

# 1 PRODUCT OVERVIEW

## SAM88RCRI PRODUCT FAMILY

Samsung's SAM88RCRI family of 8-bit single-chip CMOS microcontrollers offer fast and efficient CPU, a wide range of integrated peripherals, and supports OTP device.

A dual address/data bus architecture and 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.

## S3C9654/C9658/P9658 MICROCONTROLLER

The S3C9654/C9658/P9658 microcontroller with USB function can be used in a wide range of general purpose applications. It is especially suitable for mouse or joystick controller and is available in 16, 18, 20-pin DIP and SOP package.

The S3C9654/C9658/P9658 single-chip 8-bit microcontroller is fabricated using an advanced CMOS process. It is built around the powerful SAM88RCRI CPU core.

Stop and Idle power-down modes were implemented to reduce power consumption. To increase on-chip register space, the size of the internal register file was logically expanded. The S3C9654/C9658/P9658 has 4/8 Kbytes of program memory on-chip (S3C9654/C9658), and 208 bytes of RAM including 16 bytes of working register.

Using the SAM88RCRI design approach, the following peripherals were integrated with the SAM88RCRI core:

- Three configurable I/O ports (14 pin, at 20 pin)
- 14-bit programmable pins for external interrupts (at 20 pin)
- 8-bit timer/counter with two operating modes

## OTP

The S3C9654/C9658 microcontroller is also available in OTP (One Time Programmable) version. S3P9658 microcontroller has an on-chip 4/8 Kbyte one-time-programmable EPROM instead of masked ROM. The S3P9658 is comparable to S3C9654/C9658, both in function and in pin configuration.

## FEATURES

### CPU

- SAM88RCRI CPU core

### Memory

- 4-K byte internal program memory (ROM S3C9654)
- 8-K byte internal program memory (ROM S3P9658/C9658)
- 208-byte RAM
- 16 bytes of working register

### Instruction Set

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

### Instruction Execution Time

- 0.66  $\mu$ s at 6 MHz  $f_{OSC}$

### Interrupts

- 14 interrupt sources with one vector (20 pin)
- 12 interrupt sources with one vector (18 pin)
- 10 interrupt sources with one vector (16 pin)
- One level, one vector interrupt structure

### Oscillation Circuit Options

- 6 MHz crystal/ceramic oscillator
- External clock source
- RC oscillator
- Embedded oscillation capacitor (XI, XO, 33pF)

### General I/O

- 14 bit-programmable I/O pins (20 pin)
- 12 bit-programmable I/O pins (18 pin)
- 10 bit-programmable I/O pins (16 pin)

### Sub Oscillator

- Internal RC sub oscillator
- Auto interrupt wake-up

### Timer/Counter

- One 8-bit basic timer for watchdog function and programmable oscillation stabilization interval generation function
- One 8-bit timer/counter with Compare/Overflow counter

### USB Serial Bus

- Compatible to USB low speed (1.5 Mbps) device 1.0 specification.
- Serial bus interface engine (SIE)
  - Packet decoding/generation
  - CRC generation and checking
  - NRZI encoding/decoding and bit-stuffing
- Two 8-byte receive/transmit USB buffer

### Operating Temperature Range

- $-0^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$

### Operating Voltage Range

- 4.0 V to 5.25 V

### Package Types

- 16, 18, 20 pin DIP
- 16, 18, 20 pin SOP

### Comparator

- 6-channel mode, 32 step resolution
- 5-channel mode, external reference
- Low EMI design

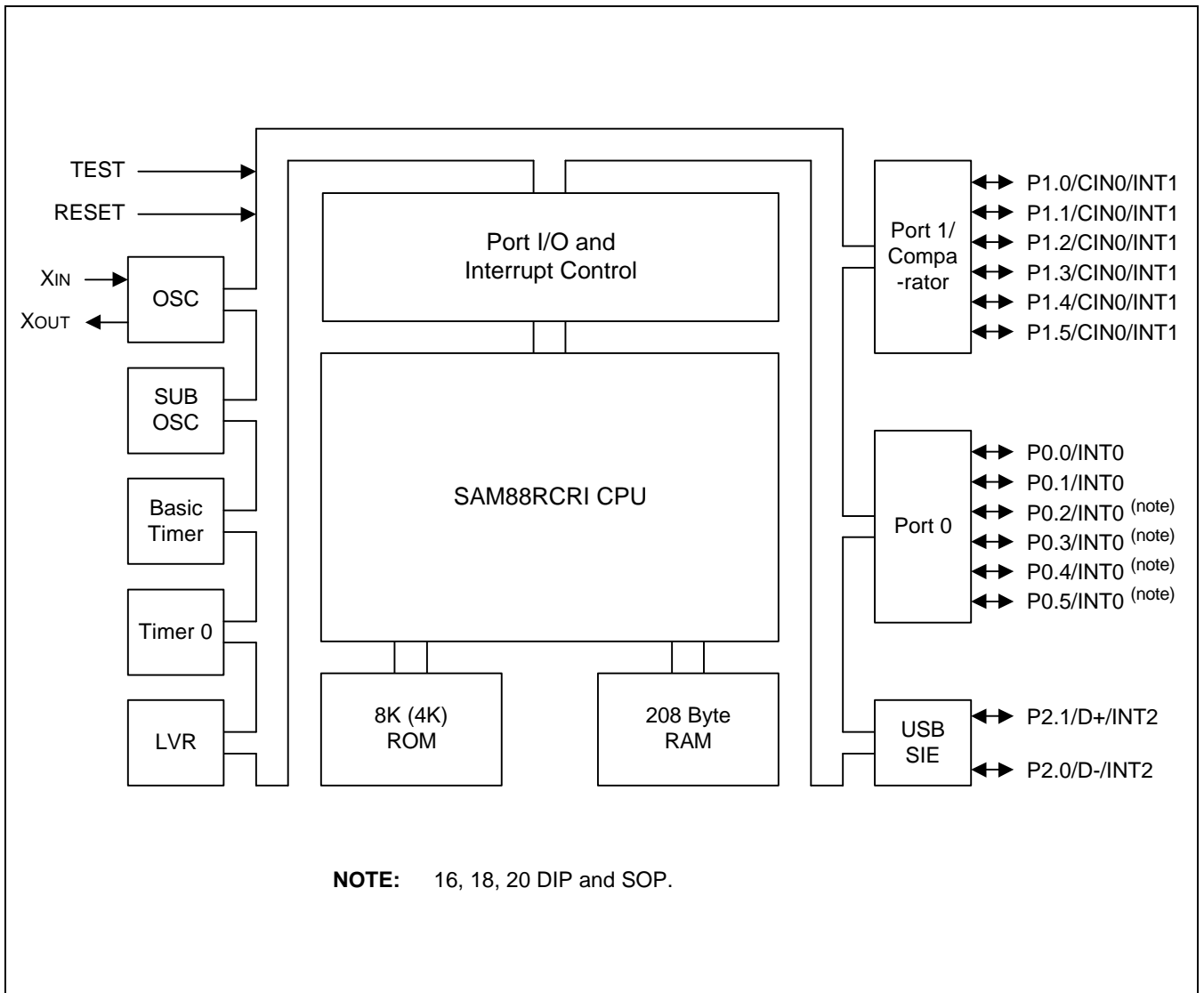
### Low Voltage Reset

- Low voltage Reset
- Power on Reset

### High Sink Current Pin for LED

- P0.0 ( $V_{OL}$ : 0.4 V, 50mA)

**BLOCK DIAGRAM**



**Figure 1-1. Block Diagram**

**PIN ASSIGNMENTS**

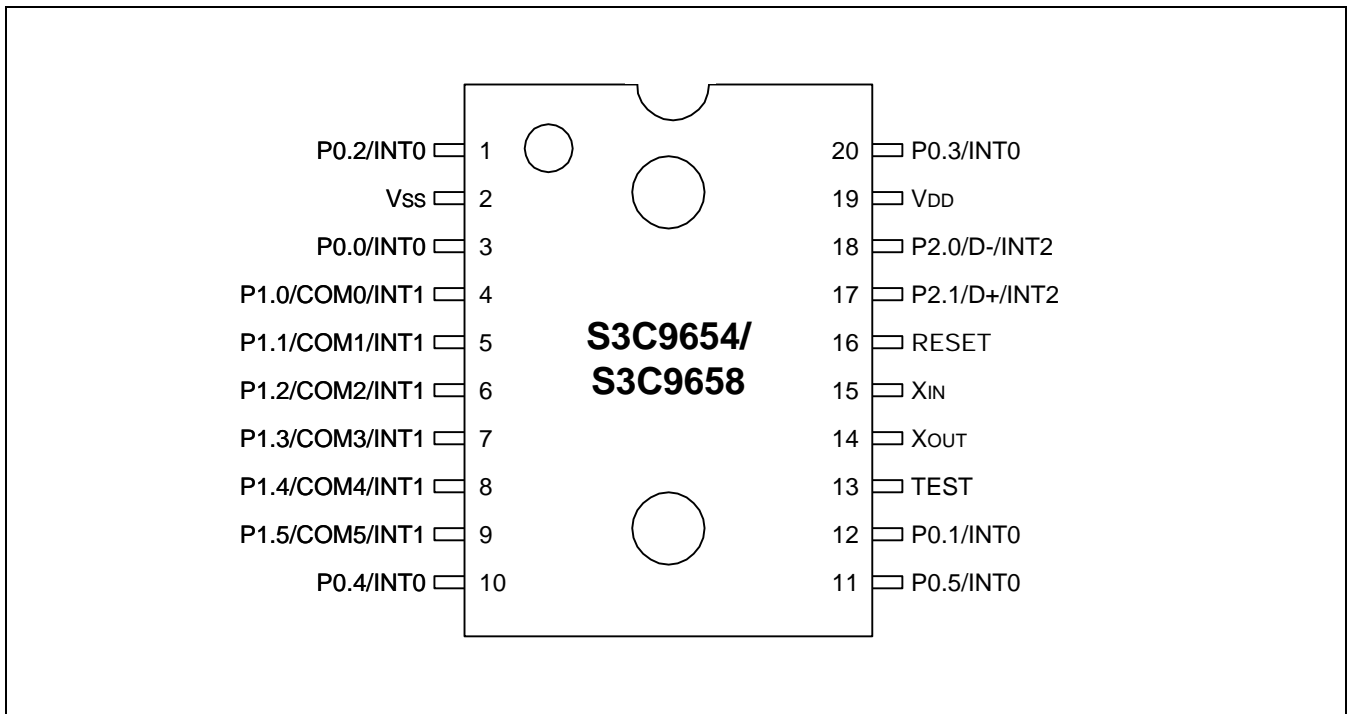


Figure 1-2. Pin Assignment (20 Pin)

