- Zero crossing detector
- External memory timing characteristics

**Table 19-1. Absolute Maximum Ratings** $(T_A = 25^\circ\text{C})$ 

Parameter	Symbol	Conditions	Rating	Unit
Supply Voltage	$V_{DD}$	–	– 0.3 to + 6.5	V
Input Voltage	$V_I$	All input ports	– 0.3 to $V_{DD} + 0.3$	V
Output Voltage	$V_O$	All output ports	– 0.3 to $V_{DD} + 0.3$	V
Output Current High	$I_{OH}$	One I/O pin active	– 18	mA
		All I/O pins active	– 60	
Output Current Low	$I_{OL}$	One I/O pin active	+ 30	mA
		Total pin current for ports 0, 2–4, and 6	+ 100	
		Total pin current for ports 1 and 5	+ 200	
Operating Temperature	$T_A$	–	– 40 to + 85	$^\circ\text{C}$
Storage Temperature	$T_{STG}$	–	– 65 to + 150	$^\circ\text{C}$

**Table 19-2. Input/Output Capacitance** $(T_A = -40^\circ\text{C} \text{ to } 85^\circ\text{C}, V_{DD} = 0 \text{ V})$ 

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Capacitance	$C_{IN}$	f = 1 MHz; unmeasured pins are tied to $V_{SS}$	–	–	10	pF
Output Capacitance	$C_{OUT}$					
I/O Capacitance	$C_{IO}$					



Table 19-3. D.C. Electrical Characteristics

(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input High Voltage	V <sub>IH1</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V All Port and RESET	0.8 V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IH2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V X <sub>IN</sub> and X <sub>OUT</sub>	V <sub>DD</sub> - 1.0			
Input Low Voltage	V <sub>IL1</sub>	V <sub>DD</sub> = 2.7 V to 5.5 V All Ports and RESET	-	-	0.2 V <sub>DD</sub>	V
	V <sub>IL2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V X <sub>IN</sub> and X <sub>OUT</sub>			0.1	
Output High Voltage	V <sub>OH</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V I <sub>OH</sub> = -1 mA All Ports	V <sub>DD</sub> - 1.0	-	-	V
Output Low Voltage	V <sub>OL1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V I <sub>OL</sub> = 15 mA Ports 1, 5, and 6	-	0.4	2.0	V
	V <sub>OL2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V I <sub>OL</sub> = 4 mA Ports 0, 2, 3, and 4				
Input High Leakage Current	I <sub>LIH1</sub>	V <sub>IN</sub> = V <sub>DD</sub> All input pins except I <sub>LIH2</sub>	-	-	1	μA
	I <sub>LIH2</sub>	V <sub>IN</sub> = V <sub>DD</sub> X <sub>IN</sub> , X <sub>OUT</sub>			20	
Input Low Leakage Current	I <sub>LIL1</sub>	V <sub>IN</sub> = 0 V All input pins except and I <sub>LIL2</sub> and RESET	-	-	-1	μA
	I <sub>LIL2</sub>	V <sub>IN</sub> = 0 V X <sub>IN</sub> , X <sub>OUT</sub>			-20	
Output High Leakage Current	I <sub>LOH1</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins	-	-	2	μA
Output Low Leakage Current	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V All output pins	-	-	-2	μA

**Table 19-3. D.C. Electrical Characteristics (Continued)**(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Pull-up Resistor	R <sub>P1</sub>	V <sub>DD</sub> = 5 V; V <sub>IN</sub> = 0 V	30	47	70	kΩ
		V <sub>DD</sub> = 3 V; Ports 0–6	30	–	350	
	R <sub>P2</sub>	V <sub>DD</sub> = 5 V; V <sub>IN</sub> = 0 V	100	200	400	
		V <sub>DD</sub> = 3 V; RESET only	200	400	800	
Supply Current (note)	I <sub>DD1</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V RUN mode 12 MHz CPU clock	–	16	30	mA
		V <sub>DD</sub> = 2.7 V to 3.3 V 8 MHz CPU clock		5.5	12	
	I <sub>DD2</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V Idle mode 12 MHz CPU clock		3	6	
		V <sub>DD</sub> = 2.7 V to 3.3 V 8 MHz CPU clock		1	2.5	
	I <sub>DD3</sub>	V <sub>DD</sub> = 4.5 V to 5.5 V Stop mode		1	5	μA
		V <sub>DD</sub> = 2.7 V to 3.3 V Stop mode				

**NOTE:** Supply current does not include current drawn through internal pull-up resistors, ZCD, ADC and external output current loads.

**Table 19-4. A.C. Electrical Characteristics**(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Interrupt Input High, Low Width	t <sub>INTL</sub> , t <sub>INTH</sub>	Ports 2, 3, and 4	–	270	–	ns
RESET Input Low Width	t <sub>RSL</sub>	Input	–	1500	–	ns

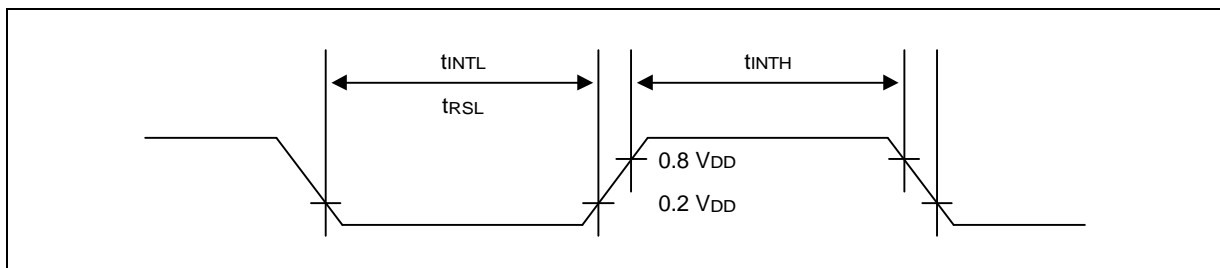
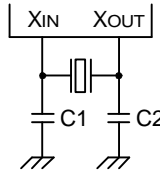
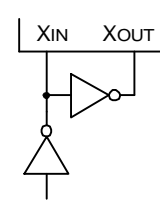
**Figure 19-1. Input Timing Measurement Points**

Table 19-5. Oscillation Characteristics

(T<sub>A</sub> = -40°C + 85°C)

Oscillator	Clock Circuit	Test Condition	Min	Typ	Max	Unit
Main Crystal or Ceramic		V <sub>DD</sub> = 4.5 V to 5.5 V	1	-	12	MHz
		V <sub>DD</sub> = 2.7 V to 4.5 V	1	-	8	
External Clock (Main System)		V <sub>DD</sub> = 4.5 V to 5.5 V	1	-	12	MHz
		V <sub>DD</sub> = 2.7 V to 4.5 V	1	-	8	

