

# 1 PRODUCT OVERVIEW

## SAM87 PRODUCT FAMILY

Samsung's SAM87 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. Important CPU features include:

- Efficient register-oriented architecture
- Selectable CPU clock sources
- Release by interrupt of Idle and Stop power-down modes
- Built-in basic timer circuit with watchdog function

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 specific interrupt levels.

## KS88C8316/C8324/P8324

The KS88C8316 microcontroller has 16 K bytes of on-chip program memory and the KS88C8324 has 24 K bytes. Both chips have a 272-byte general-purpose internal register file. The interrupt structure has seven interrupt sources with six interrupt vectors. The CPU recognizes six interrupt priority levels.

Using a modular design approach, the following peripherals were integrated with the SAM87 core to make the KS88C8316/C8324/P8324 suitable for use in color television and other types of screen display applications:

- Four programmable I/O ports (26 pins total: 16 general-purpose I/O pins; 8 n-channel, open-drain output pins)
- 2 channel A/D converter (4-bit resolution)
- 14-bit PWM output (one channels: push-pull type)
- Basic timer (BT) with watchdog timer function
- One 8-bit timer/counter (T0) with interval timer
- One 8-bit general-purpose timer/counter (TA) with prescalers
- On-screen display (OSD) with a wide range of programmable features including halftone control signal output

The KS88C8316/C8324 are available in a versatile 42-pin SDIP package.

## OTP

The KS88C8316/C8324 microcontroller is also available in OTP (One Time Programmable) version, KS88P8324. KS88P8324 microcontroller has an on-chip 24K-byte one-time-programmable EPROM instead of masked ROM. The KS88P8324 is comparable to KS88C8316/C8324, both in function and in pin configuration.

## FEATURES

### CPU

- SAM87 CPU core

### Memory

- 16-K byte (KS88C8316) or 24-K byte (KS88C8324) internal program memory
- 272-byte general-purpose register area

### Instruction Set

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

### Instruction Execution Time

- 750 ns (minimum) with an 8-MHz CPU clock

### Interrupts

- 7 interrupt sources with 6 vectors
- 6 interrupt levels
- Fast interrupt processing for select levels

### General I/O

- Four I/O ports (26 pins total)
- Six open-drain pins for up to 6-volt loads
- Two open-drain pins for up to 5-volt loads

### 8-Bit Basic Timer

- Three selectable internal clock frequencies
- Watchdog or oscillation stabilization function

### Timer/Counters

- One 8-bit timer/counter (T0) with three internal clocks and interval timer mode.
- One general-purpose 8-bit timer/counters with interval timer mode (timer A)

### A/D Converter

- Two analog input pins; 4-bit resolution
- 3.125  $\mu$ s conversion time (8-MHz CPU clock)

### Pulse Width Modulation Module

- 14-bit PWM with one-channel output (push-pull type)
- PWM counter and data capture input pin
- Frequency: 5.859 kHz to 23.437 kHz with a 6-MHz CPU clock

### On-Screen Display (OSD)

- Video RAM: 252  $\times$  12 bits
- Character generator ROM: 256  $\times$  18  $\times$  16 bits (256 display characters: fixed: 2, variable: 254)
- 252 display positions (12 rows  $\times$  21 columns)
- 16-dot  $\times$  18-dot character resolution
- 16 different character sizes
- Eight character colors
- Vertical direction fade-in/fade-out control
- Eight colors for character and frame background
- Halftone control signal output; selectable for individual characters
- Synchronous polarity selector for H-sync and V-sync input