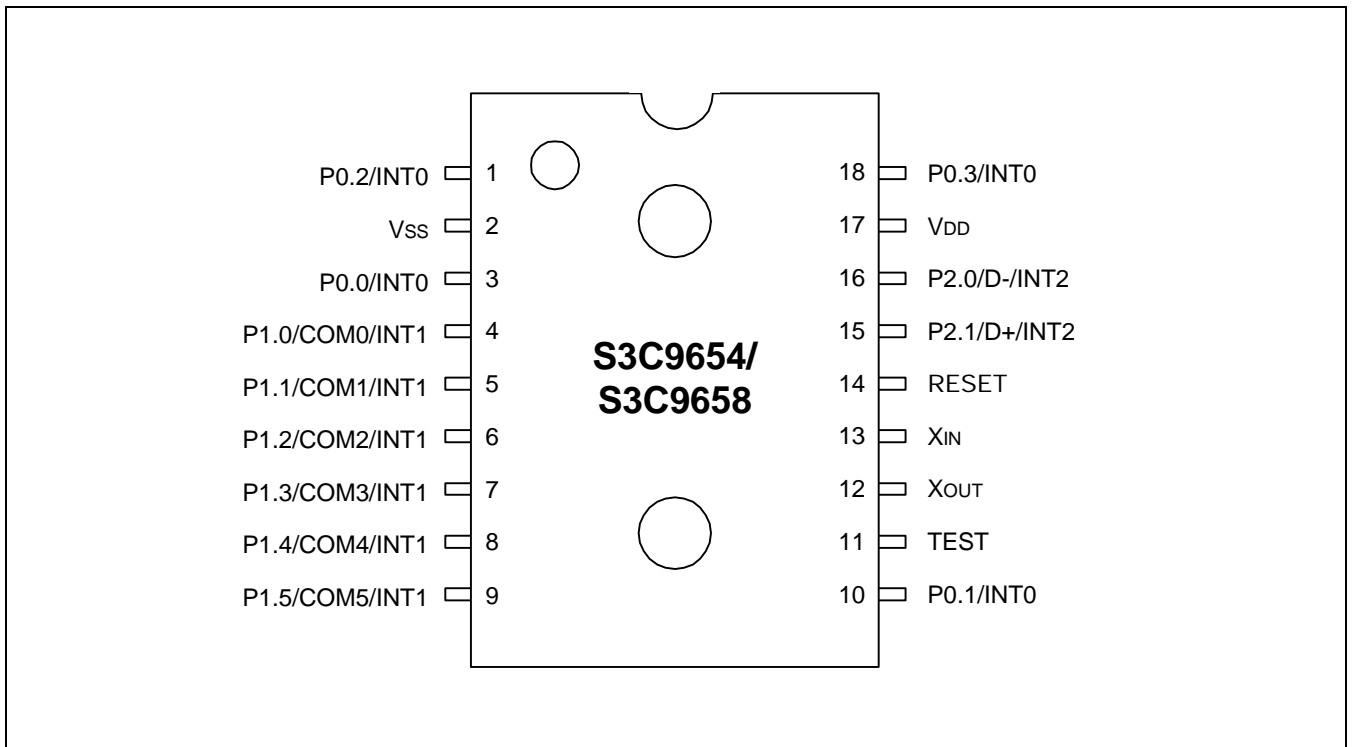


Figure 1-3. Pin Assignment (18 Pin)

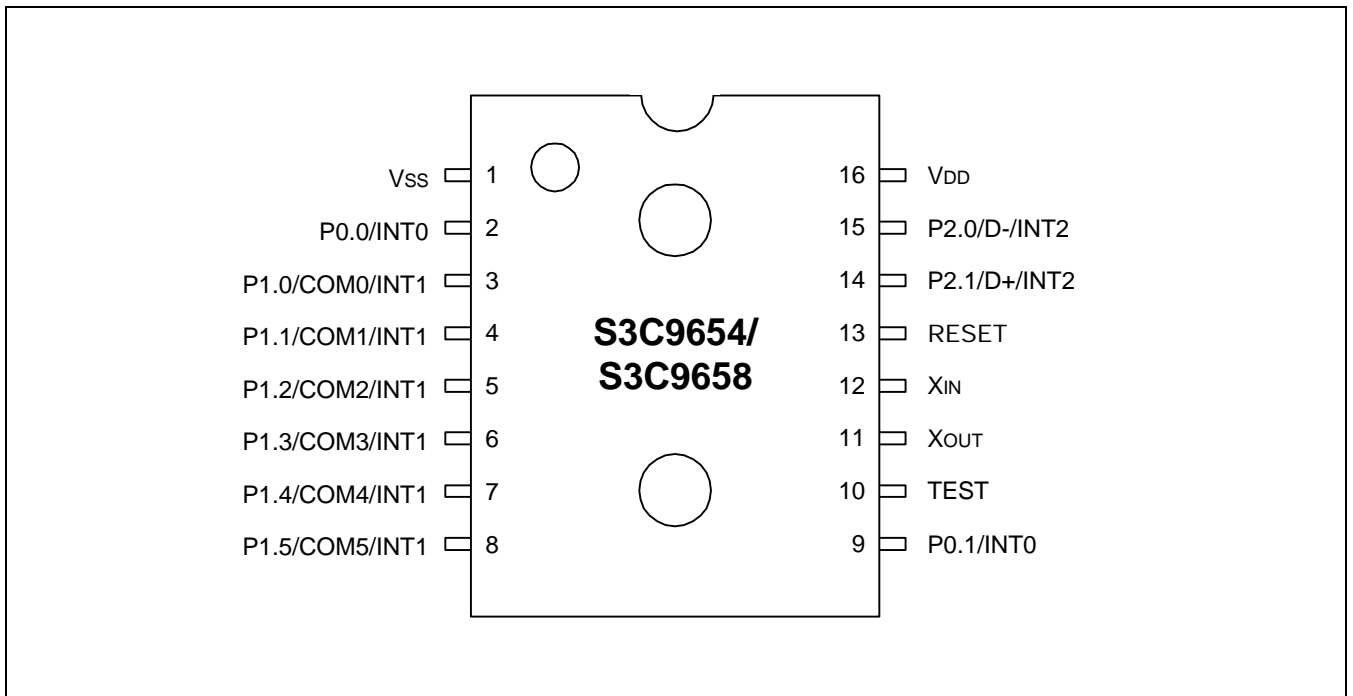


Figure 1-4. Pin Assignment (16 Pin)

Table 1-1. Signal Descriptions

Pin Names	Pin Type	Pin Description	Circuit Number	Pin Numbers	Share Pins
P0.0	I/O	Bit-programmable I/O port for Schmitt trigger input or n-ch open drain output (50 mA). Pull-up resistor is assignable to input pin by software and is automatically disabled for output pin. Port 0 can be individually configured as external interrupt input.	SK	3	INT0
P0.1–P0.5	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull output. Pull-up resistors individually assignable to input pins by software and are automatically disabled for output pins. Port 0 can be individually configured as external interrupt inputs.	D	1, 10, 11, 12, 20	INT0
P1.0–P1.5	I/O	Bit-programmable I/O port for Schmitt trigger input or push-pull output. Pull-up resistors are individually assignable to input pins by software. Port 1 can be configured as comparator input or external interrupt inputs. Pull-down resistors are individually assignable. (in comparator input)	CP	4–9	CIN0-5 INT1
P2.0/D- – P2.1/D+	I/O	Bit-programmable I/O port for Schmitt trigger input or n-ch open drain output. Pull-up resistors are individually assignable to input pins by software and are automatically disabled for output pins. Port 2 can be individually configured as external interrupt inputs. Also it can be configured as an USB ports.	CP	17, 18	INT2
X <sub>OUT</sub> , X <sub>IN</sub>	–	System clock input and output pin (crystal/ceramic oscillator, or external clock source)	–	14, 15	–
INT0	I	External interrupt for bit-programmable port 0	D	1, 3, 10, 11, 12, 20	Port 0
INT1	I	External interrupt for bit-programmable port 1	D	4–9	Port 1
INT2	I	External interrupt for bit-programmable port 2	D	17, 18	Port 2
V <sub>DD</sub>	–	Power input pin	–	19	–
V <sub>SS</sub>	–	V <sub>SS</sub> is a ground power for CPU core.	–	2	–
RESET	1	Reset input pin (Pull-up register embedded)	–	16	–

Table 1-2. Pin Circuit Assignments for the S3C9654/C9658/P9658

Circuit Number	Circuit Type	S3C9654/C9658/P9658 Assignments
C	O	
D	I/O	Port 0.1–5, INT0, INT1, INT2
SK	I/O	Port 0.0
CP	I/O	Port 1, Port 2

NOTE: Diagrams of circuit types C–D, and F-8 are presented below.