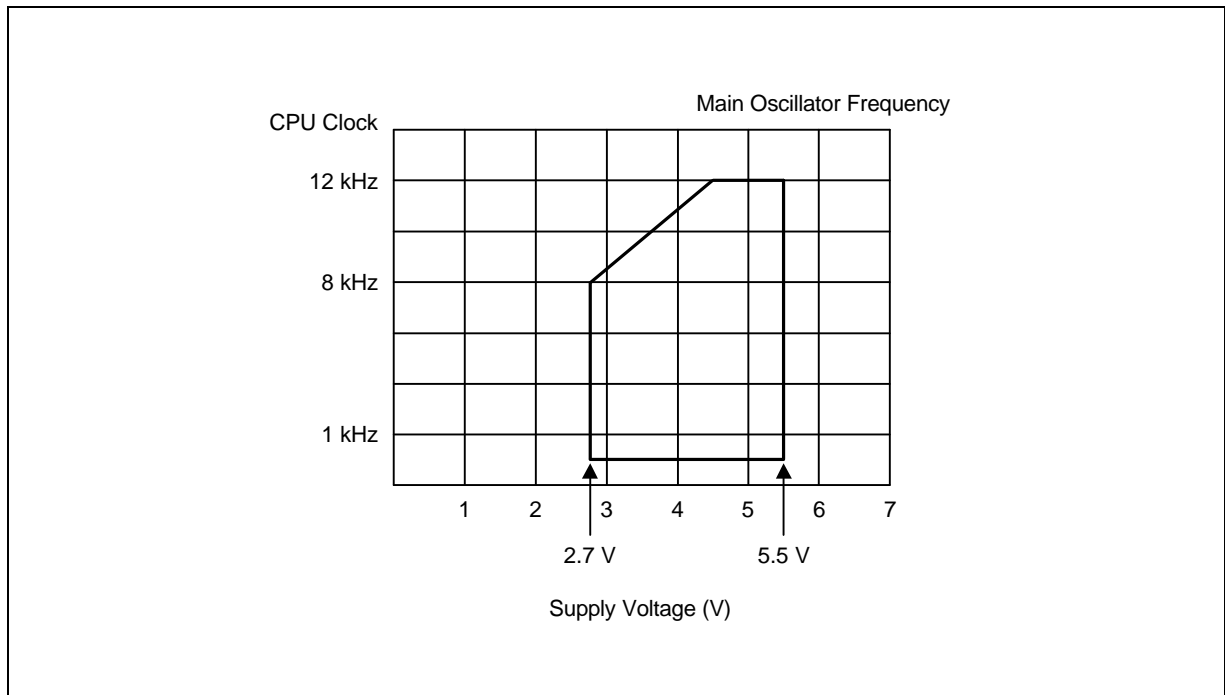


Figure 19-2. Operating Voltage Range

Table 19-6. Oscillation Stabilization Time

(T<sub>A</sub> = -40°C + 85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Oscillator	Test Condition	Min	Typ	Max	Unit
Main Crystal	f <sub>OSC</sub> > 400 kHz;	–	–	20	ms
Main Ceramic	Oscillation stabilization occurs when V <sub>DD</sub> is equal to the minimum oscillator voltage range.	–	–	10	ms
External Clock (Main System)	X <sub>IN</sub> input High and Low width (t <sub>XH</sub> , t <sub>XL</sub> )	25	–	500	ns
Oscillator Stabilization Wait Time	t <sub>WAIT</sub> when released by a reset <sup>(1)</sup>	–	2 <sup>16</sup> /f <sub>OSC</sub>	–	ms
	t <sub>WAIT</sub> when released by an interrupt <sup>(2)</sup>	–	–	–	ms

**NOTES:**

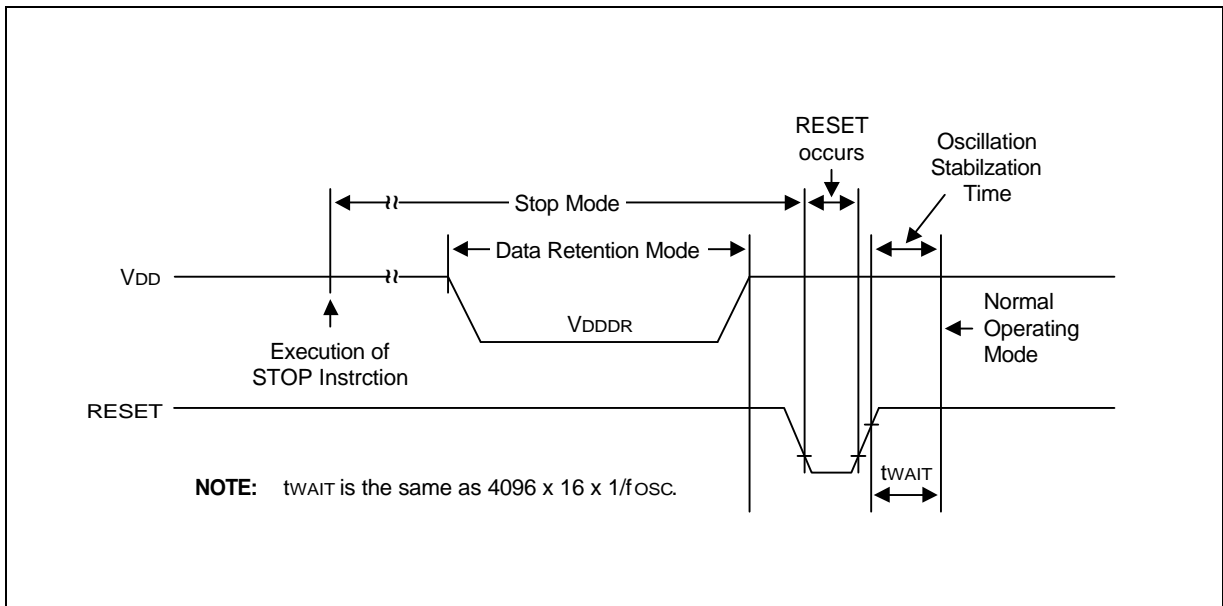
1. f<sub>OSC</sub> is the oscillator frequency.
2. The duration of the oscillator stabilization wait time, t<sub>WAIT</sub>, when it is released by an interrupt is determined by the settings in the basic timer control register, BTCON.

**Table 19-7. Data Retention Supply Voltage in Stop Mode**

( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$ )

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data Retention Supply Voltage	$V_{DDDR}$	Stop mode	2	–	5.5	V
Data Retention Supply Current	$I_{DDDR}$	Stop mode, $V_{DDDR} = 2.0\text{ V}$	–	–	5	$\mu\text{A}$

**NOTE:** Supply current does not include current drawn through internal pull-up resistors or external output current loads.