### Oscillator Frequency

- 5-MHz to 8-MHz external crystal oscillator
- Maximum 8-MHz CPU clock

### Operating Temperature Range

- $-20^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$

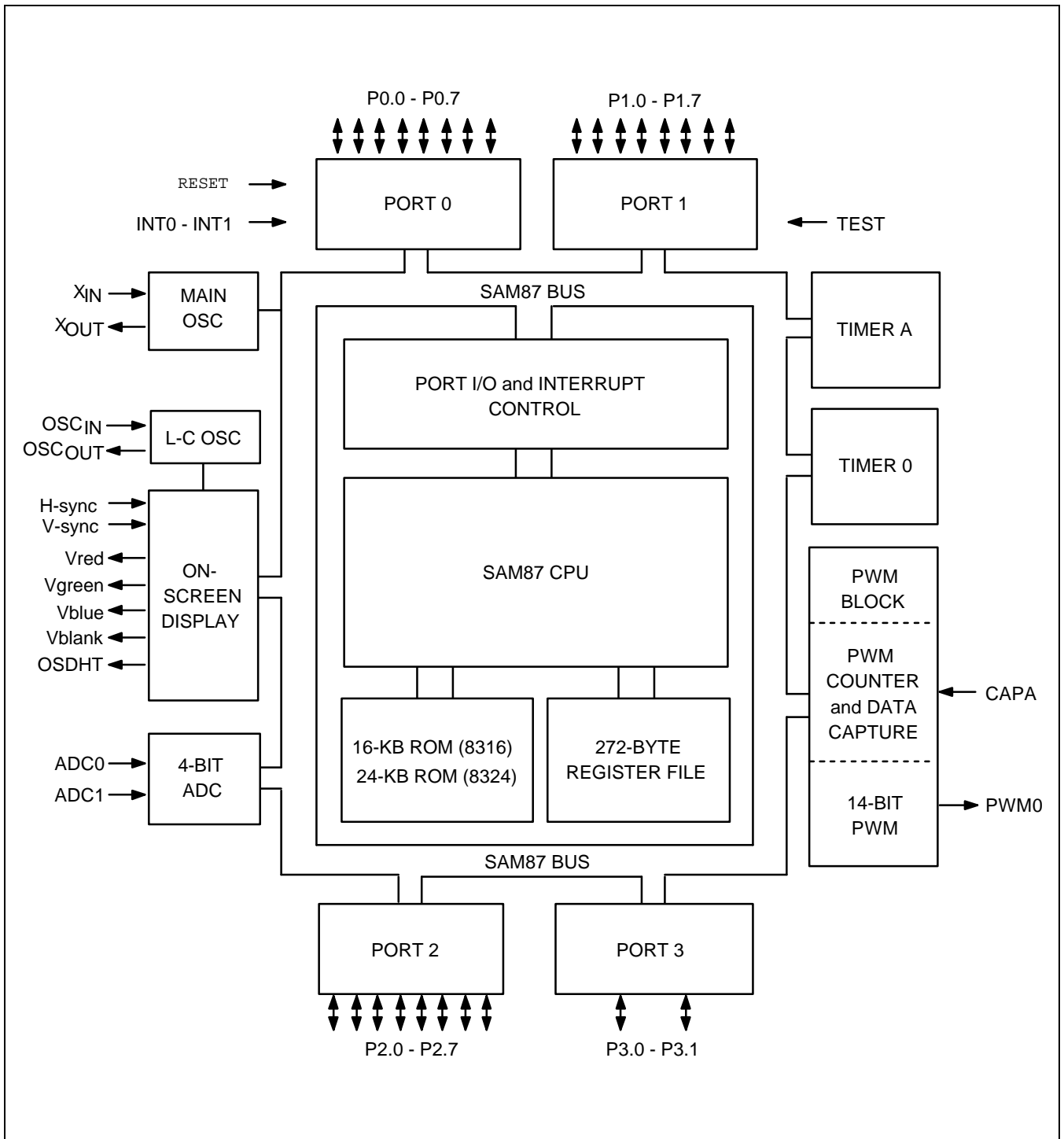
### Operating Voltage Range

- 4.5 V to 5.5 V

### Package Type

- 42-pin SDIP

**BLOCK DIAGRAM**



**Figure 1-1. Block Diagram**

PIN ASSIGNMENTS

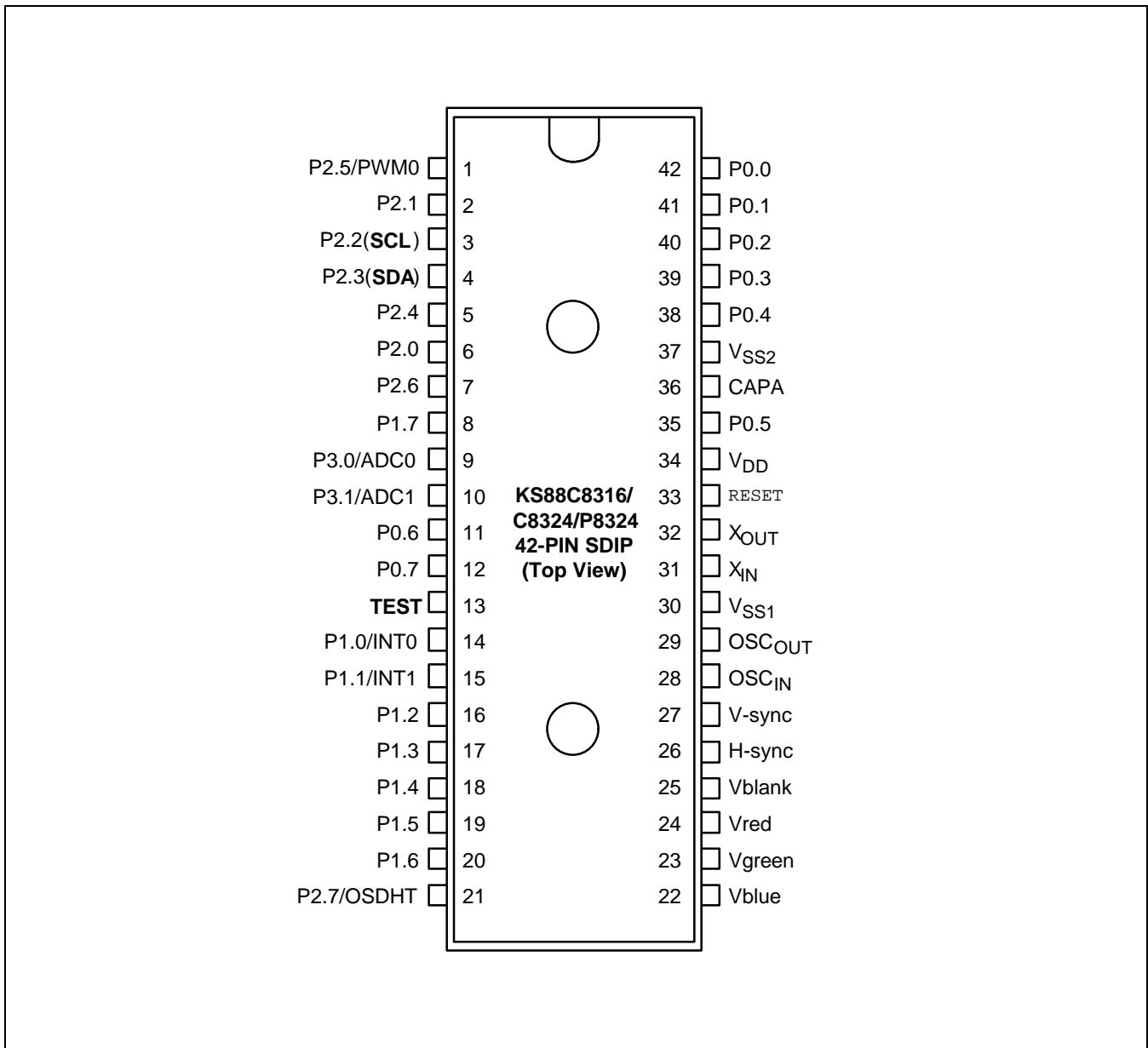


Figure 1-2. KS88C8316/C8324/P8324 Pin Assignment Diagram

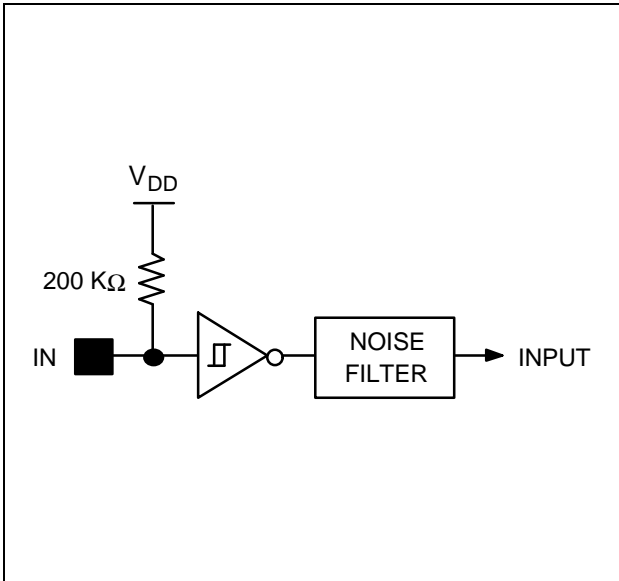
Table 1-1. KS88C8316/C8324 Pin Descriptions