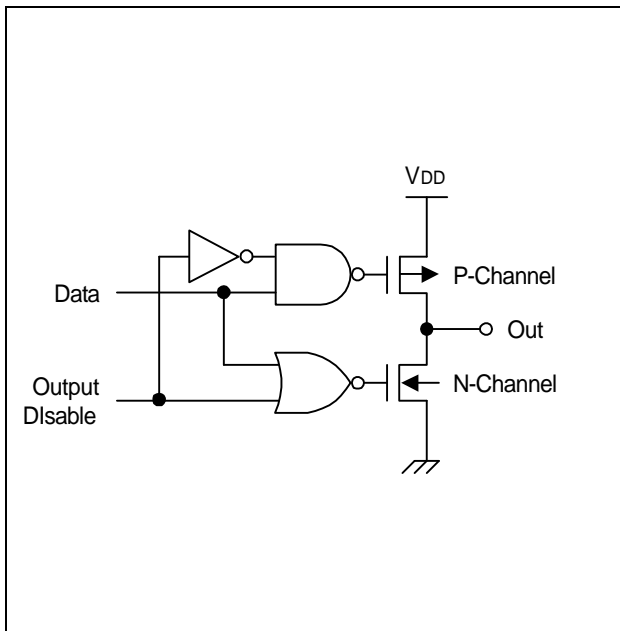


Figure 1-5. Pin Circuit Type C

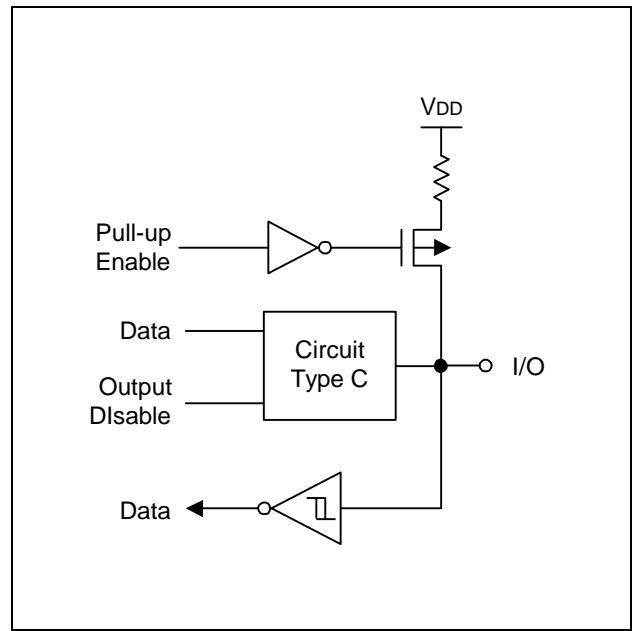


Figure 1-6. Pin Circuit Type D

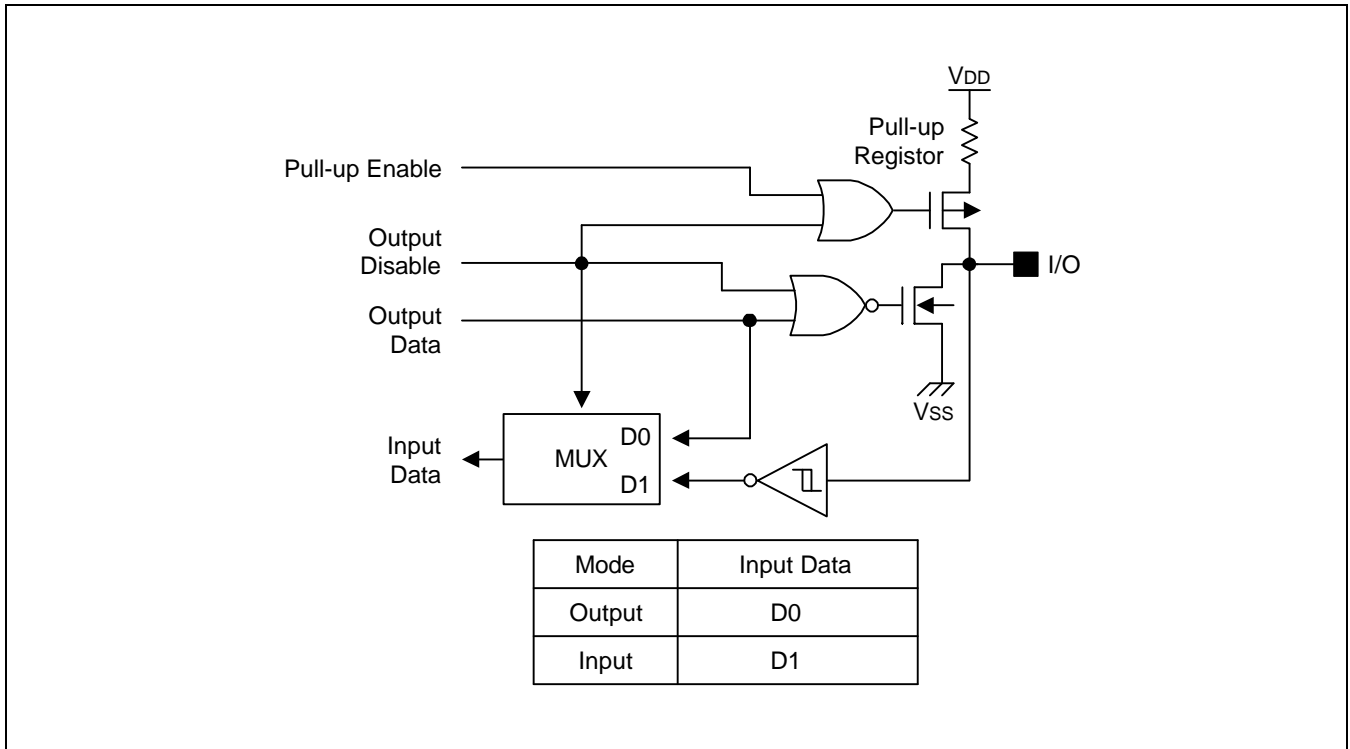


Figure 1-7. Pin Circuit Type SK

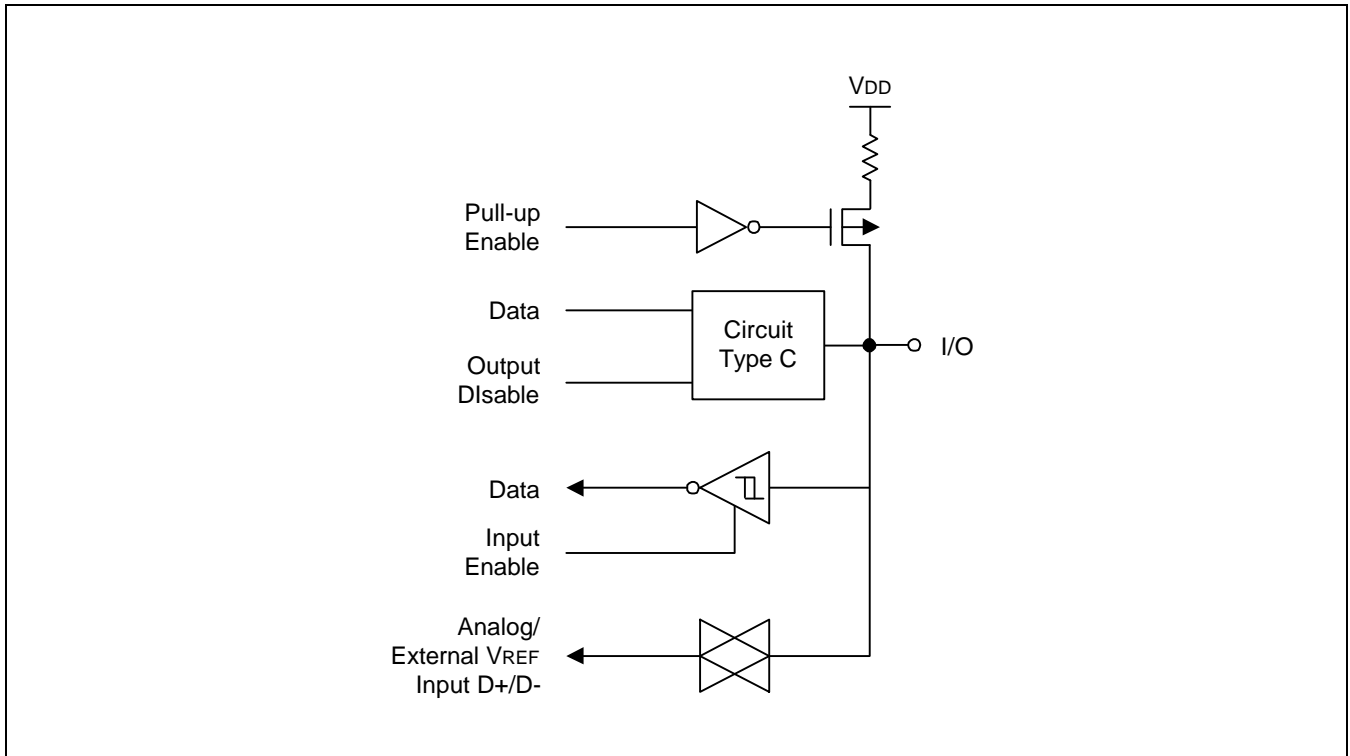


Figure 1-8. Pin Circuit Type CP



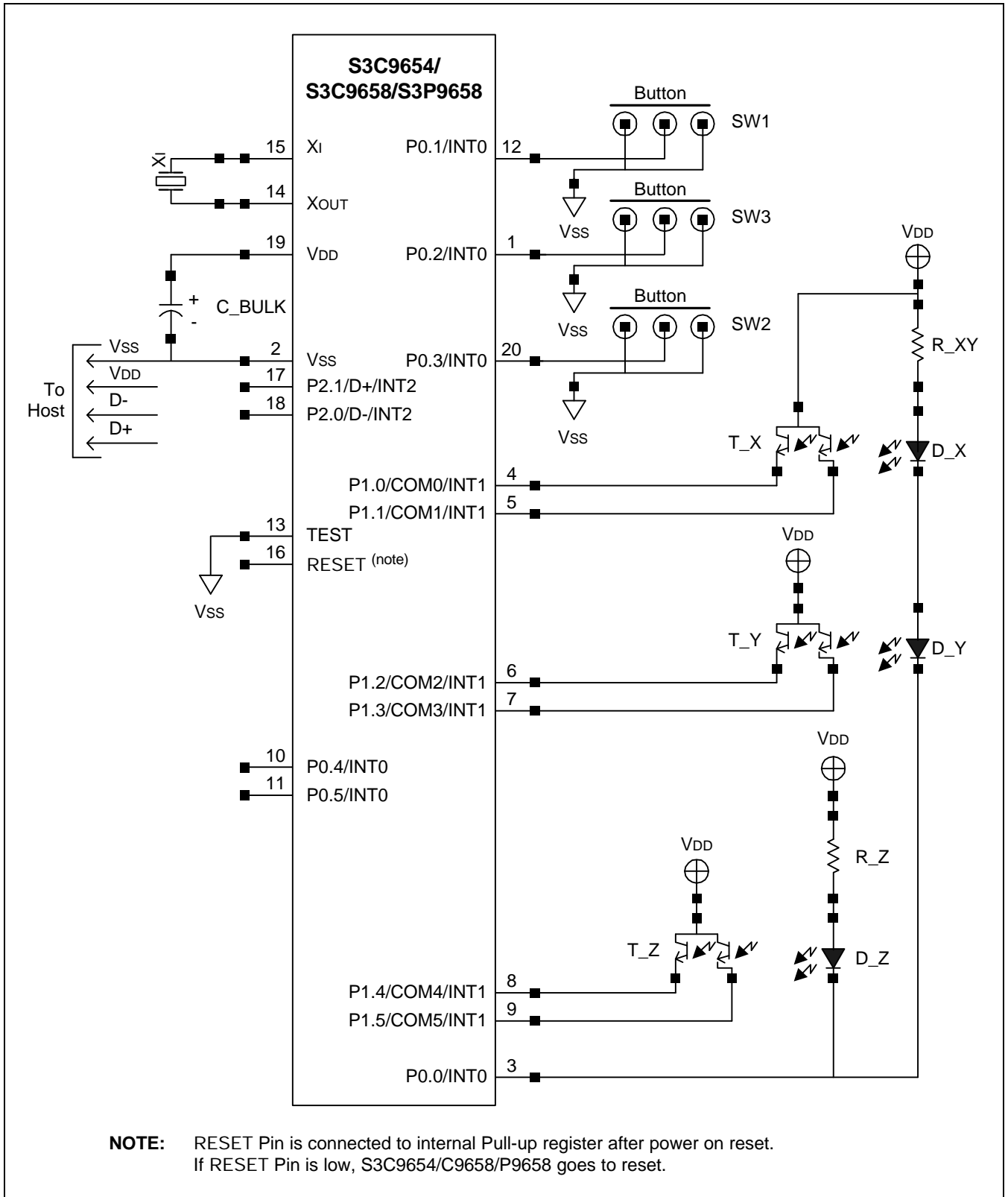


Figure 1-9. USB Mouse Circuit Diagram

# 15 ELECTRICAL DATA

## OVERVIEW

In this section, the following S3C9654/C9658/P9658 electrical characteristics are presented in tables and graphs:

- Absolute maximum ratings
- D.C. electrical characteristics
- I/O capacitance
- A.C. electrical characteristics
- Oscillator characteristics
- Operating voltage range
- Oscillation stabilization time
- Clock timing measurement points at  $X_{IN}$
- Data retention supply voltage in Stop mode
- Stop mode release timing when initiated by a RESET
- Stop mode release timing when initiated by an external interrupt
- Characteristic curves
- Comparator Electrical Characteristics

Table 15-1. Absolute Maximum Ratings

(T<sub>A</sub> = 25°C)

Parameter	Symbol	Conditions	Rating	Unit
Supply voltage	V <sub>DD</sub>	–	– 0.3 to + 6.5	V
Input voltage	V <sub>I</sub>	All ports	– 0.3 to V <sub>DD</sub> + 0.3	V
Output voltage	V <sub>O</sub>	All output ports	– 0.3 to V <sub>DD</sub> + 0.3	V
Output current high	I <sub>OH</sub>	One I/O pin active	– 18	mA
		All I/O pins active	– 60	
Output current low	I <sub>OL</sub>	One I/O pin active (except P0.0)	+ 30	mA
		Total pin current for ports 0, 1, 2 (except P0.0)	+ 100	
		P0.0	+ 50	
Operating temperature	T <sub>A</sub>	–	0 to + 85	°C
Storage temperature	T <sub>STG</sub>	–	– 60 to + 150	