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

Table 19-8. Serial I/O Timing Characteristics

(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
SCK Cycle Time	t <sub>CKY</sub>	External SCK source	1000	-	-	ns
		Internal SCK source	1000			
SCK High, Low Width	t <sub>KH</sub> , t <sub>KL</sub>	External SCK source	500	-	-	
		Internal SCK source	t <sub>CKY</sub> /2 - 50			
SI Setup Time to SCK Low	t <sub>SIK</sub>	External SCK source	250	-	-	
		Internal SCK source	250			
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>	External SCK source	-	-	300	
		Internal SCK source	-		250	

**NOTE:** "SCK" means serial I/O clock frequency, "SI" means serial data input, and "SO" means serial data output.

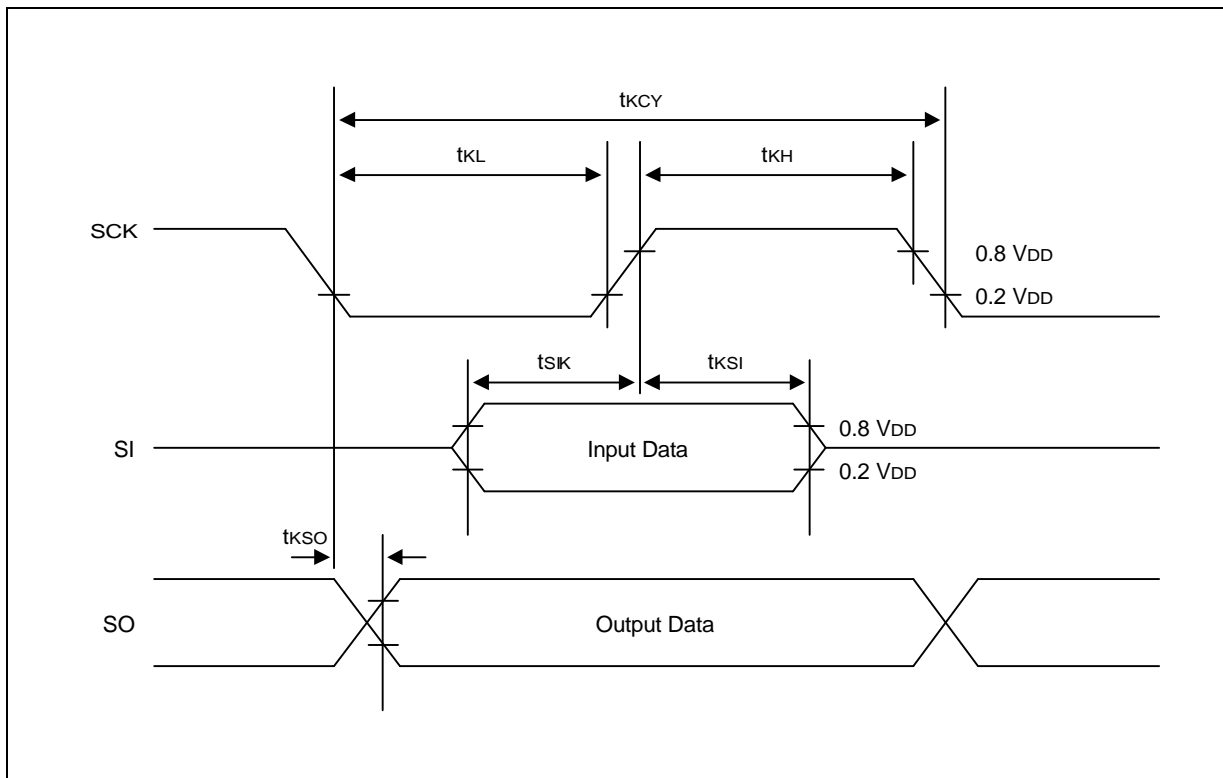


Figure 19-4. Serial Data Transfer Timing

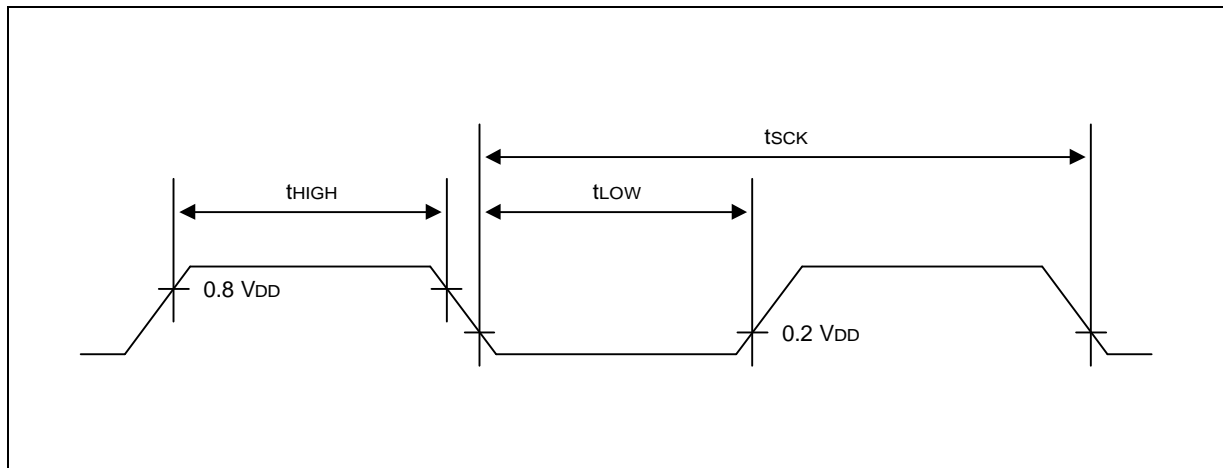
**Table 19-9. UART Timing Characteristics in Mode 0 (10 MHz)**

( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{DD} = 2.7\text{ V}$  to  $5.5\text{ V}$ , Load capacitance =  $80\text{ pF}$ )

Parameter	Symbol	Min	Typ	Max	Unit
Serial port clock cycle time	$t_{SCK}$	500	$t_{CPU} \times 6$	700	ns
Output data setup to clock rising edge	$t_{S1}$	300	$t_{CPU} \times 5$	–	
Clock rising edge to input data valid	$t_{S2}$	–	–	300	
Output data hold after clock rising edge	$t_{H1}$	$t_{CPU} - 50$	$t_{CPU}$	–	
Input data hold after clock rising edge	$t_{H2}$	0	–	–	
Serial port clock High, Low level width	$t_{HIGH}, t_{LOW}$	200	$t_{CPU} \times 3$	400	

**NOTES:**

1. All timings are in nanoseconds (ns) and assume a 10-MHz CPU clock frequency.
2. The unit  $t_{CPU}$  means one CPU clock period.