Pin Name	Pin Type	Pin Description	Circuit Type	Pin Numbers	Share Pins
P0.0–P0.7	I/O	General I/O port (8-bit), configurable for digital input or push-pull output.	3	11–12, 35, 38–42	
P1.0–P1.1	I/O	General I/O port (2-bit), configurable for digital input or n-channel open-drain output. P1.0–P1.1 can withstand up to 6-volt loads. Multiplexed for alternative use as external interrupt inputs INTO–INT1.	7	14–15	INT0–INT1
P1.2–P1.5		General I/O port (4-bit), configurable for digital input or n-channel open-drain output. P1.2–P1.5 can withstand up to 6-volt loads. High current port (10mA).	5	16–19	
P1.6–P1.7		General I/O port (2-bit), configurable for digital input or push-pull output.	3	20, 8	
P2.0–P2.4, P2.6	I/O	General I/O port (6-bit). I/O mode or n-channel open-drain, push-pull output mode is software configurable. Pins can withstand up to 5-volt loads. P2.2: OTP serial clock pin P2.3: OTP serial data pin	2	2–7	
P2.5, P2.7		General I/O port (2-bit). I/O mode or n-channel open-drain, push-pull output mode is software configurable. Pins can withstand up to 5-volt loads. Each pin has an alternative function. P2.5: PWM0 (14-bit PWM output) P2.7: OSDHT (Halftone signal output)	2	1, 21	PWM0 OSDHT

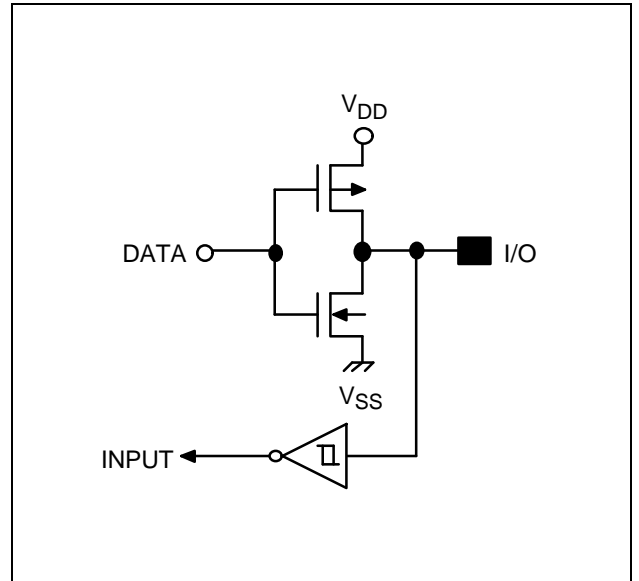
Table 1-1. KS88C8316/C8324 Pin Descriptions (Continued)

Pin Name	Pin Type	Pin Description	Circuit Type	Pin Numbers	Share Pins
P3.0–P3.1	I/O	General I/O port (2 bits), configurable for digital input or n-channel open-drain output. P3.0–P3.1 can withstand up to 5-volt loads. Multiplexed for alternative use as external interrupt inputs ADC0–ADC1.	6	9–10	ADC0 ADC1
PWM0	O	Output pin for 14-bit PWM0 circuit	2	1	P2.5
ADC0–ADC1	I	Analog inputs for 4-bit A/D converter	6	9,10	P3.0– P3.1
INT0–INT1	I	External interrupt input pins	7	14,15	P1.0– P1.1
OSDHT	O	Halftone control signal output for OSD	2	21	P2.7
Vblue, Vgreen Vred, Vblank	O	Digital blue, green, red, and video blank signal outputs for OSD	4	22–25	–
H-sync	I	H-sync input for OSD	8	26	–
V-sync		V-sync input for OSD		27	
OSC <sub>IN</sub> , OSC <sub>OUT</sub>	I, O	L-C oscillator pins for OSD clock frequency generation	–	28,29	–
TEST	I	<b>0 V:</b> Normal operation mode <b>5 V:</b> Factory test mode <b>12.5 V:</b> OTP write mode	–	13	–
X <sub>IN</sub> , X <sub>OUT</sub>	I, O	System clock pins	–	31, 32	–
RESET	I	System reset input pin	1	33	–
V <sub>DD</sub> , V <sub>SS1</sub> , V <sub>SS2</sub>	–	Power supply pins	–	13	–
CAPA	I	Input for capture A module	8	26	–

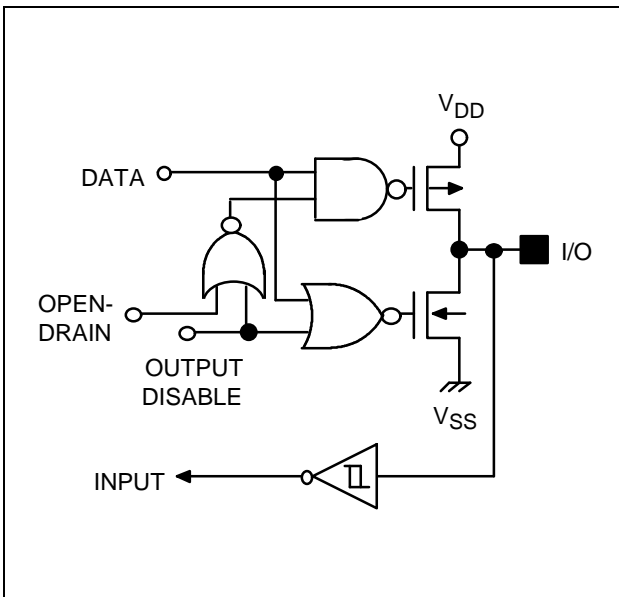
**PIN CIRCUITS**



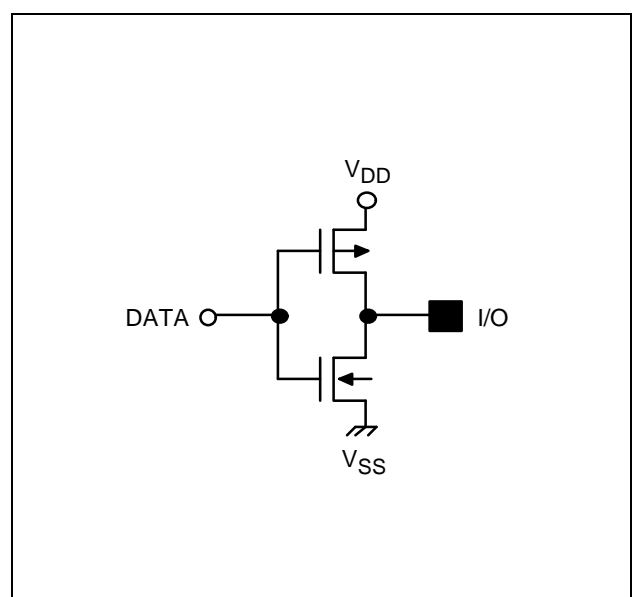
**Figure 1-3. Pin Circuit Type 1 (RESET)**