Table 15-2. D.C. Electrical Characteristics

(T<sub>A</sub> = 0°C to +85°C, V<sub>DD</sub> = 4.0 V to 5.25 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input high voltage	V <sub>IH1</sub>	All input pins except V <sub>IH2</sub> , D+, D-	0.8 V <sub>DD</sub>	-	V <sub>DD</sub>	V
	V <sub>IH2</sub>	X <sub>IN</sub>	V <sub>DD</sub> - 0.5		V <sub>DD</sub>	
Input low voltage	V <sub>IL1</sub>	All input pins except V <sub>IL2</sub> , D+, D-	-	-	0.2 V <sub>DD</sub>	
	V <sub>IL2</sub>	X <sub>IN</sub>	-	-	0.4	
Output high voltage	V <sub>OH</sub>	V <sub>DD</sub> = 4.0 V-5.25 V I <sub>OH</sub> = -200 μA All output ports except D+, D-	V <sub>DD</sub> - 1.0	-	-	
Output low voltage	V <sub>OL</sub>	V <sub>DD</sub> = 4.0 V-5.25 V I <sub>OL</sub> = 2 mA All output ports except D+, D-, P0.0	-	-	0.4	
Output low Current	I <sub>OL</sub>	V <sub>OL</sub> = 0.4 V		50 <sup>(4)</sup>		mA
Input high leakage current	I <sub>LIH1</sub>	V <sub>IN</sub> = V <sub>DD</sub> All inputs except I <sub>LIH2</sub> except D+, D-, X <sub>OUT</sub>	-	-	3	μA
	I <sub>LIH2</sub>	V <sub>IN</sub> = V <sub>DD</sub> , X <sub>IN</sub>	-	-	20	
Input low leakage current	I <sub>LIL1</sub>	V <sub>IN</sub> = 0 V All inputs except I <sub>LIL2</sub> except D+, D-, X <sub>OUT</sub>	-	-	-3	
	I <sub>LIL2</sub>	V <sub>IN</sub> = 0 V, X <sub>IN</sub>	-	-	-20	
Output high leakage current	I <sub>LOH</sub>	V <sub>OUT</sub> = V <sub>DD</sub> All output pins except D+, D-	-	-	3	
Output low leakage current	I <sub>LOL</sub>	V <sub>OUT</sub> = 0 V All output pins except D+, D- X <sub>OUT</sub> , P0.0	-	-	-3	
Pull-up resistors	R <sub>L1</sub>	V <sub>IN</sub> = 0 V, V <sub>DD</sub> = 5.0 V, Port 0, Port 1	25	50	100	KΩ
	R <sub>L2</sub>	V <sub>IN</sub> = 0 V, V <sub>DD</sub> = 5.0 V, Port 2	-	4.3	-	
Supply current	I <sub>DD1</sub>	Normal operation mode, V <sub>DD</sub> = 4.0 V-5.25 V 6 MHz, CPU clock	-	6.5	15	mA
	I <sub>DD2</sub>	IDLE mode V <sub>DD</sub> = 4.0 V-5.25 V 6 MHz, CPU clock	-	2	4	
	I <sub>DD3</sub>	Stop mode, oscillator stop V <sub>DD</sub> = 4.0 V-5.25 V	-	13	25	μA

**NOTES:**

1. Supply current does not include current drawn through internal pull-up resistors or external output current load.
2. This parameter is guaranteed, but not tested (include D+, D-).
3. Only in 4.0 V to 5.25 V, D+ and D- satisfy the USB spec 1.0.
4. P0.0 designed for direct LED current sink, see the SNKCON resistor and Figure 1-9 (Page 1-9).

Table 15-3. Input/Output Capacitance

(T<sub>A</sub> = 0°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>	Except X <sub>IN</sub> , X <sub>OUT</sub>				
I/O capacitance	C <sub>IO</sub>					
XI/XO capacitance	C <sub>XI</sub> , C <sub>XO</sub>	X <sub>IN</sub> , X <sub>OUT</sub>	–	33	–	

Table 15-4. A.C. Electrical Characteristics

(T<sub>A</sub> = 0°C to +85°C, V<sub>DD</sub> = 4.0 V to 5.25 V)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Noise filter	t <sub>NF1H</sub> , t <sub>NF1L</sub>	P1 (RC delay)	100	–	200	ns

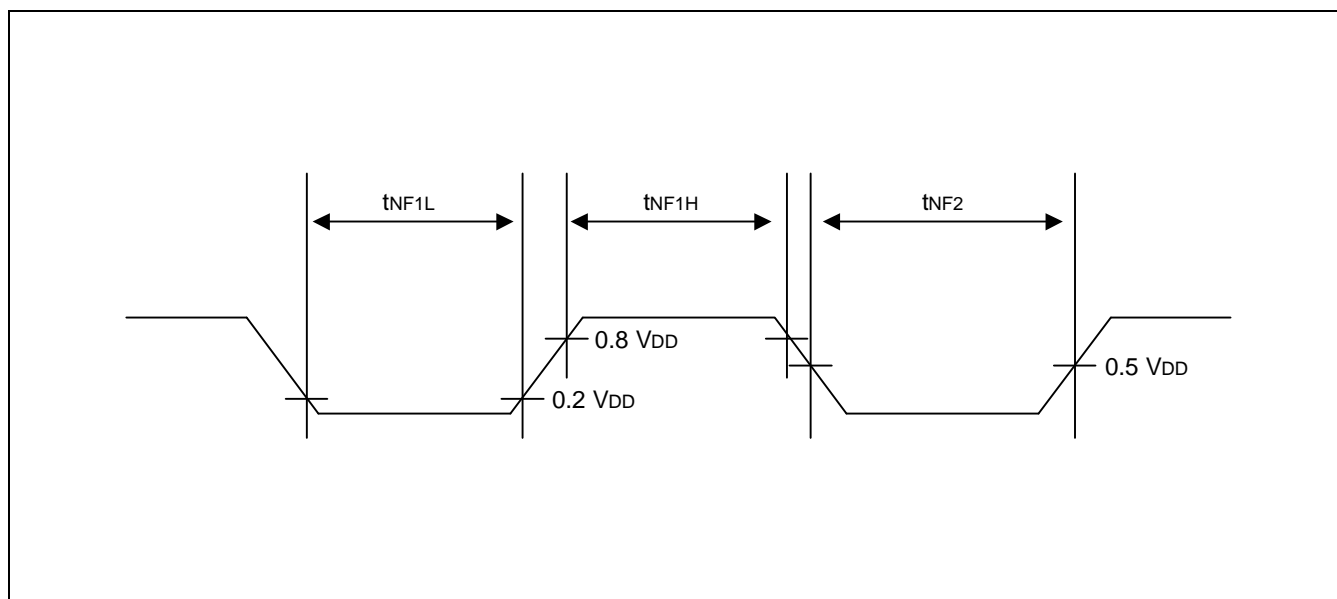


Figure 15-1. Noise Filter Timing Measurement Points

Table 15-5. Oscillator Characteristics

(T<sub>A</sub> = 0°C + 85°C)

Oscillator	Clock Circuit	Test Condition	Min	Typ	Max	Unit
Main crystal Main ceramic (f <sub>osc</sub> )		Oscillation frequency V <sub>DD</sub> = 4.0 V–5.25 V	–	6.0	–	MHz
External clock		Oscillation frequency V <sub>DD</sub> = 4.0 V–5.25 V	–	6.0	–	MHz
RC oscillator		Oscillation frequency V <sub>DD</sub> = 5.0 V R = 22.6 K R = 8.8 K R = 3.2 K	– – –	1.0 2.0 4.0	– – –	MHz

Table 15-6. Oscillation Stabilization Time

(T<sub>A</sub> = 0°C + 85°C, V<sub>DD</sub> = 4.0 V to 5.25 V)

Oscillator	Test Condition	Min	Typ	Max	Unit
Main crystal	V <sub>DD</sub> = 4.0 V to 5.25 V, f <sub>OSC</sub> > 6.0 MHz (Oscillation stabilization occurs when V <sub>DD</sub> is equal to the minimum oscillator voltage range.)	–	–	10	ms
Main ceramic					
Oscillator	t <sub>WAIT</sub> stop mode release time by a reset	–	2 <sup>16</sup> /f <sub>OSC</sub>	–	
stabilization wait time	t <sub>WAIT</sub> stop mode release time by an interrupt	–	–	–	

**NOTE:** The oscillator stabilization wait time, t<sub>WAIT</sub>, when it is released by an interrupt, is determined by the setting in the basic timer control register, BTCON.

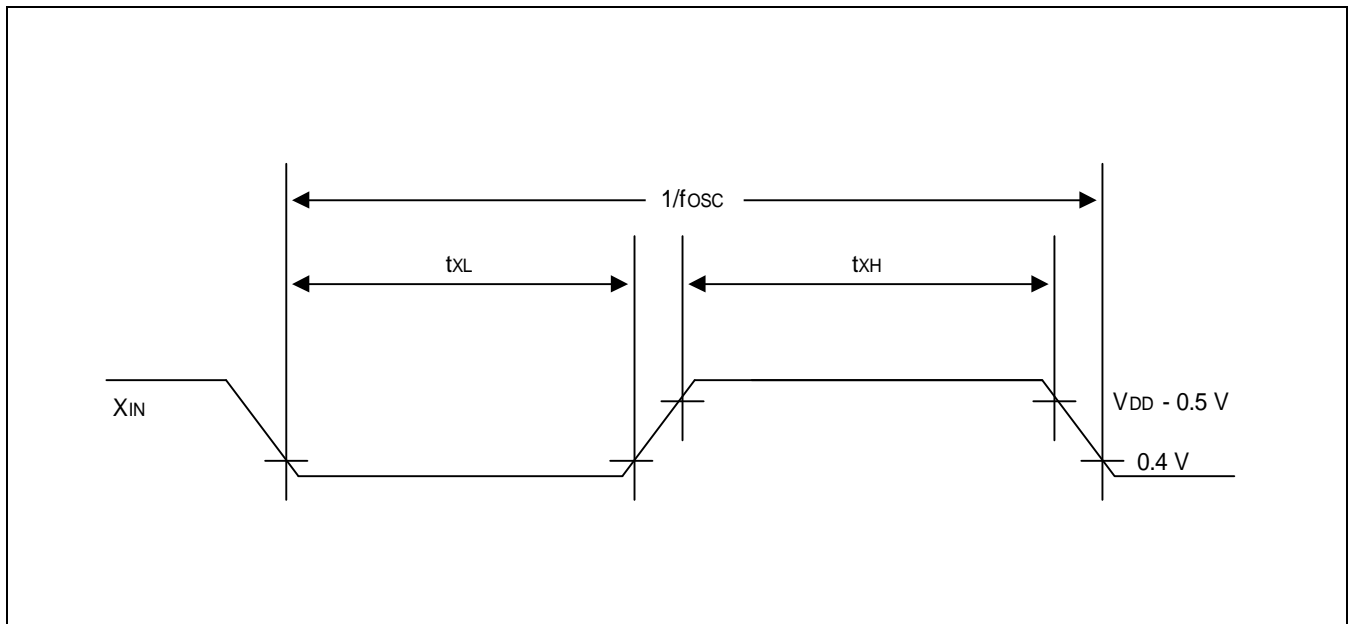
Figure 15-2. Clock Timing Measurement Points at  $X_{IN}$ 

Table 15-7. Data Retention Supply Voltage in Stop Mode

(T<sub>A</sub> = 0°C to +70°C)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Data retention supply voltage	$V_{DDDR}$	Stop mode	2.0	–	6	V
Data retention supply current	$I_{DDDR}$	Stop mode; $V_{DDDR} = 2.0 V$	–	–	5	$\mu A$

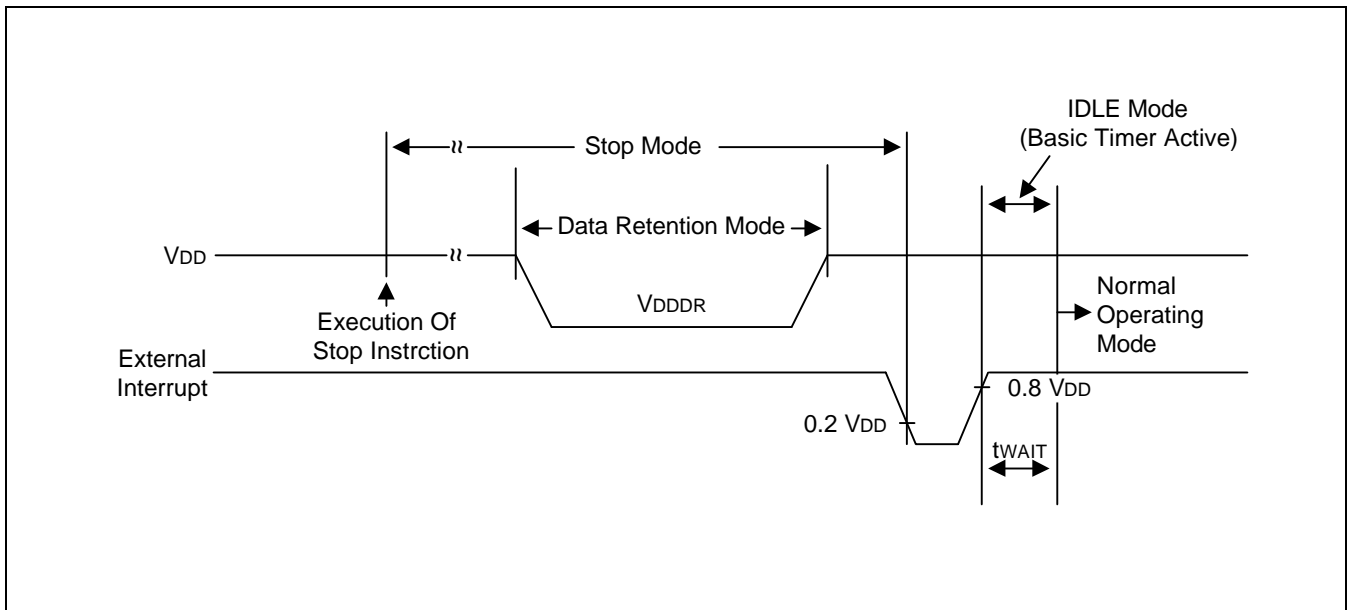


Figure 15-3. Stop Mode Release Timing When Initiated by an External Interrupt

Table 15-8. Comparator Electrical Characteristics

( $T_A = 0^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{DD} = 4.0\text{ V}$  to  $5.25\text{ V}$ )