**Figure 19-5. Waveform for UART Timing Characteristics**

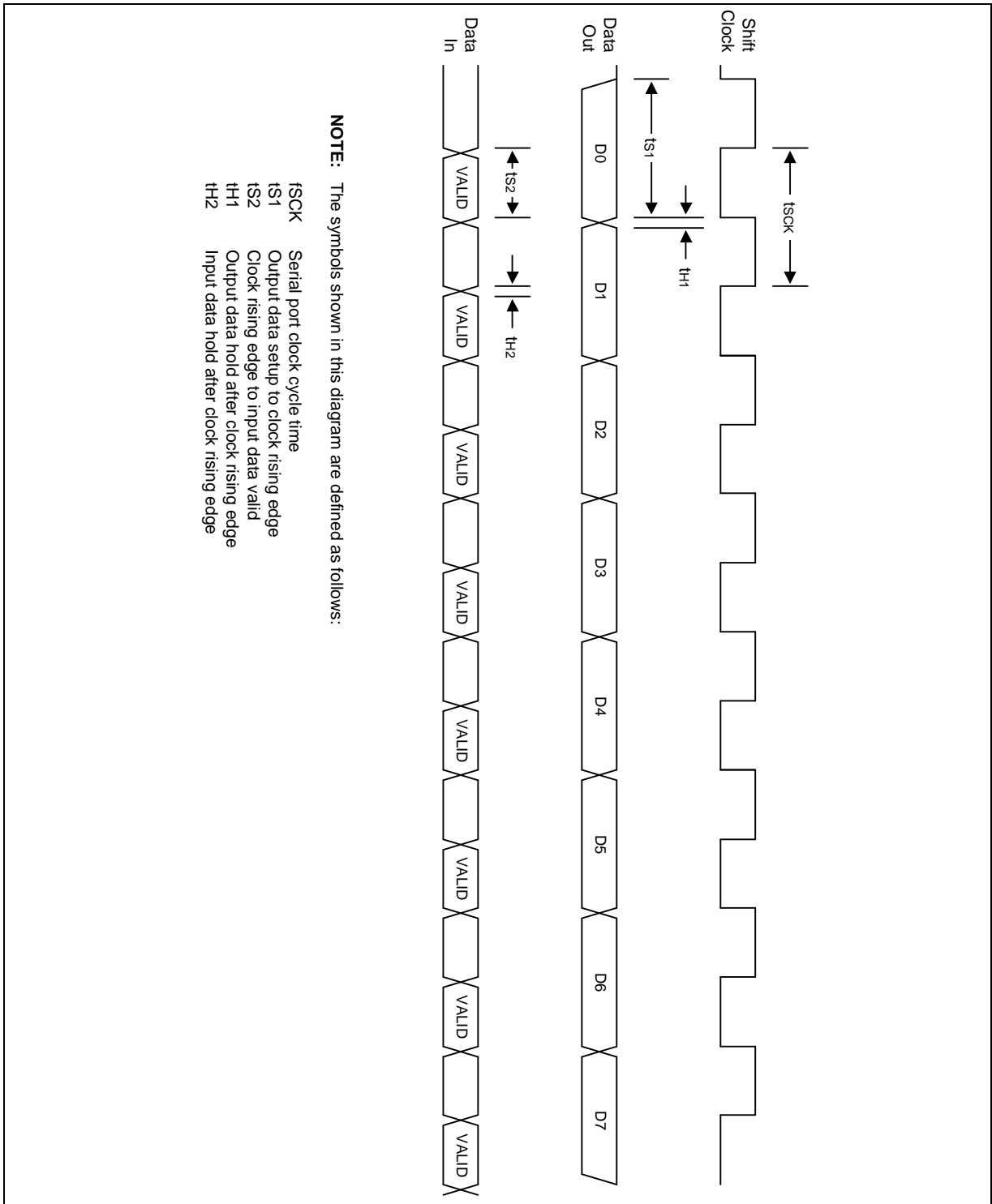


Figure 19-6. A.C. Timing Waveform for the UART Module



Table 19-10. A/D Converter Electrical Characteristics

(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Resolution			-	10	-	bit
Total accuracy		V <sub>DD</sub> = 5.12 V	-	-	± 3	LSB
Integral linearity error	ILE	CPU clock = 10 MHz AV <sub>REF</sub> = 5.12 V		-	± 2	
Differential linearity error	DLE	AV <sub>SS</sub> = 0 V		-	± 1	
Offset error of top	EOT			± 1	± 3	
Offset error of bottom	EOB			± 0.5	± 2	
Conversion time (1)	t <sub>CON</sub>	10-bit conversion 50 × 4/f <sub>OSC</sub> (3), f <sub>OSC</sub> = 10 MHz	20	-	-	μs
Analog input voltage	V <sub>IAN</sub>	-	AV <sub>SS</sub>	-	AV <sub>REF</sub>	V
Analog input impedance	R <sub>AN</sub>	-	2	-	-	MΩ
Analog reference voltage	AV <sub>REF</sub>	-	2.5	-	V <sub>DD</sub>	V
Analog ground	AV <sub>SS</sub>	-	V <sub>SS</sub>	-	V <sub>SS</sub> + 0.3	V
Analog input current	I <sub>ADIN</sub>	AV <sub>REF</sub> = V <sub>DD</sub> = 5 V conversion time = 20 μs	-	-	10	μA
Analog block current (2)	I <sub>ADC</sub>	AV <sub>REF</sub> = V <sub>DD</sub> = 5 V conversion time = 20 μs		1	3	mA
		AV <sub>REF</sub> = V <sub>DD</sub> = 3 V conversion time = 20 μs		0.5	1.5	mA
		AV <sub>REF</sub> = V <sub>DD</sub> = 5 V when power down mode		100	500	nA

**NOTES:**

- "Conversion time" is the time required from the moment a conversion operation starts until it ends.
- I<sub>ADC</sub> is operating current during A/D conversion.
- f<sub>OSC</sub> is the main oscillator clock.