**Figure 1-5. Pin Circuit Type 3 (P0.0-P0.7, P1.6-P1.7)**



**Figure 1-4. Pin Circuit Type 2 (P2.0-P2.7, PWM0, OSDHT)**



**Figure 1-6. Pin Circuit Type 4 (Vblue, Vgreen, Vred, Vblank)**

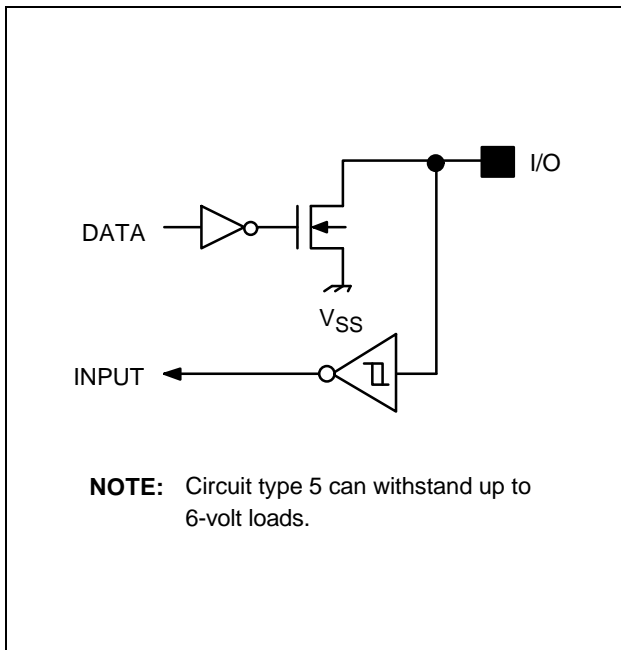


Figure 1-7. Pin Circuit Type 5 (P1.2–P1.5)

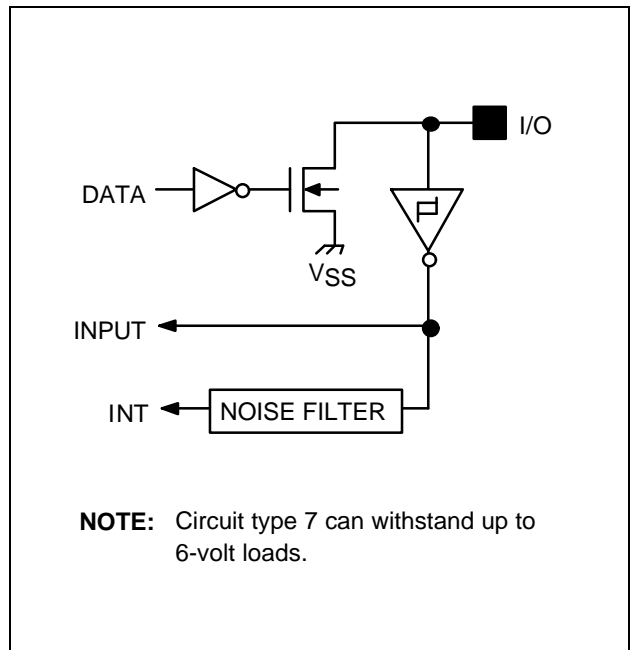


Figure 1-9. Pin Circuit Type 7 (P1.0–P1.1, INT0–INT1)

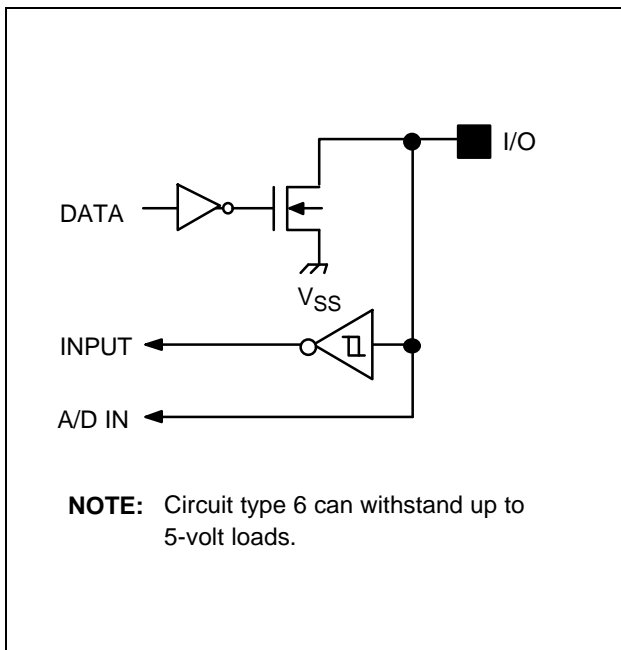


Figure 1-8. Pin Circuit Type 6 (P3.0–P3.1, ADC0–ADC1)

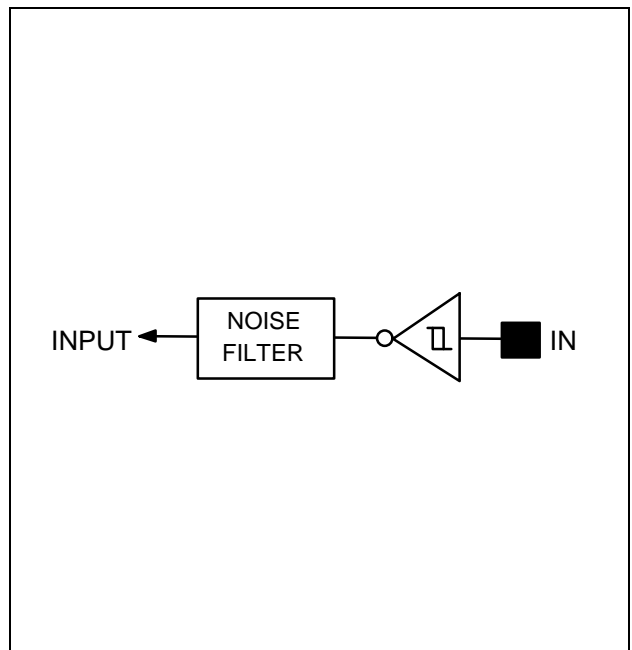


Figure 1-10. Pin Circuit Type 8 (V-Sync H-Sync, CAPA)



# 15 ELECTRICAL DATA

## OVERVIEW

In this section, KS88C8316/C8324 electrical characteristics are presented in tables and graphs. The information is arranged in the following order:

- Absolute maximum ratings
- D.C. electrical characteristics
- I/O capacitance
- A.C. electrical characteristics
- Input timing measurement points for  $t_{NF1}$  and  $t_{NF2}$
- Data retention supply voltage in Stop mode
- Stop mode release timing when initiated by RESET
- Main oscillator and L-C oscillator frequency
- Clock timing measurement points for  $X_{IN}$
- Main oscillator clock stabilization time ( $t_{ST}$ )
- A/D converter electrical characteristics
- Characteristic curves