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Conversion time (1)	tCON	–	–	6 × 12 or 6 × 192	–	f <sub>CPU</sub>
Comparator input voltage	V <sub>ICN</sub>	–	V <sub>SS</sub>	–	V <sub>DD</sub>	V
Comparator input impedance	R <sub>CN</sub>	–	2	1000	–	MΩ
Comparator reference voltage	V <sub>REF</sub>	–	1.8	–	V <sub>DD</sub>	V
Comparator input current	I <sub>CIN</sub>	V <sub>DD</sub> = 5 V	–3	–	3	μA
Reference input current	I <sub>REF</sub>	V <sub>DD</sub> = 5 V	–3	–	3	μA
Comparator block current (2)	I <sub>COM</sub>	V <sub>DD</sub> = 5.5 V	–	1	2	mA
		V <sub>DD</sub> = 4.5 V		0.5	1	mA
		V <sub>DD</sub> = 5 V (when power down mode)		100	500	nA

**NOTES:**

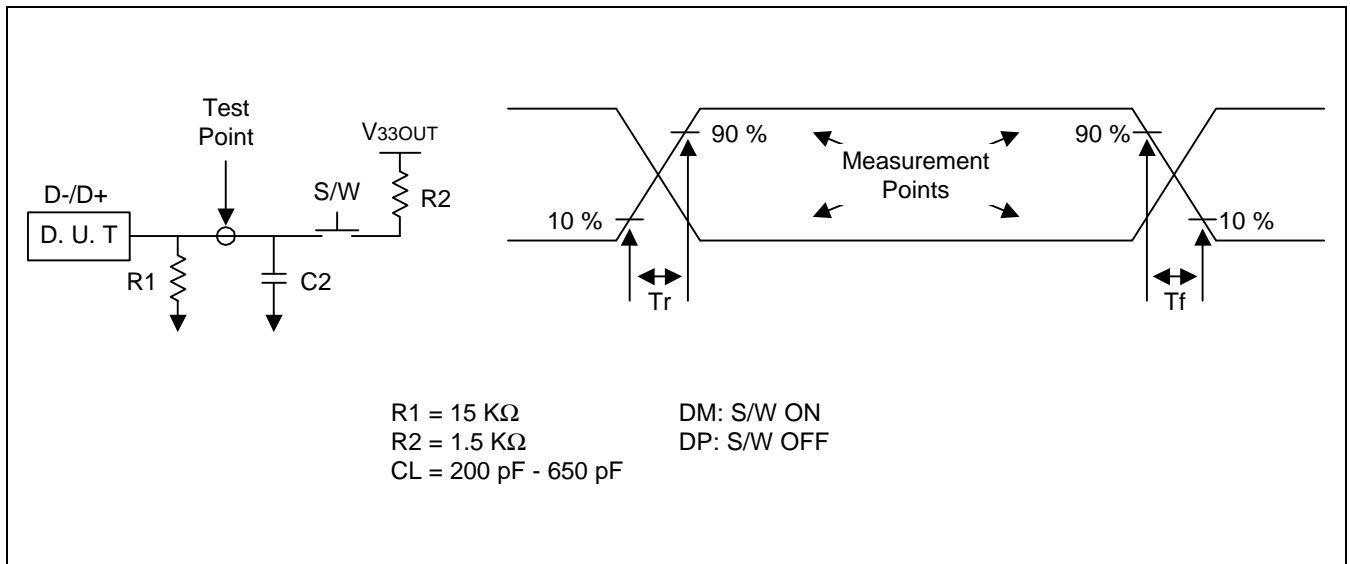
1. Conversion time is the time required from the moment a conversion operation starts until it ends.
2. I<sub>COM</sub> is an operating current during conversion.



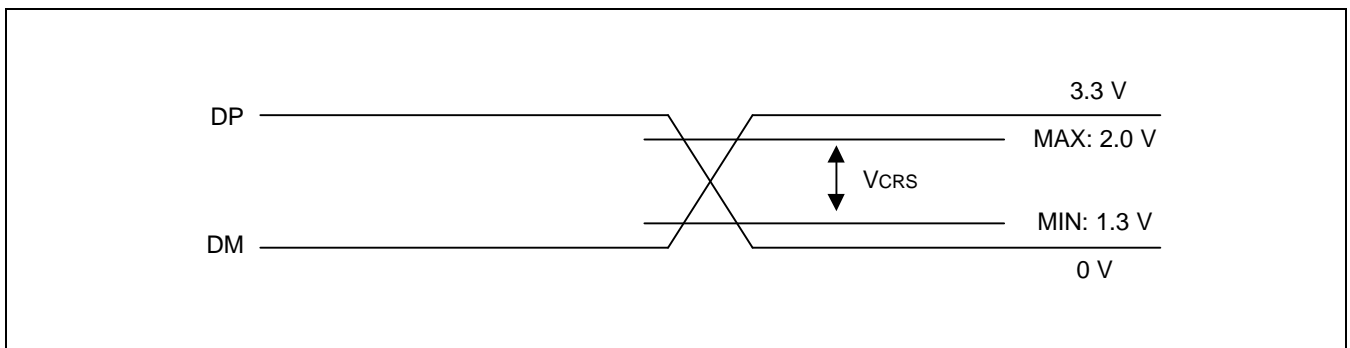
**Table 15-9. Low Speed Source Electrical Characteristics (USB)**

( $T_A = 0^\circ\text{C}$  to  $+85^\circ\text{C}$ , Internal Voltage Regulator Output  $V_{33\text{OUT}} = 2.8\text{ V}$  to  $3.6\text{ V}$ , typ  $3.3\text{ V}$ )

Parameter	Symbol	Conditions	Min	Max	Unit
Transition Time:					
Rise Time	$T_r$	$CL = 200\text{ pF}$	75	–	ns
		$CL = 650\text{ pF}$	–	300	
Fall Time	$T_f$	$CL = 200\text{ pF}$	75	–	
		$CL = 650\text{ pF}$	–	300	
Rise/Fall Time Matching	$T_{rfm}$	$(T_r/T_f) CL = 50\text{ pF}$	80	125	%
Output Signal Crossover Voltage	$V_{crs}$	$CL = 50\text{ pF}$	1.3	2.0	V
Internal Voltage Regulator Output Voltage	$V_{33\text{OUT}}$	$V_{DD} = 4.0 - 5.25\text{ V}$	2.8	3.6	V



**Figure 15-4. USB Data Signal Rise and Fall Time**



**Figure 15-5. USB Output Signal Crossover Point Voltage**

# 16 MECHANICAL DATA

## OVERVIEW

This section contains the following information about the device package:

- Package dimensions in millimeters
- Pad diagram

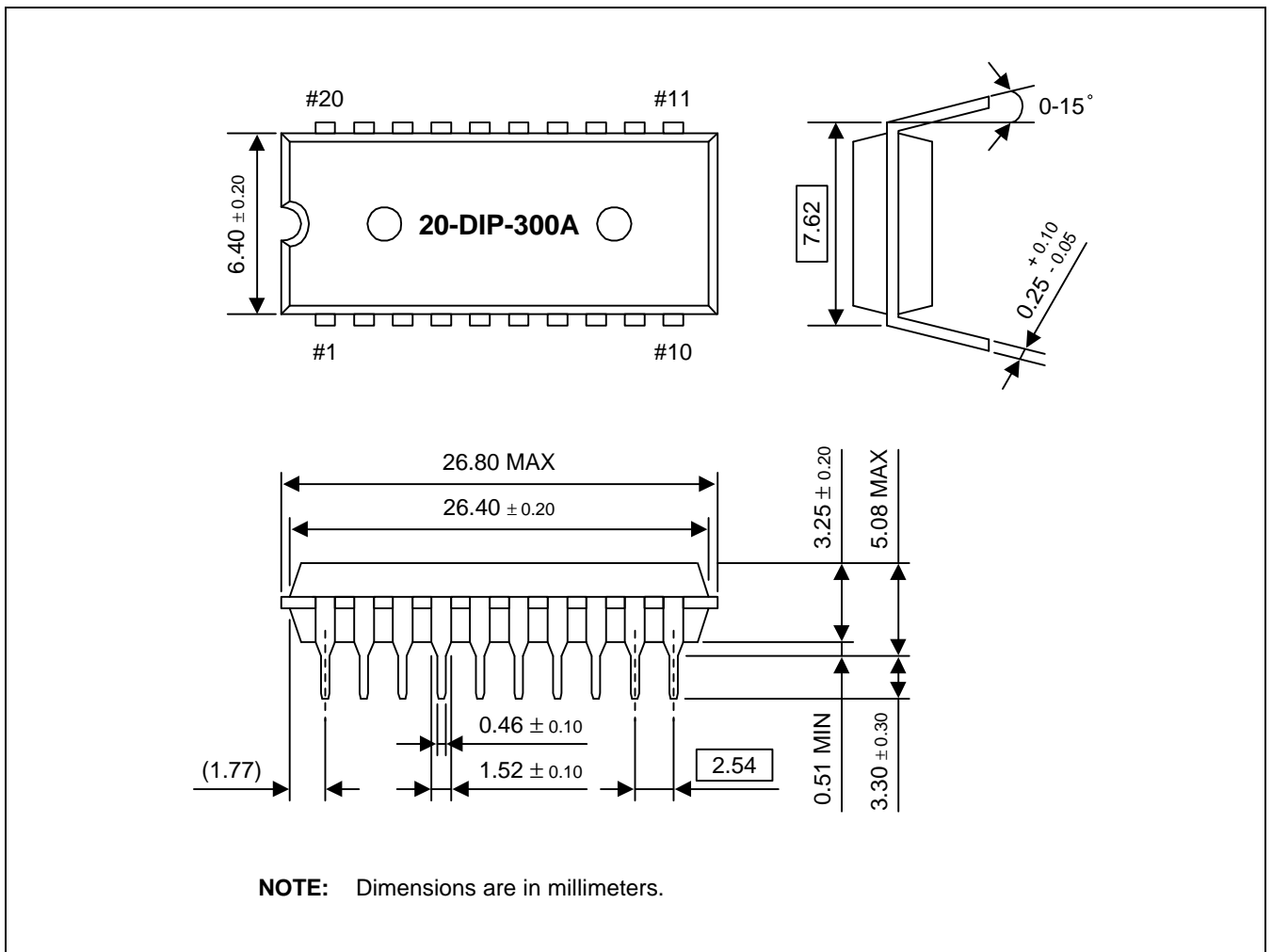


Figure 16-1. 20-DIP 300A Package Dimensions

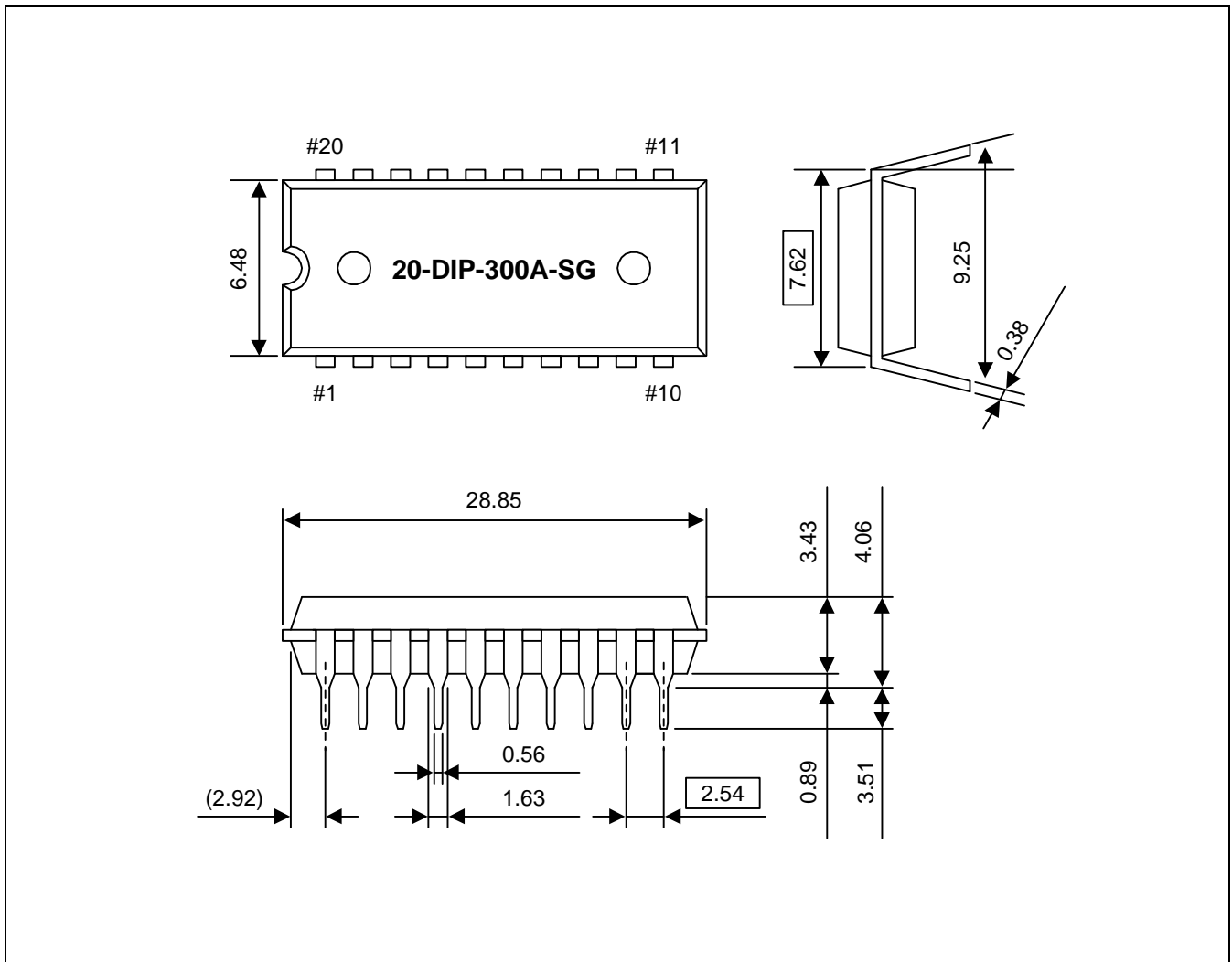


Figure 16-2. 20-DIP-300A-SG Package Dimensions

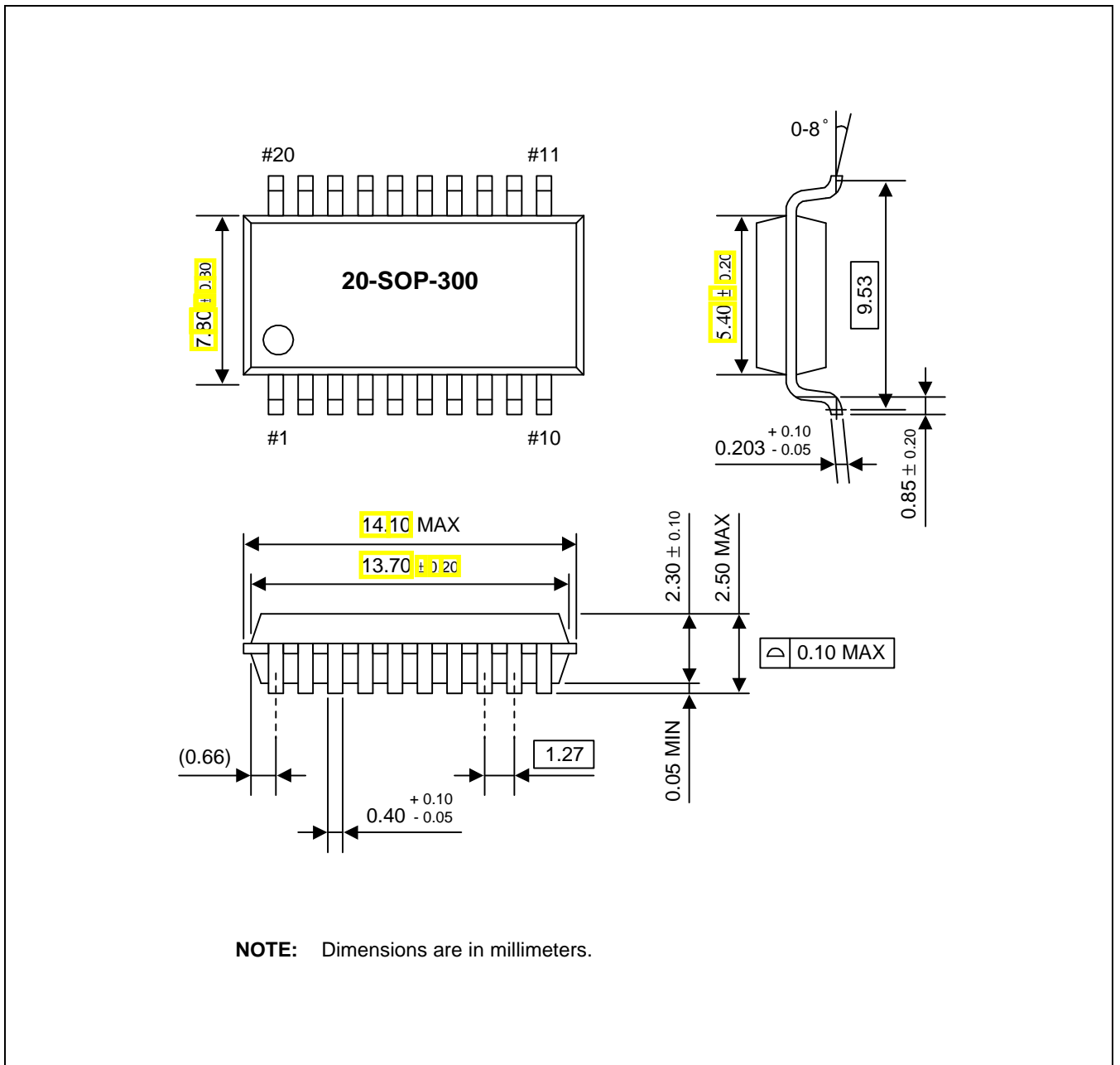


Figure 16-3. 20-SOP-300 Package Dimensions

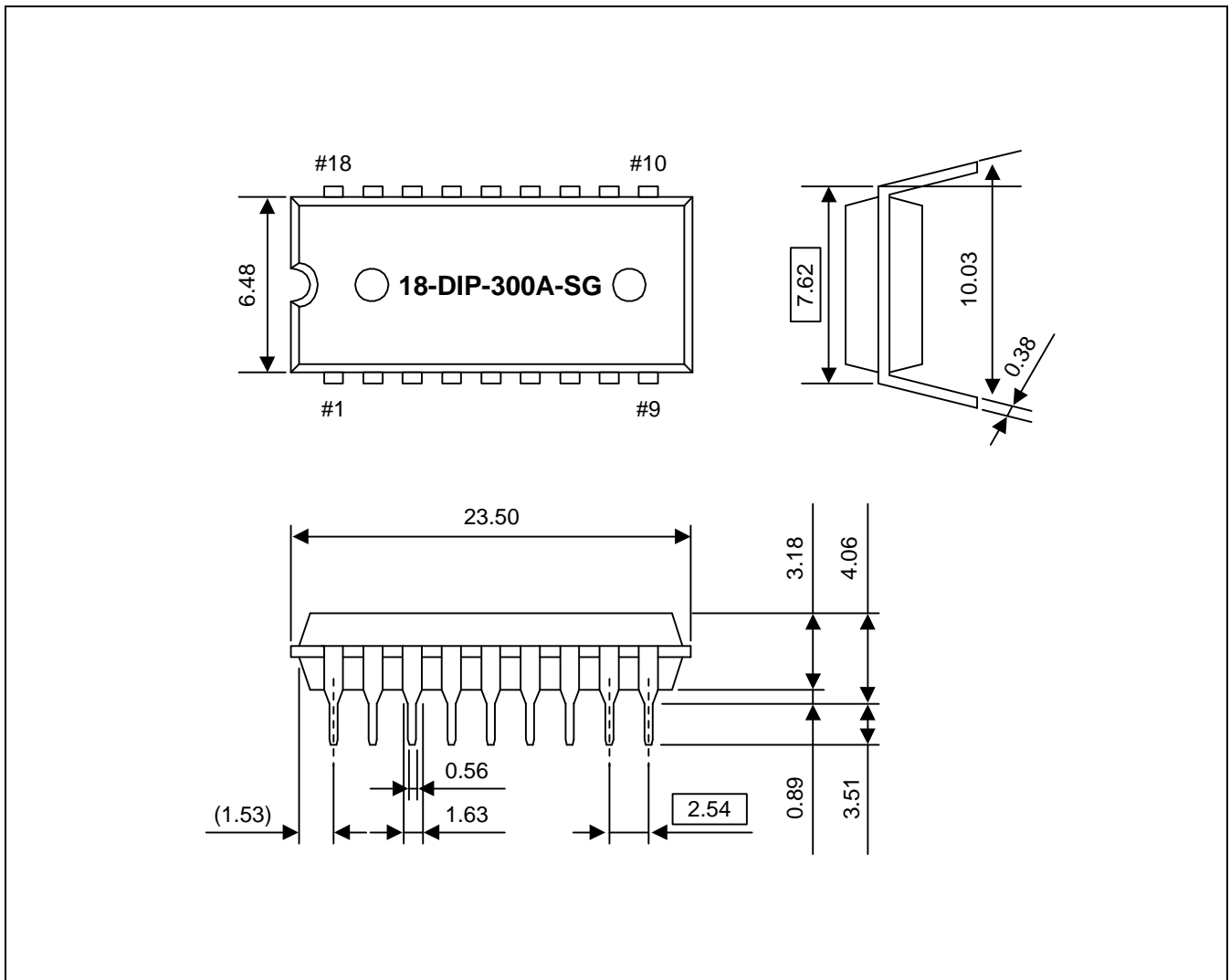


Figure 16-4. 18-DIP-300A-SG Package Dimensions

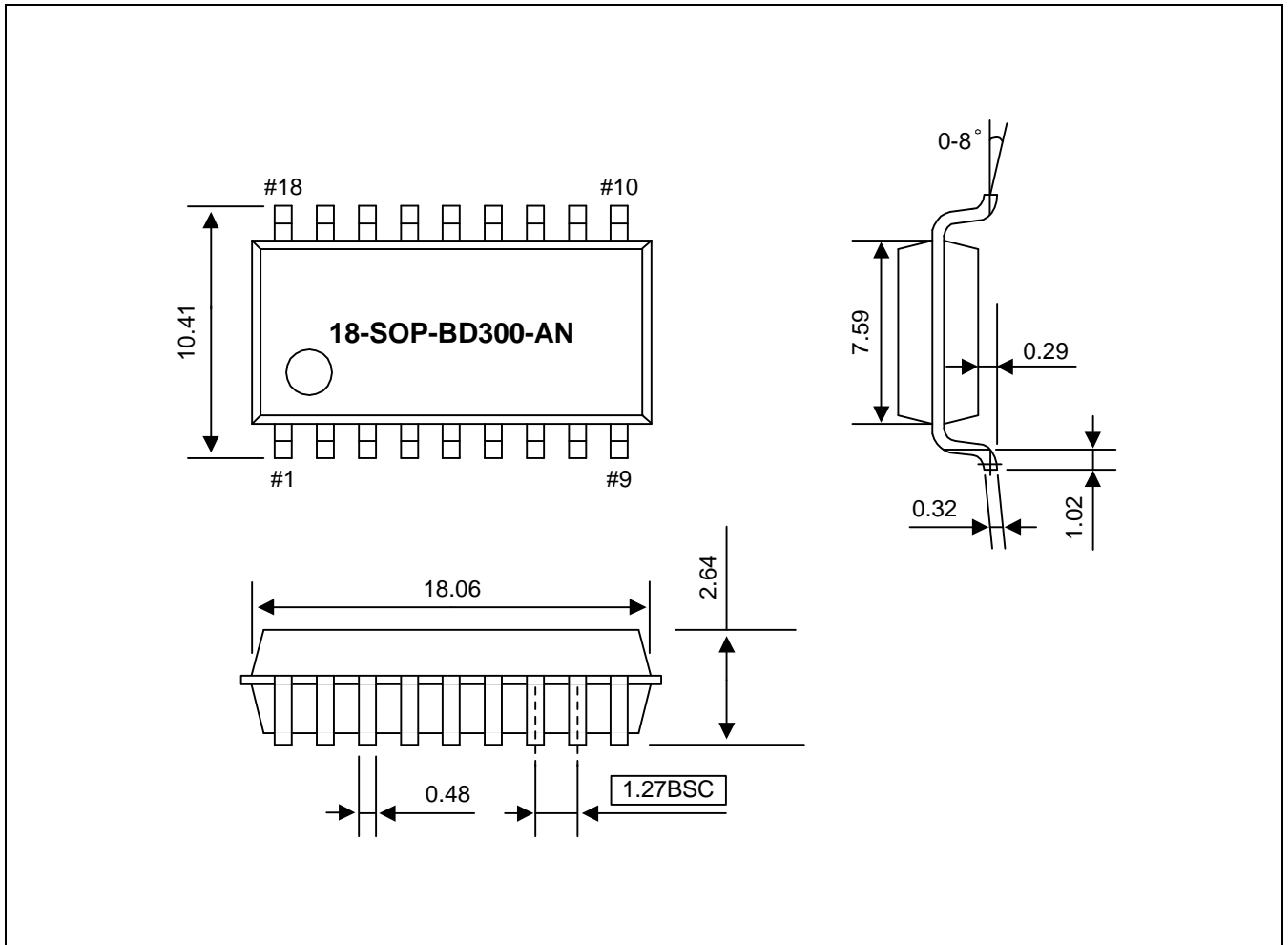


Figure 16-5. 18-SOP-BD300-AN Package Dimensions

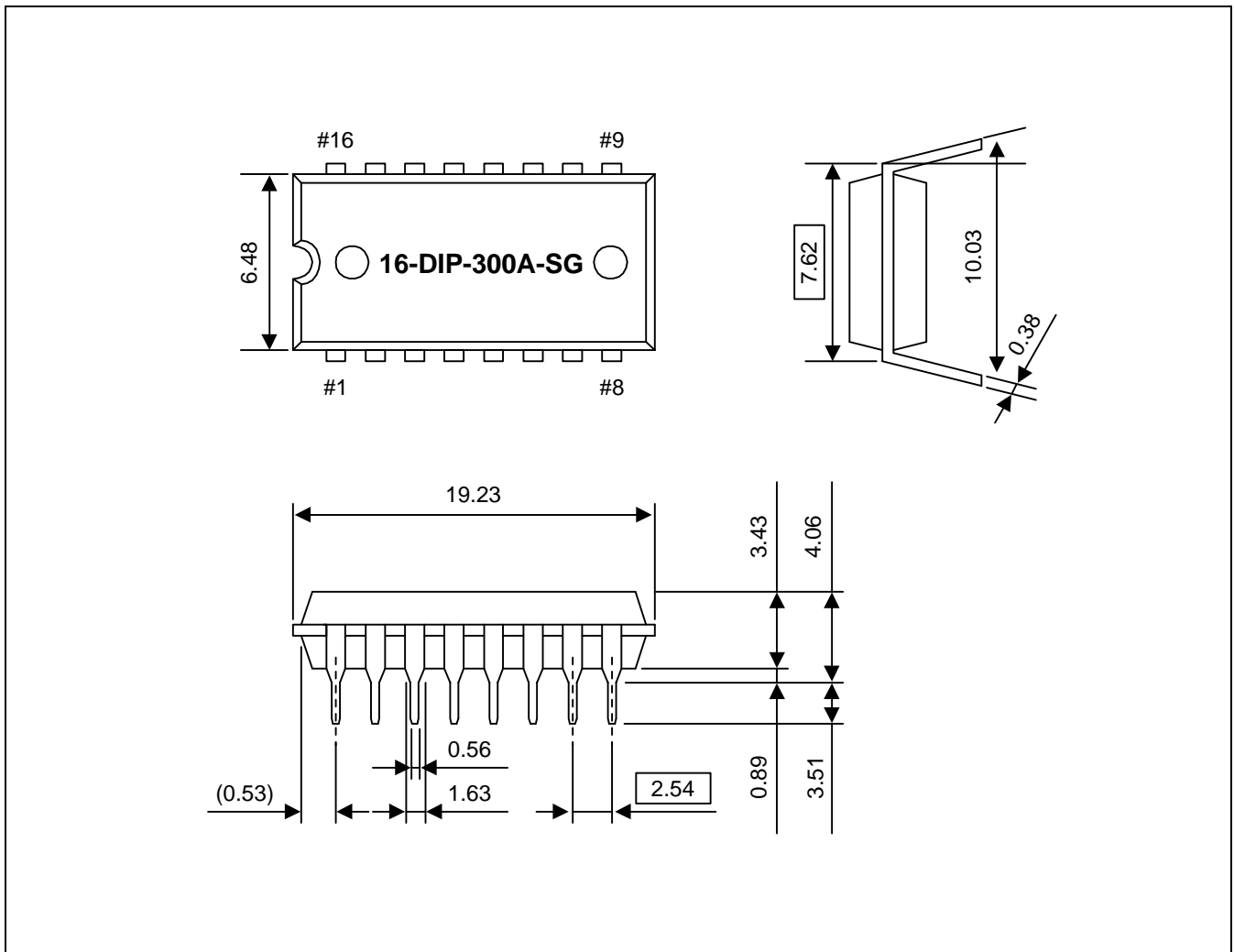


Figure 16-6. 16-DIP-300A-SG Package Dimensions