Table 19-11. Zero Crossing Detector

(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Zero-crossing detection input voltage	V <sub>ZC</sub>	AC connection c = 0.1 μF	1.0	–	3.0	Vp-p
Zero-crossing detection accuracy	V <sub>AZC</sub>	f <sub>ZC</sub> = 60 Hz (sine wave) V <sub>DD</sub> = 5 V f <sub>OSC</sub> = 10 MHz	–	–	± 150	mV
Zero-crossing detection input frequency	f <sub>ZC</sub>	–	40	–	200	Hz

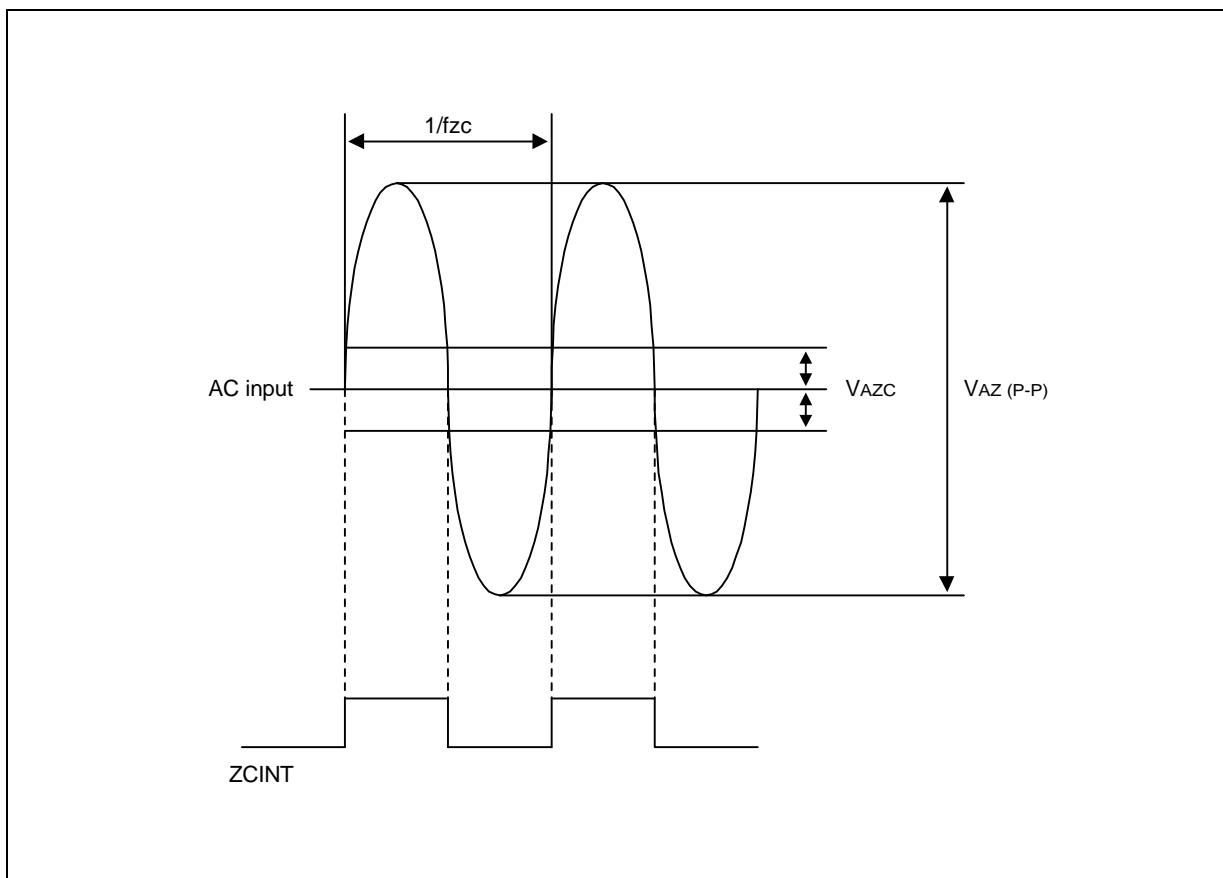


Figure 19-7. Zero Crossing Waveform Diagram

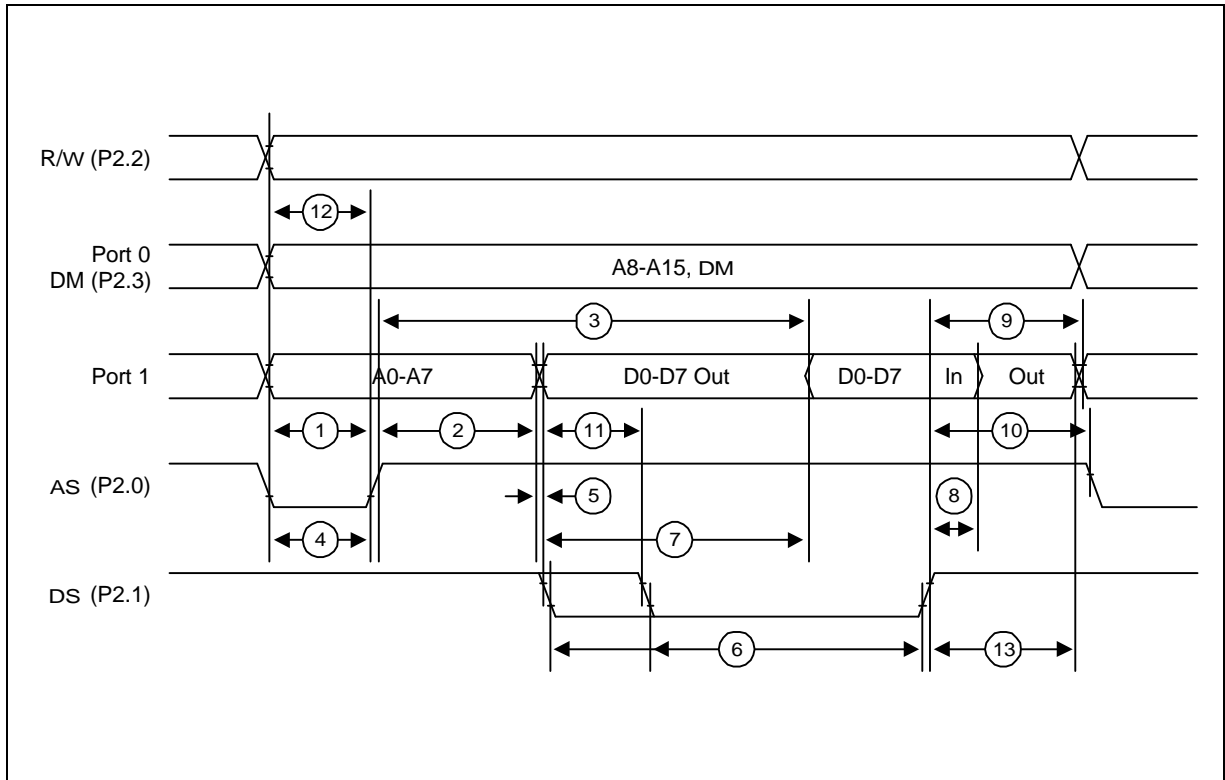
Table 19-12. External Memory Timing Characteristics (8 MHz)