Table 15-1. Absolute Maximum Ratings

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

Parameter	Symbol	Conditions	Rating	Unit
Supply Voltage	$V_{DD}$	–	– 0.3 to + 6.0	V
Input Voltage	$V_{I1}$	P1.0–P1.5 (open-drain)	– 0.3 to + 7	V
	$V_{I2}$	All port pins except $V_{I1}$	– 0.3 to $V_{DD} + 0.3$	
Output Voltage	$V_O$	All output pins	– 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 port 1	+ 100	
		Total pin current for ports 0, 2, and 3	+ 100	
Operating Temperature	$T_A$	–	– 20 to + 85	$^\circ\text{C}$
Storage Temperature	$T_{STG}$	–	– 65 to + 150	$^\circ\text{C}$

Table 15-2. D.C. Electrical Characteristics

 $(T_A = -20^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 4.5\text{ V}$  to  $5.5\text{ V}$ )

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input High Voltage	$V_{IH1}$	All input pins except $V_{IH2}$	$0.8 V_{DD}$	–	$V_{DD}$	V
	$V_{IH2}$	$X_{IN}$ , $X_{OUT}$	2.7 V			
Input Low Voltage	$V_{IL1}$	All input pins except $V_{IL2}$	–	–	$0.2 V_{DD}$	V
	$V_{IL2}$	$X_{IN}$ , $X_{OUT}$			1.0 V	
Output High Voltage	$V_{OH}$	$I_{OH} = -500\ \mu\text{A}$ P0, P1.6–P1.7, P2 R, G, B, Vblank	$V_{DD} - 0.8$	–	–	V
Output Low Voltage	$V_{OL1}$	$I_{OL} = 4\ \text{mA}$ P0, P1.6–P1.7	–	–	0.4	V
	$V_{OL2}$	$I_{OL} = 10\ \text{mA}$ P1.2–P1.5	–	–	0.8	
	$V_{OL3}$	$I_{OL} = 2\ \text{mA}$ P1.0–P1.1, P3.0–P3.1	–	–	0.4	
	$V_{OL4}$	$I_{OL} = 1\ \text{mA}$ R, G, B, Vblank, P2	–	–	0.4	V

Table 15-2. D.C. Electrical Characteristics (Continued)

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input High Leakage Current	I <sub>LIH1</sub>	V <sub>IN</sub> = V <sub>DD</sub> All input pins except I <sub>LIH2</sub> and I <sub>LIH3</sub>	–	–	3	μA
	I <sub>LIH2</sub>	V <sub>IN</sub> = V <sub>DD</sub> , OSC <sub>IN</sub> , OSC <sub>OUT</sub>			10	
	I <sub>LIH3</sub>	V <sub>IN</sub> = V <sub>DD</sub> , X <sub>IN</sub> , X <sub>OUT</sub>	2.5	10	20	
Input Low Leakage Current	I <sub>LIL1</sub>	V <sub>IN</sub> = 0 V All input pins except I <sub>LIL2</sub> , I <sub>LIL3</sub> , and RESET	–	–	–3	μA
	I <sub>LIL2</sub>	V <sub>IN</sub> = 0 V, OSC <sub>IN</sub> , OSC <sub>OUT</sub>			–10	
	I <sub>LIL3</sub>	V <sub>IN</sub> = 0 V, X <sub>IN</sub> , X <sub>OUT</sub>	–2.5	–10	–20	
Output High Leakage Current	I <sub>LOH1</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins except I <sub>LOH2</sub>	–	–	3	μA
	I <sub>LOH2</sub>	V <sub>OUT</sub> = 6 V P1.0–P1.5			10	
Output Low Leakage Current	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V All output pins	–	–	–3	μA
Supply Current (note)	I <sub>DD1</sub>	Normal mode; V <sub>DD</sub> = 4.5 V to 5.5 V 8-MHz CPU clock	–	7	20	mA
	I <sub>DD2</sub>	Idle mode; V <sub>DD</sub> = 4.5 V to 5.5 V 8-MHz CPU clock		2	10	
	I <sub>DD3</sub>	Stop mode; V <sub>DD</sub> = 4.5 V to 5.5 V		1	10	μA

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

Table 15-3. Input/Output Capacitance

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 0 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input capacitance	C <sub>IN</sub>	f = 1 MHz; unmeasured pins are connected to V <sub>SS</sub>	-	-	10	pF
Output capacitance	C <sub>OUT</sub>					
I/O capacitance	C <sub>IO</sub>					

Table 15-4. A.C. Electrical Characteristics

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V-sync Pulse Width	t <sub>VW</sub>	-	4	-	-	μs
H-sync Pulse Width	t <sub>HW</sub>	-	3	-	-	μs
Noise Filter	t <sub>NF1</sub>	P1.0-P1.1, V-sync	-	350	-	ns
	t <sub>NF2</sub>	RESET	-	1000		
	t <sub>NF3</sub>	Glitch filter (oscillator block)	-	15		
	t <sub>NF4</sub>	CAPA	-	5	-	t <sub>CAPA</sub>
	t <sub>NF5</sub>	H-sync	-	650	-	ns

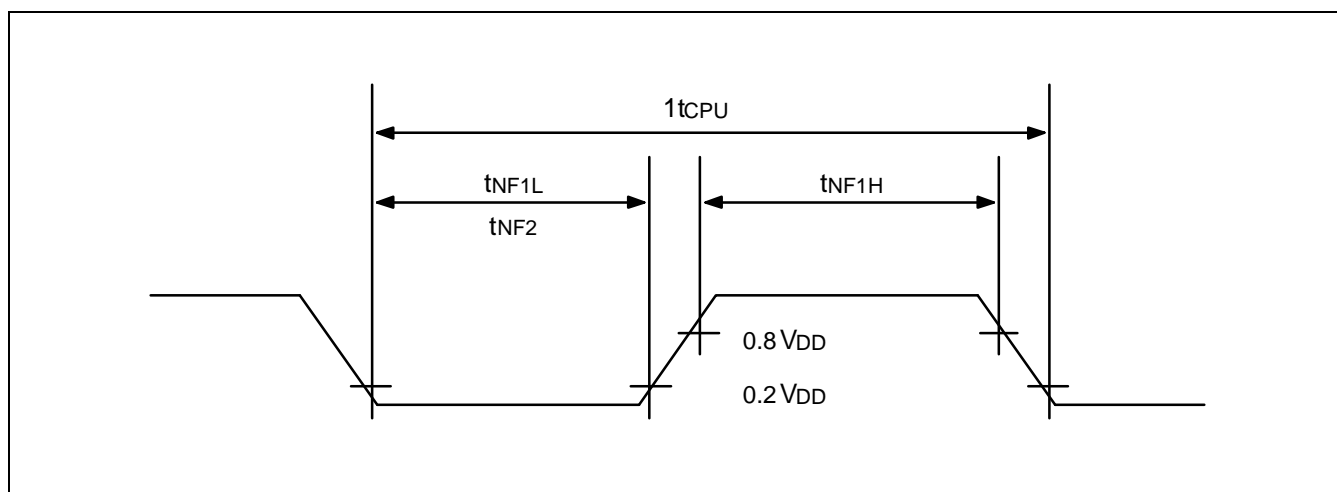
NOTE: t<sub>CAPA</sub> = f<sub>OSC</sub>/128.Figure 15-1. Input Timing Measurement Points for t<sub>NF1</sub> and t<sub>NF2</sub>