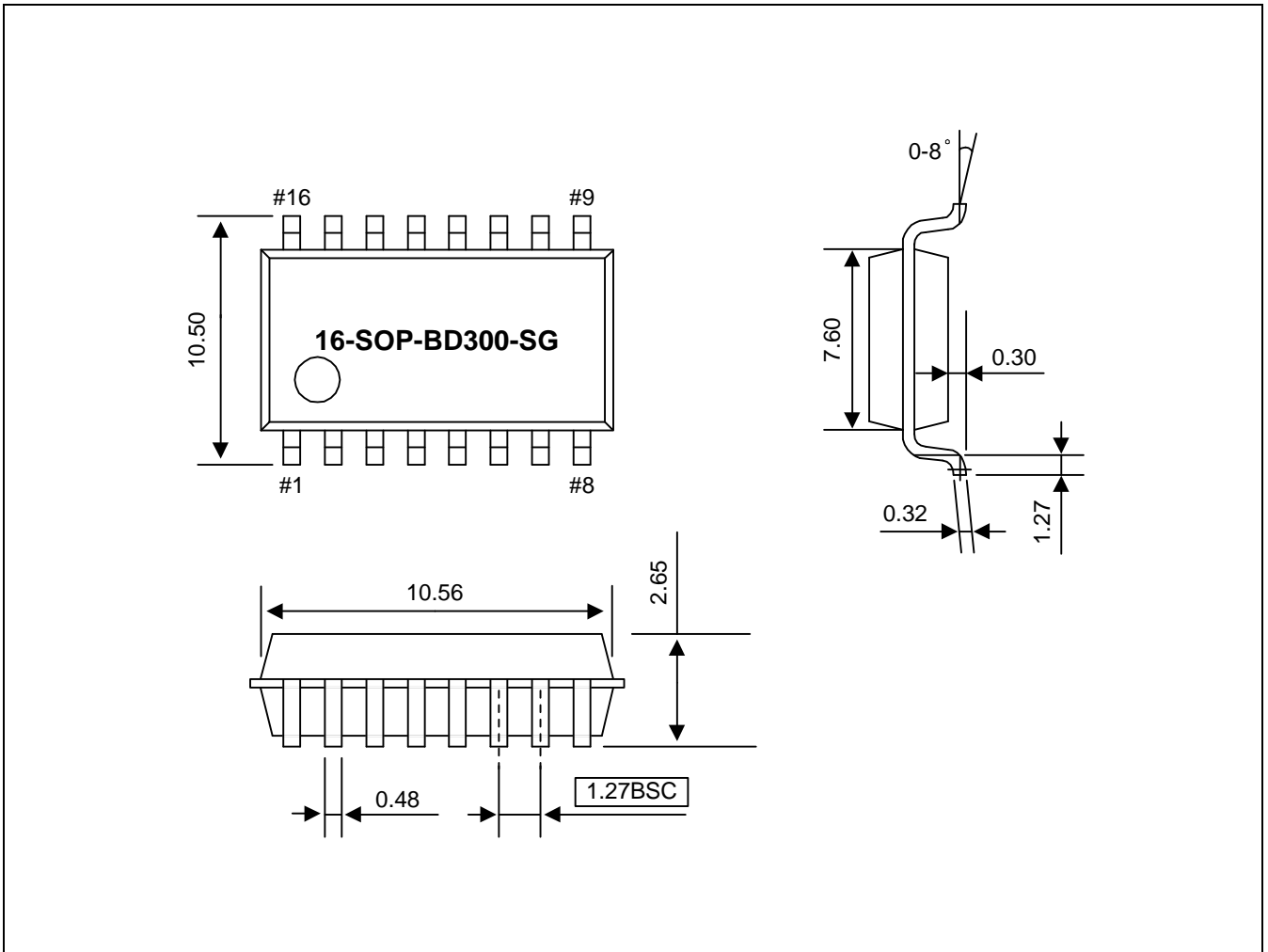


Figure 16-7. 16-SOP-BD300-SG Package Dimensions



# 17

## S3P9658 OTP

### OVERVIEW

The S3P9658 single-chip CMOS microcontroller is the OTP (One Time Programmable) version of the S3P9658 microcontroller. It has an on-chip OTP ROM instead of masked ROM. The EPROM is accessed by serial data format.

The S3P9658 is fully compatible with the S3P9658, both in function and in pin configuration. Because of its simple programming requirements, the S3P9658 is ideal for use as an evaluation chip for the S3P9658.