(T<sub>A</sub> = -40°C to +85°C, V<sub>DD</sub> = 2.7 V to 5.5 V)

Number	Symbol	Parameter	Normal Timing (ns)	
			Min	Max
1	t <sub>dA</sub> (AS)	Address valid to AS ↑ delay	10	–
2	t <sub>dAS</sub> (A)	AS ↑ to address float delay	35	–
3	t <sub>dAS</sub> (DR)	AS ↑ to read data required valid	–	140
4	t <sub>wAS</sub>	AS Low width	43.75 (35)	–
5	t <sub>dA</sub> (DS)	Address float to DS ↓	0	–
6a	t <sub>wDS</sub> (read)	DS (read) Low width	156.25 (125)	–
6b	t <sub>wDS</sub> (write)	DS (write) Low width	81.25 (65)	–
7	t <sub>dDS</sub> (DR)	DS ↓ to read data required valid	–	80
8	t <sub>hDS</sub> (DR)	Read data to DS ↑ hold time	0	–
9	t <sub>dDS</sub> (A)	DS ↑ to address active delay	20	–
10	t <sub>dDS</sub> (AS)	DS ↑ to AS ↓ delay	30	–
11	t <sub>dDO</sub> (DS)	Write data valid to DS (write) ↓ delay	10	–
12	t <sub>dRW</sub> (AS)	R/W valid to AS ↑ delay	20	–
13	t <sub>dDS</sub> (DW)	DS ↑ to write data not valid delay	20	–

**NOTES:**

1. All times are in nanoseconds (ns) and assume an 8-MHz input frequency.
2. Wait states add 100 ns to the time of numbers 3, 6a, 6b, and 7.
3. The values for t<sub>wAS</sub> and t<sub>wDS</sub> that are shown in parentheses "( )" assume a 10-MHz input clock.



**Figure 19-8. External Memory Read and Write Timing**

(See Table 19-10 for a description of each timing point.)

# 20 MECHANICAL DATA

## OVERVIEW

The KS88C4616/C4632/P4632 microcontrollers are available in a 64-SDIP-750, 64-QFP-1420F package.