Table 15-5. Data Retention Supply Voltage in Stop Mode

( $T_A = -20\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$ )

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data Retention Supply Voltage	$V_{DDDR}$	Stop mode	2	–	6	V
Data Retention Supply Current	$I_{DDDR}$	Stop mode, $V_{DDDR} = 2.0\text{ V}$	–	–	5	$\mu\text{A}$

**NOTES:**

1. Supply current does not include current drawn through internal pull-up resistors or external output current loads.
2. During the oscillator stabilization wait time ( $t_{WAIT}$ ), all CPU operations must be stopped.

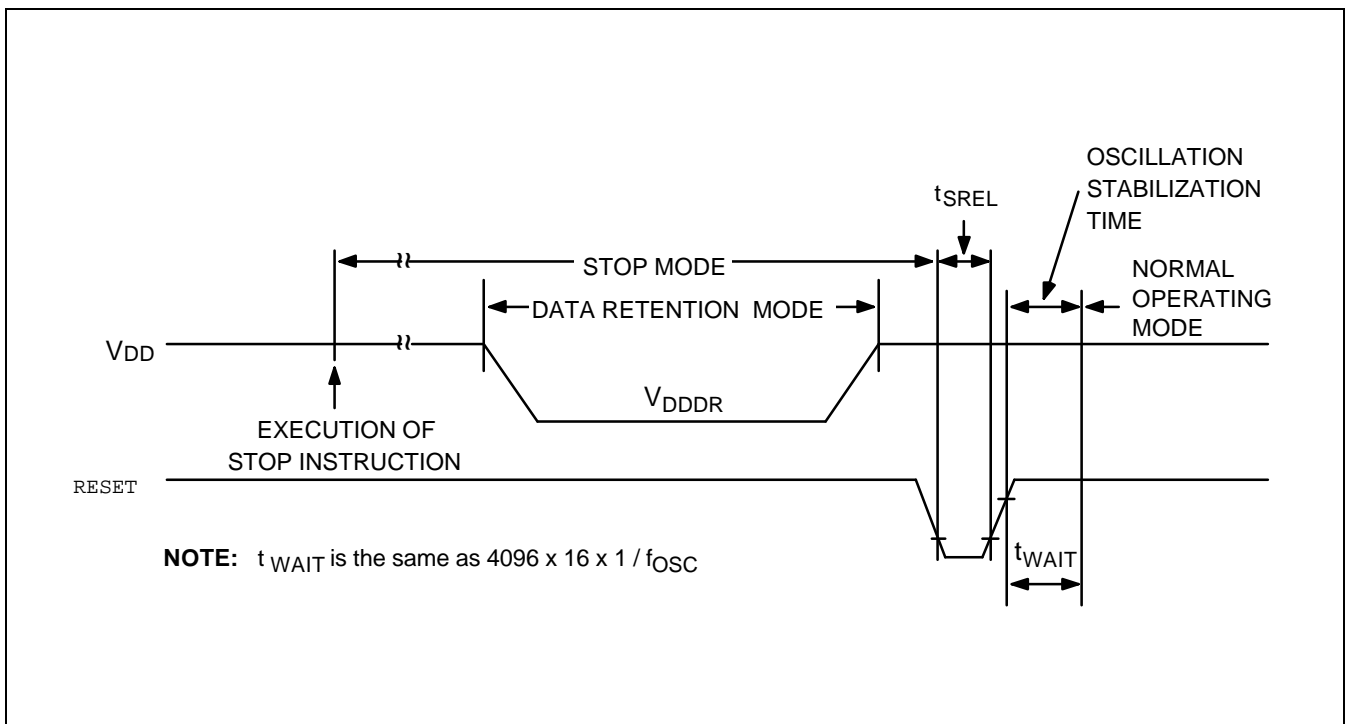
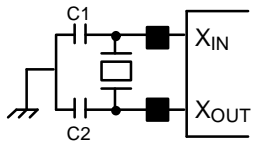
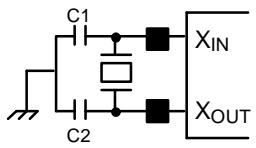
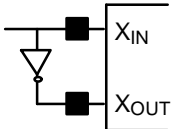
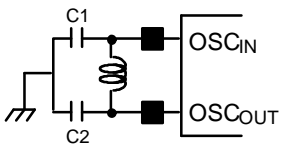


Figure 15-2. Stop Mode Release Timing When Initiated by a Reset

Table 15-6. Main Oscillator and L-C Oscillator Frequency

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V)

Oscillator	Clock Circuit	Conditions	Min	Typ	Max	Unit
Crystal		OSD block active	5	6	8	MHz
		OSD block inactive	0.5	6	8	
Ceramic		OSD block active	5	6	8	MHz
		OSD block inactive	0.5	6	8	
External Clock		OSD block active	5	6	8	MHz
		OSD block inactive	0.5	6	8	
L-C Oscillator		Recommend value: C1 = C2 = 20 pF	5	6.5	8	MHz
CPU Clock Frequency		—	0.032	6.0	8	MHz