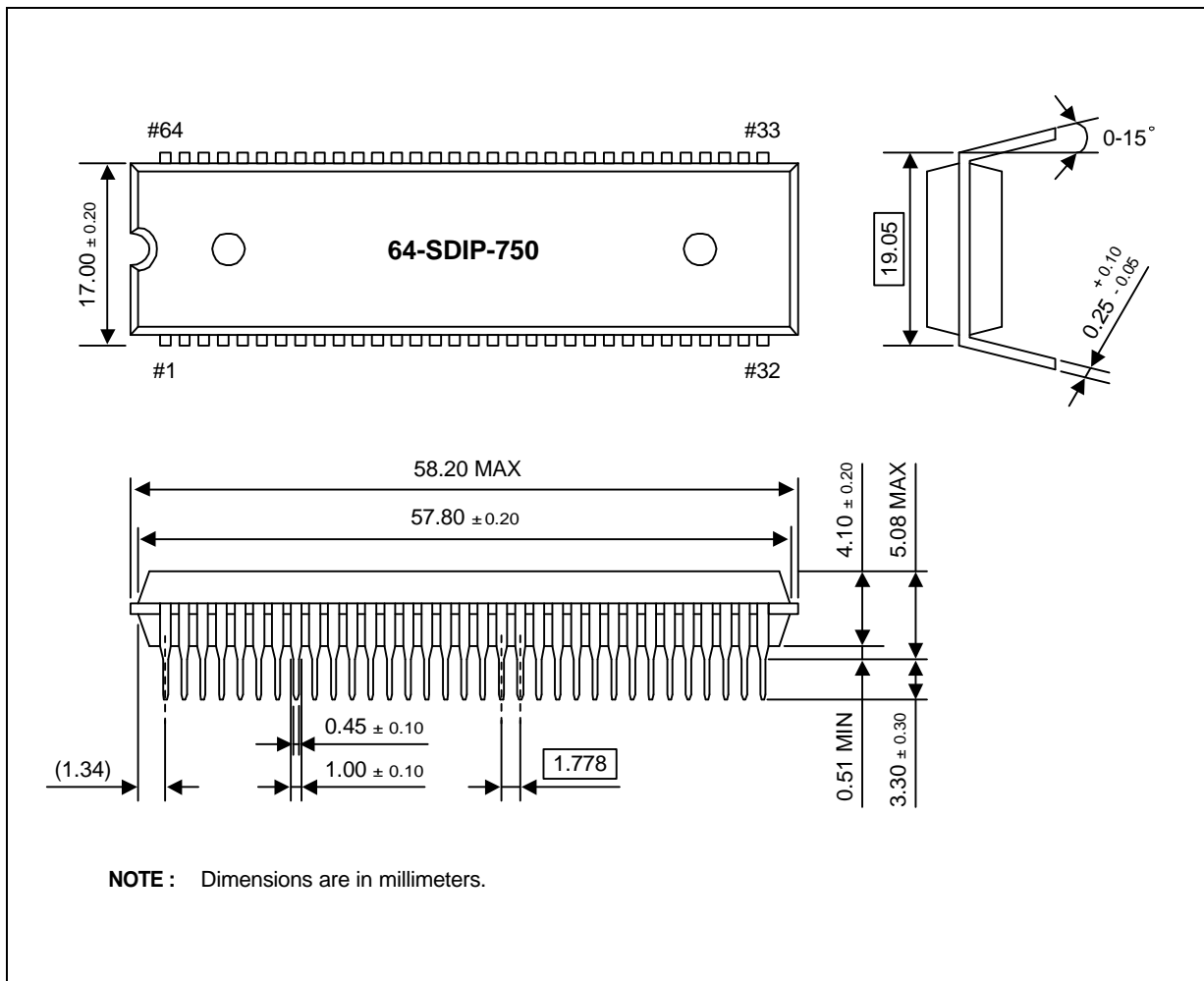


Figure 20-1. 64-SDIP-750 Package Dimensions

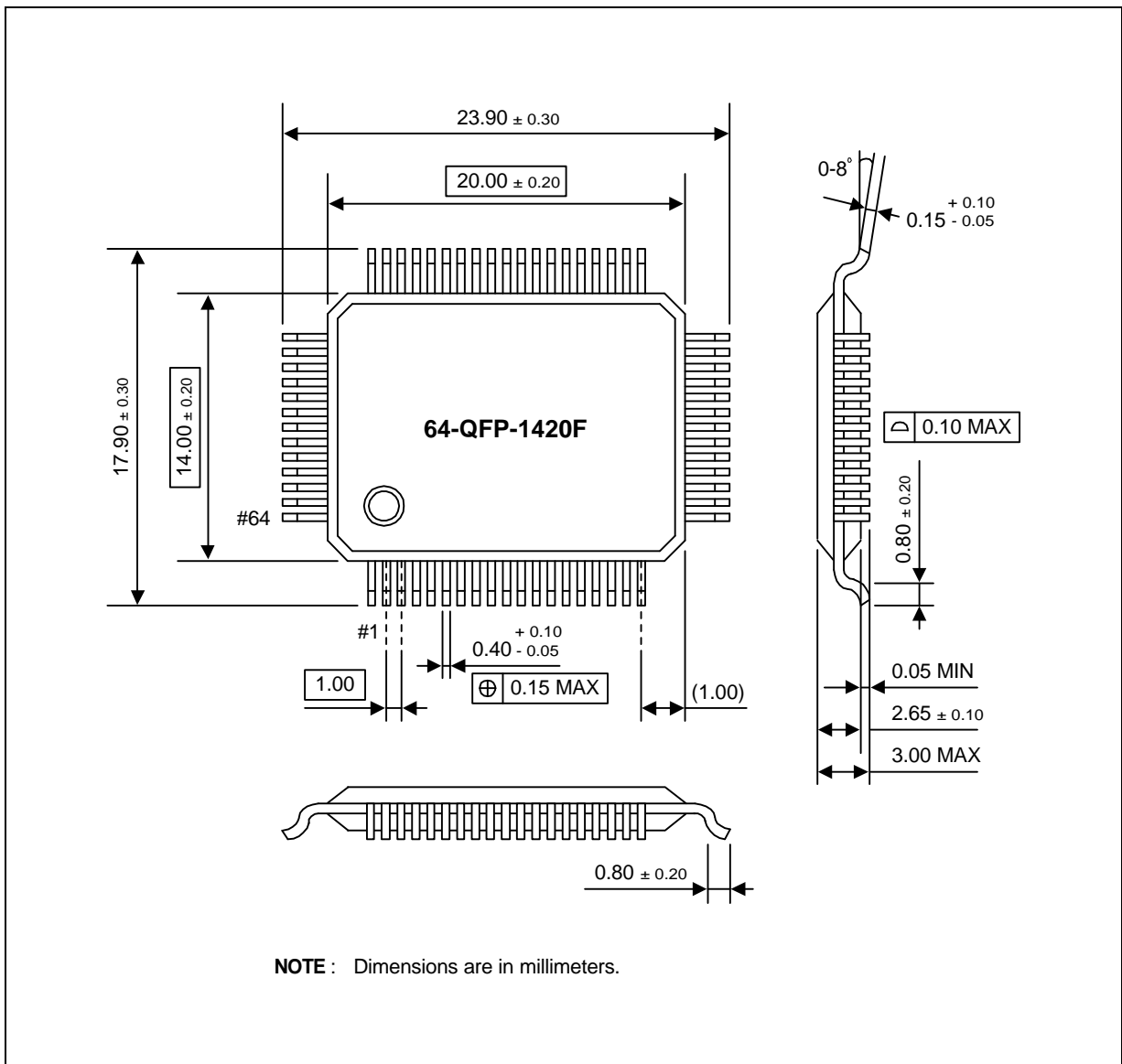


Figure 20-2. 64-QFP-1420F Package Dimensions

# 21

## KS88P4632 OTP

### OVERVIEW

The KS88P4632 single-chip CMOS microcontroller is the OTP (One Time Programmable) version of the KS88C4616/C4632 microcontroller. It has an on-chip OTP ROM instead of a masked ROM. The EPROM is accessed by serial data format.

The KS88P4632 is fully compatible with the KS88C4616/C4632, both in function in D.C. electrical characteristics and in pin configuration. Because of its simple programming requirements, the KS88P4632 is ideal as an evaluation chip for the KS88C4616/C4632.

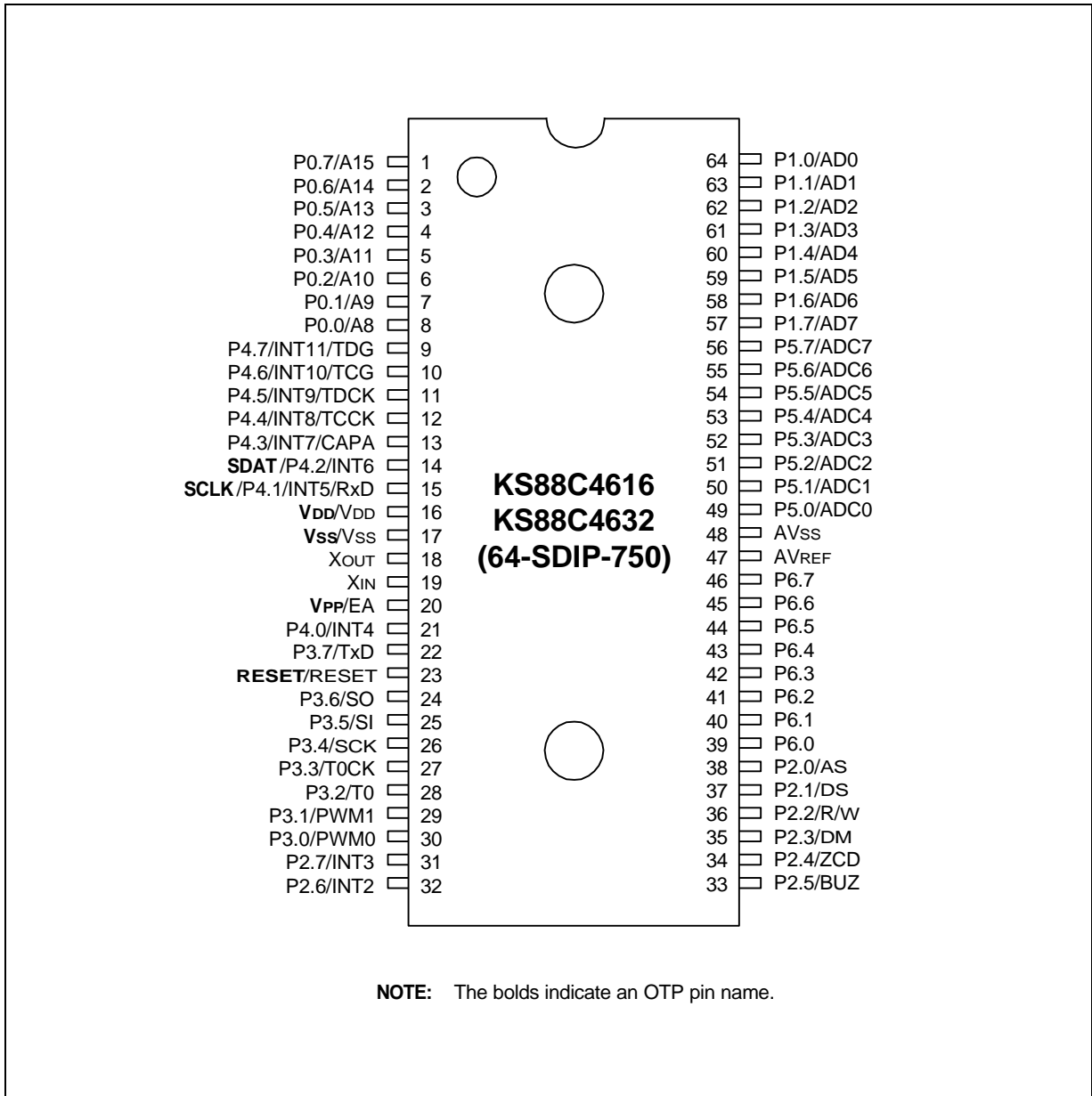


Figure 21-1. KS88P4632 Pin Assignments (64-SDIP Package)



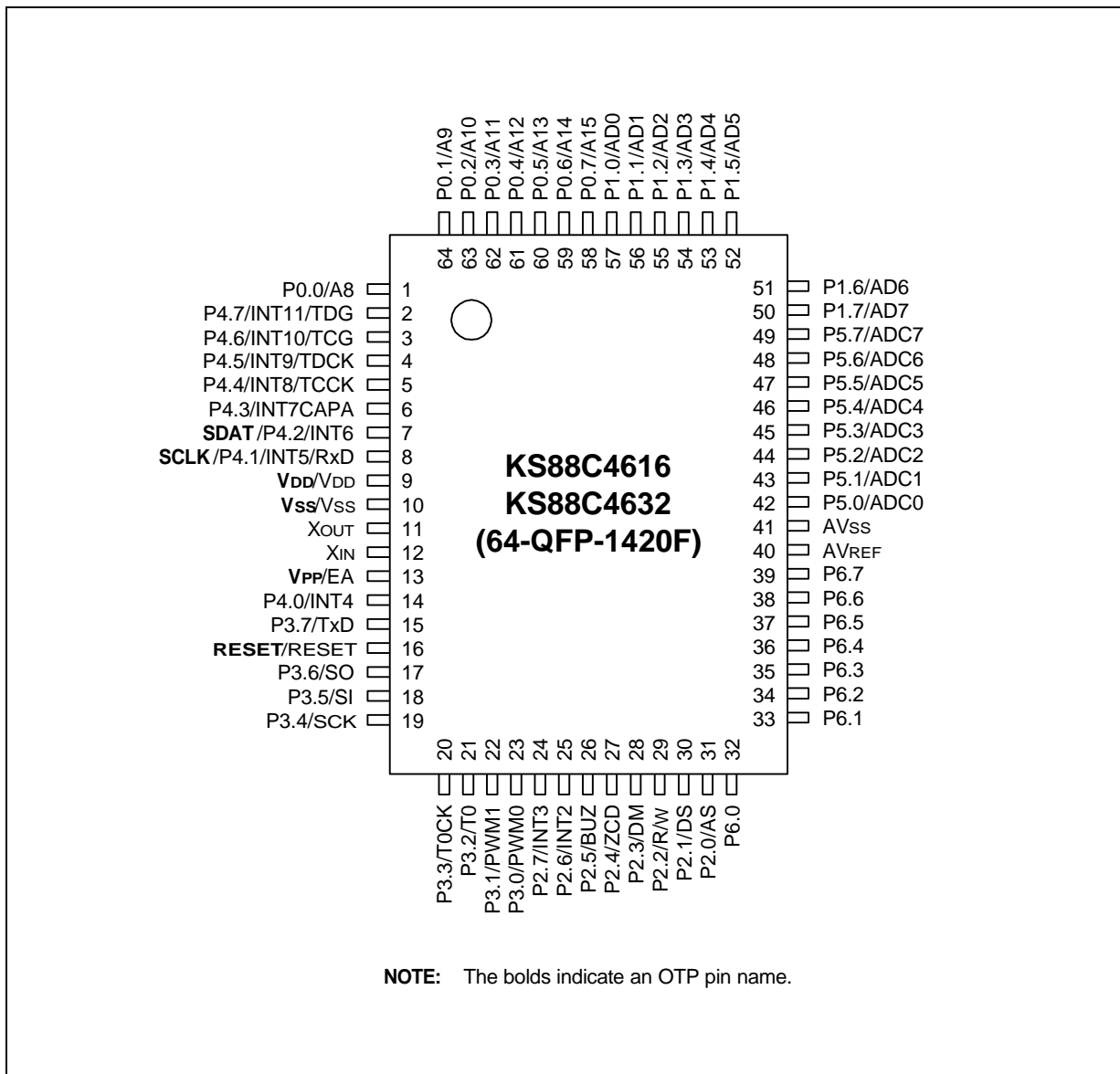


Figure 21-2. KS88P4632 Pin Assignments (64-QFP Package)

Table 21-1. Descriptions of Pins Used to Read/Write the EPROM

Main Chip Pin Name	During Programming			
	Pin Name	Pin No.	I/O	Function
P4.2	SDAT	14(7)	I/O	Serial data pin. Output port when reading and input port when writing. Can be assigned as a Input/push-pull output port.
P4.1	SCLK	15(8)	I	Serial clock pin. Input only pin.
EA	V <sub>PP</sub>	20(13)	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. (Option)
RESET	RESET	23(16)	I	Chip Initialization
V <sub>DD</sub> /V <sub>SS</sub>	V <sub>DD</sub> /V <sub>SS</sub>	16(9)/17(10)	–	Logic power supply pin. V <sub>DD</sub> should be tied to +5 V during programming.

NOTE: ( ) means 64 QFP package.

Table 21-2. Comparison of KS88P4632 and KS88C4616/C4632 Features

Characteristic	KS88P4632	KS88C4616/C4632
Program Memory	32-Kbyte EPROM	16/32-Kbyte mask ROM
Operating Voltage (V <sub>DD</sub> )	2.7 V to 5.5 V	2.7 V to 5.5 V
OTP Programming Mode	V <sub>DD</sub> = 5 V, V <sub>PP</sub> (EA) = 12.5 V	
Pin Configuration	64 SDIP/64 QFP	64 SDIP/64 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> (EA) pin of the KS88P4632, 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 21-3 below.

Table 21-3. Operating Mode Selection Criteria

V <sub>DD</sub>	V <sub>PP</sub> (EA)	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.