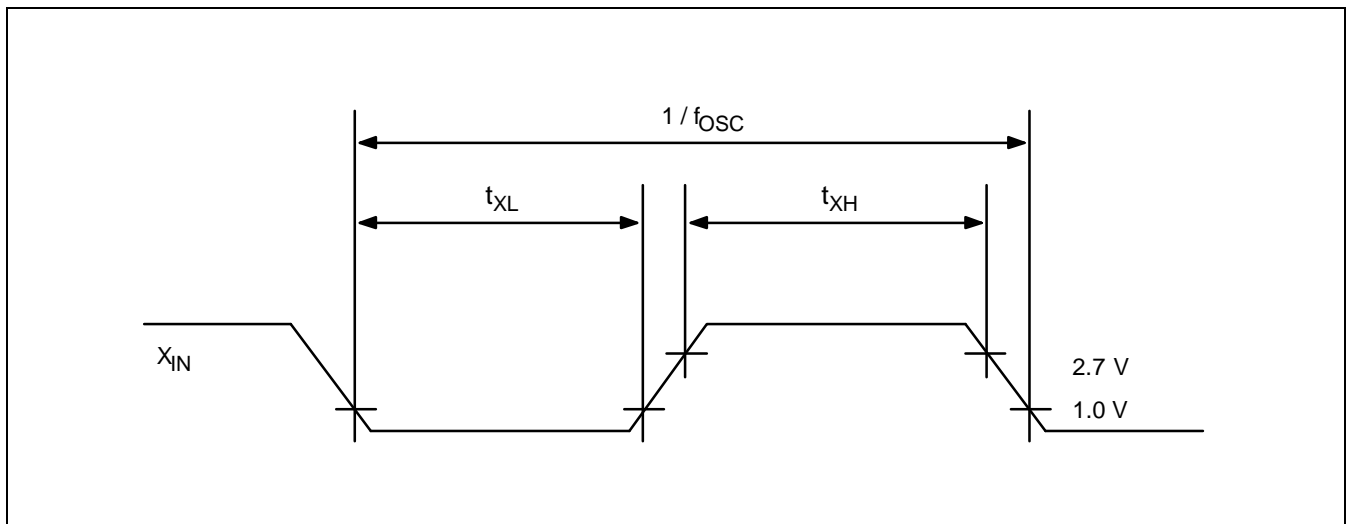
Figure 15-3. Clock Timing Measurement Points for X<sub>IN</sub>

Table 15-7. Main Oscillator Clock Stabilization Time

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V)

Oscillator	Symbol	Test Condition	Min	Typ	Max	Unit
Crystal	-	V <sub>DD</sub> = 4.5 V to 6.0 V	-	-	20	ms
Ceramic		(Oscillation stabilization occurs when V <sub>DD</sub> is equal to the minimum oscillator voltage range.)			10	
External Clock		X <sub>IN</sub> input High and Low level width (t <sub>XH</sub> , t <sub>XL</sub> )			65	
Release Signal Setup Time	t <sub>SREL</sub>	Normal operation	-	1000	-	ns
Oscillation Stabilization Wait Time <sup>(1)</sup>	t <sub>WAIT</sub>	CPU clock = 8 MHz; Stop mode released by RESET	-	8.3	-	ms
		CPU clock = 8 MHz; Stop mode released by an interrupt		(2)		

**NOTES:**

- Oscillation stabilization time is the time required for the CPU clock to return to its normal oscillation frequency after a power-on occurs, or when Stop mode is released.
- The oscillation stabilization interval is determined by the basic timer (BT) input clock setting.

Table 15-8. A/D Converter Electrical Characteristics

(T<sub>A</sub> = -20°C to +85°C, V<sub>DD</sub> = 4.5 V to 5.5 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Absolute Accuracy <sup>(1)</sup>	-	CPU clock = 8 MHz	-	-	± 0.5	LSB
Conversion Time <sup>(2)</sup>	t <sub>CON</sub>					t <sub>CPU</sub> × 25 <sup>(3)</sup>
Analog Input Voltage	V <sub>IAN</sub>	-	V <sub>SS</sub>	-	V <sub>DD</sub>	V
Analog Input Impedance	R <sub>AN</sub>	-	2	-	-	MΩ

**NOTES:**

- Excluding quantization error, absolute accuracy values are within ± 1/2 LSB.
- 'Conversion time' is the time required from the moment a conversion operation starts until it ends.
- The unit t<sub>CPU</sub> means one CPU clock period.

# 16 MECHANICAL DATA

## OVERVIEW

The KS88C8316/C8324 microcontrollers are available in a 42-pin SIP package (42-SDIP-600).

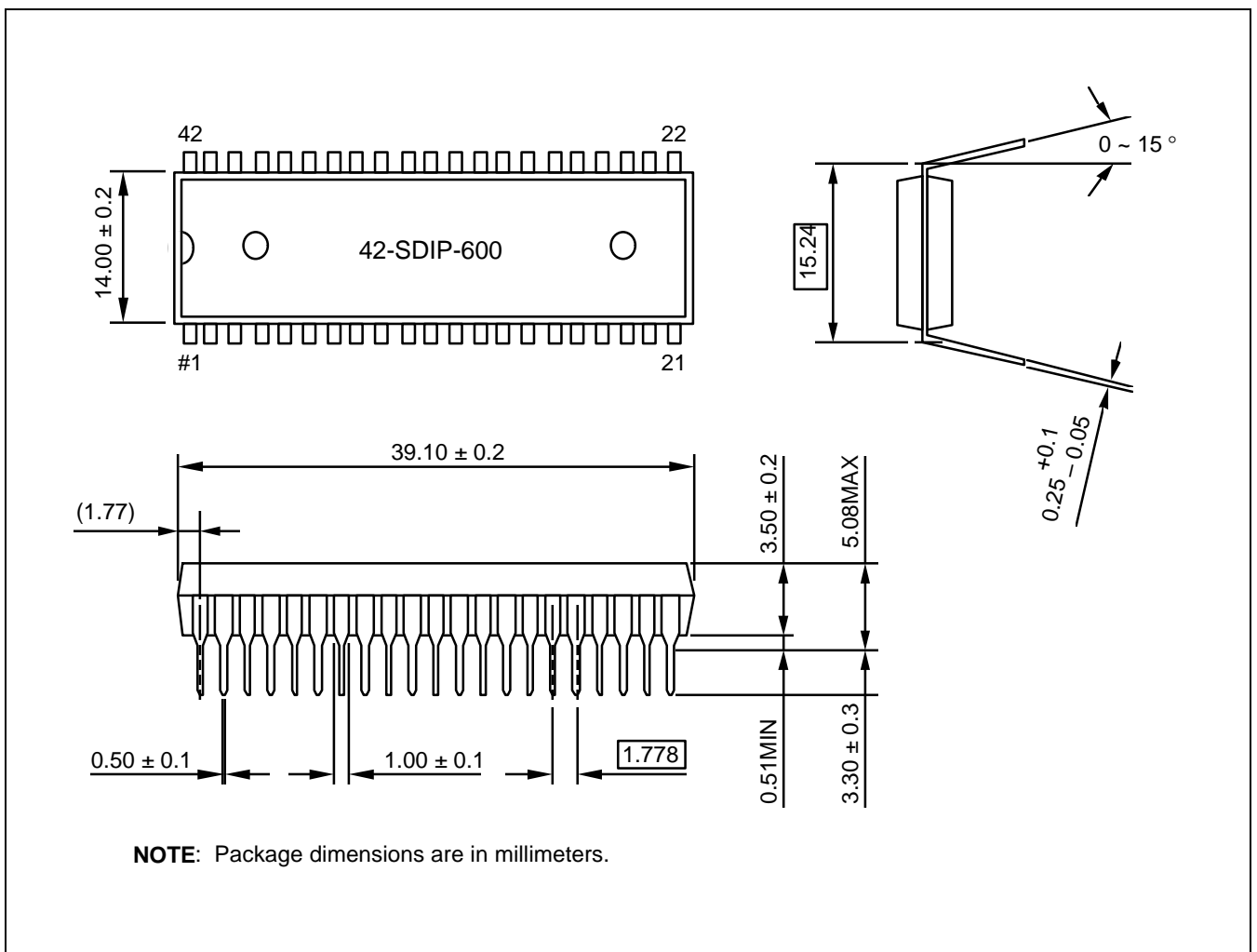


Figure 16-1. 42-Pin SDIP Package Mechanical Data (42-SDIP-600)



# 17

## KS88P8324 OTP

### OVERVIEW

The KS88P8324 single-chip CMOS microcontroller is the OTP (One Time Programmable) version of the KS88C8316/C8324 microcontroller. It has an on-chip OTP ROM instead of masked ROM. The EPROM is accessed by serial data format.

The KS88P8324 is fully compatible with the KS88C8316/C8324, both in function and in pin configuration. Because of its simple programming requirements, the KS88P8324 is ideal for use as an evaluation chip for the KS88C8316/C8324.

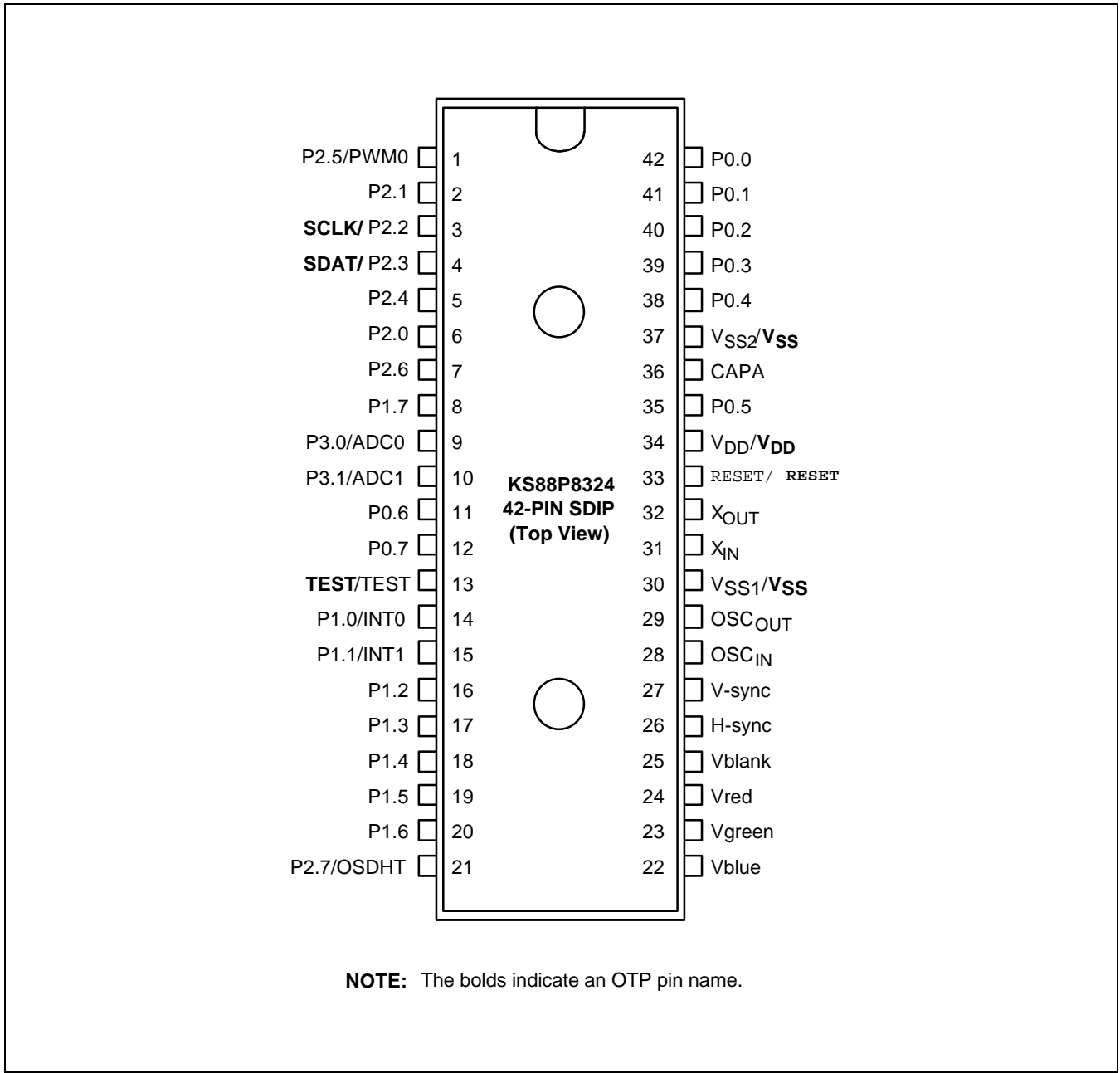


Figure 17-1. KS88P8324 Pin Assignments (42-SDIP)

Table 17-1. Descriptions of Pins Used to Read/Write the EPROM

Main Chip Pin Name	During Programming			
	Pin Name	Pin No.	I/O	Function
P2.3 (Pin 4)	SDAT	4	I/O	Serial data Pin (Output when reading, Input when writing) Input and Push-pull Output Port can be assigned
P2.2 (Pin 3)	SCLK	3	I/O	Serial clock Pin (Input Only Pin)
TEST	V <sub>PP</sub> (TEST)	13	I	0 V: Operating mode 5 V: Test mode 12.5 V: OTP mode
RESET	RESET	33	I	0 V: Chip initialization, OTP mode 5 V: Operating mode
V <sub>DD</sub> /V <sub>SS</sub>	V <sub>DD</sub> /V <sub>SS</sub>	34/30, 37	I	Logic Power Supply Pin.

Table 17-2. Comparison of KS88P8324 and KS88C8316/C8324 Features

Characteristic	KS88P8324	KS88C8316/C8324
Program Memory	24 K byte EPROM	24 K byte mask ROM
Operating Voltage (V <sub>DD</sub> )	4.5 V to 5.5 V	4.5 V to 5.5 V
OTP Programming Mode	V <sub>DD</sub> = 5 V, V <sub>PP</sub> (TEST) = 12.5 V	–
Pin Configuration	42 SDIP	42 SDIP
EPROM Programmability	User Program 1 time	Programmed at the factory