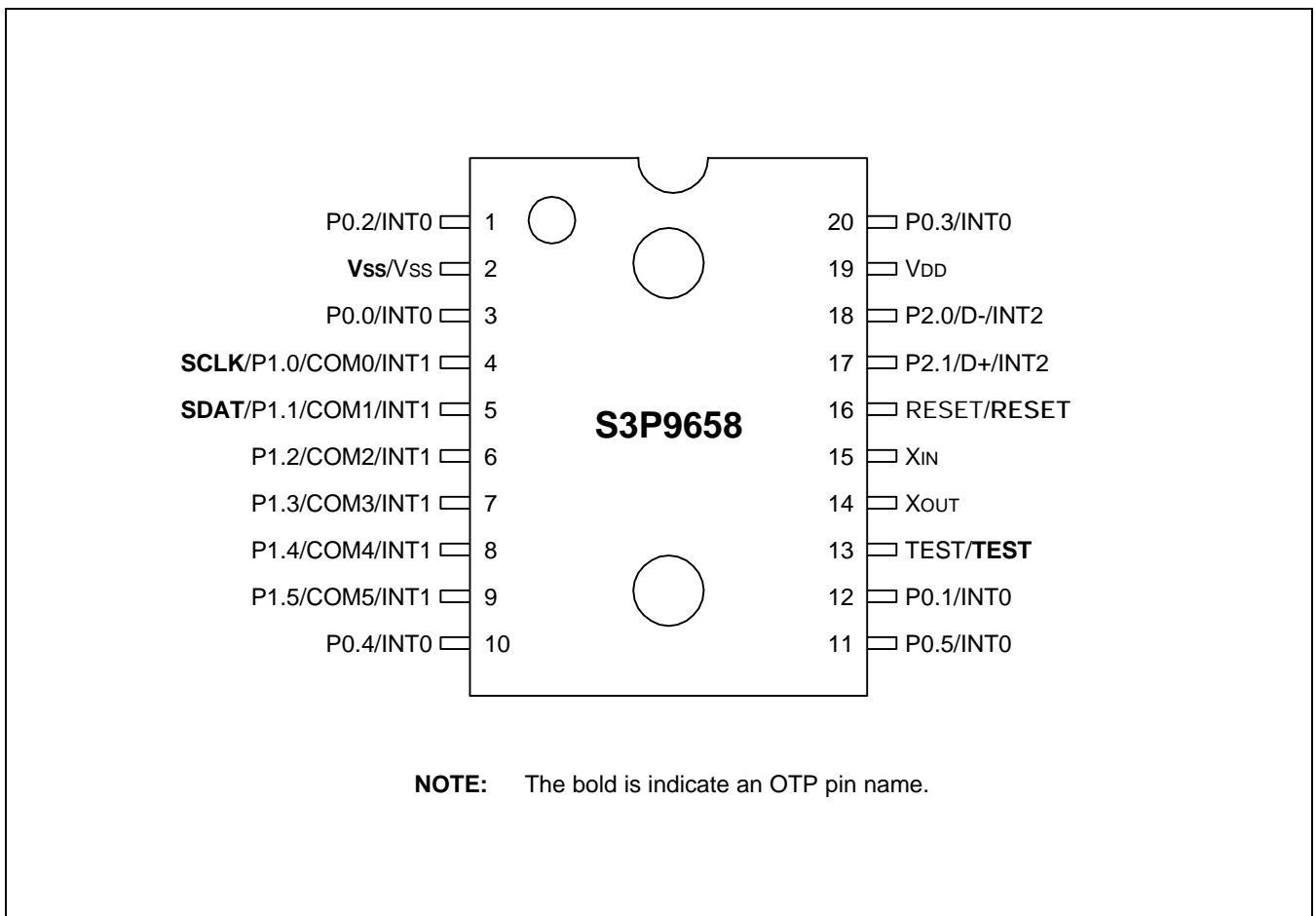


Figure 17-1. S3P9658 Pin Assignments (20 Pin)

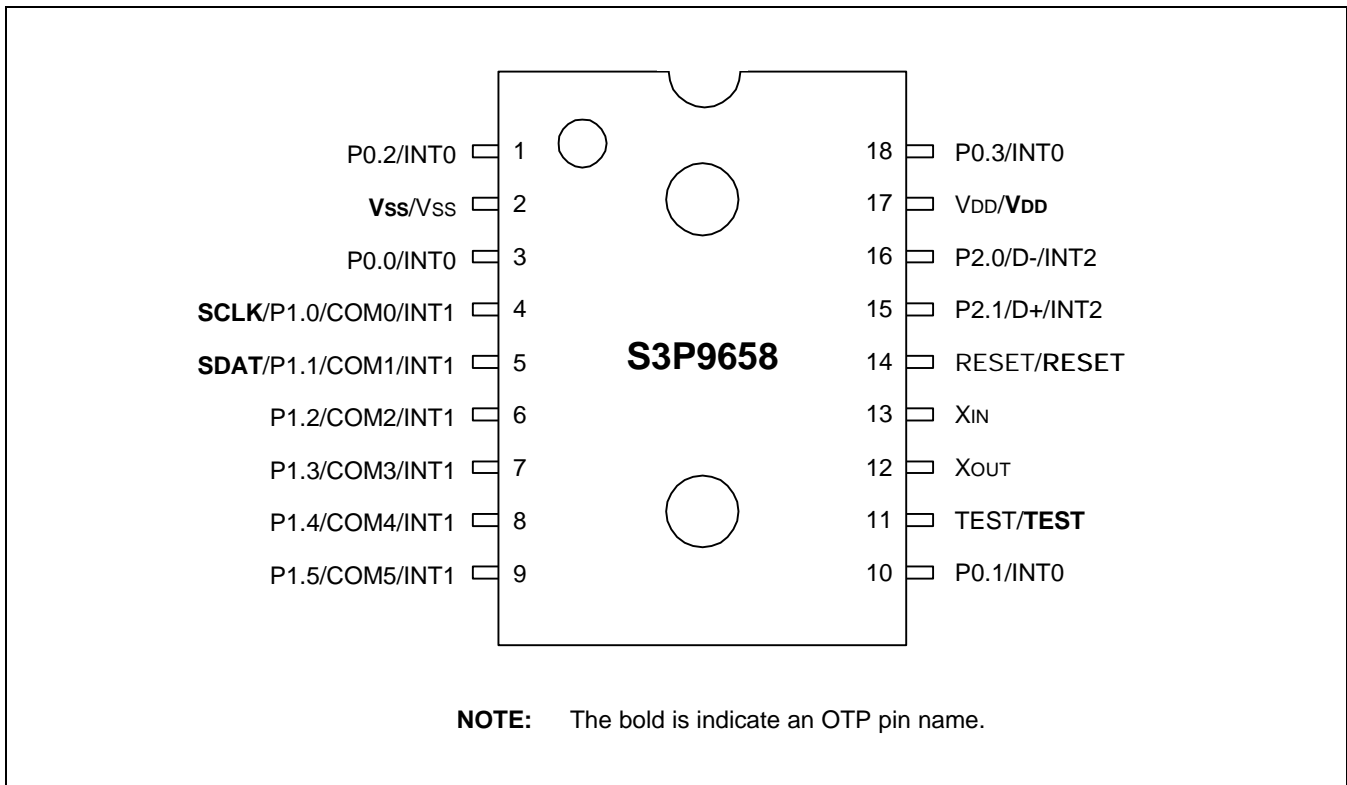


Figure 17-2. S3P9658 Pin Assignments (18 Pin)

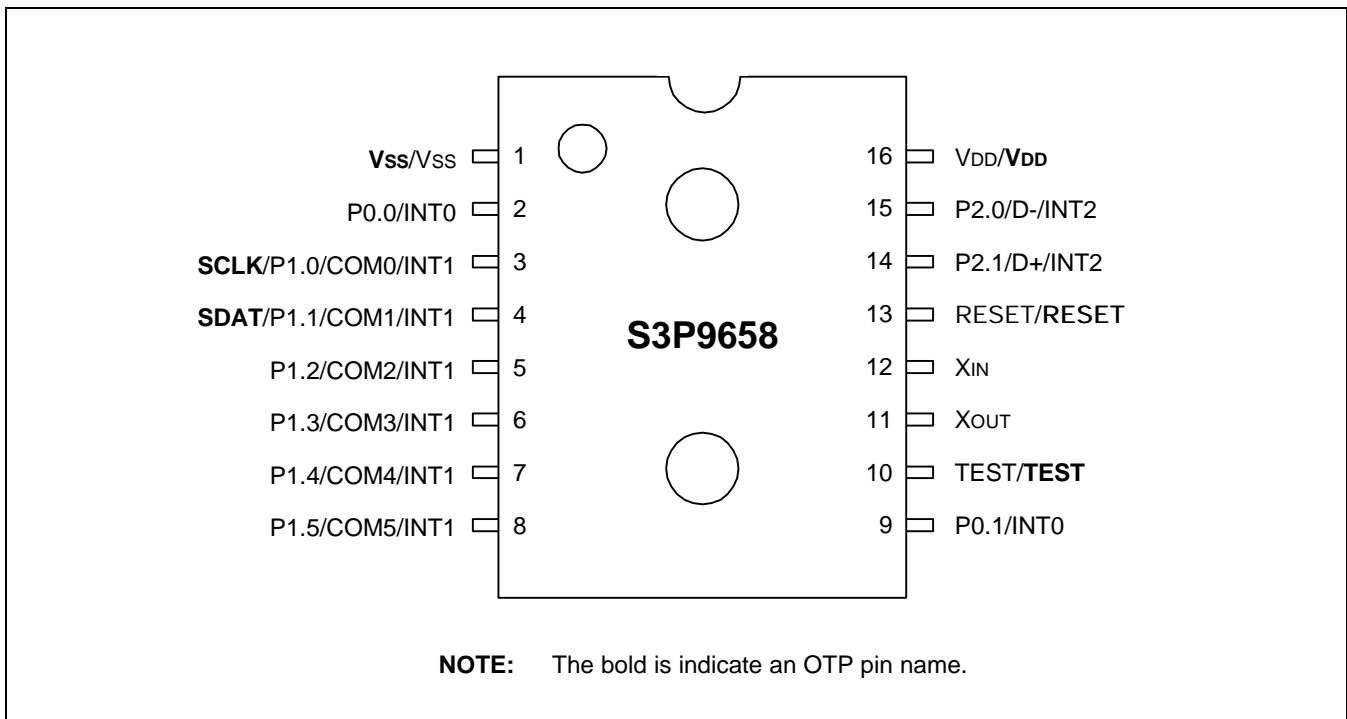


Figure 17-3. S3P9658 Pin Assignments (16 Pin)

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

Main Chip Pin Name	During Programming			
	Pin Name	Pin Number (20 DIP)	I/O	Function
P1.0	SDAT	5	I/O	Serial Data Pin (Output when reading, Input when writing) Input and Push-pull Output Port can be assigned
P1.1	SCLK	4	I/O	Serial Clock Pin (Input Only Pin)
RESET	RESET	16	I	0 V : OTP write and test mode 5 V : Operating mode
TEST	V <sub>PP</sub> (TEST)	13	I	Chip Initialization and EPROM Cell Writing Power Supply Pin (Indicates OTP Mode Entering) When writing 12.5 V is applied and when reading.
V <sub>DD</sub> /V <sub>SS</sub>	V <sub>DD</sub> /V <sub>SS</sub>	19/2	I	Logic Power Supply Pin.

Table 17-2. Comparison of S3P9658 and S3C9654/C9658 Features

Characteristic	S3P9658	S3C9654/C9658
Program Memory	8 K-byte EPROM	4/8 K-byte mask ROM
Operating Voltage (V <sub>DD</sub> )	4.0 V to 5.25 V	4.0 V to 5.25 V
OTP Programming Mode	V <sub>DD</sub> = 5 V, V <sub>PP</sub> (TEST) = 12.5 V	
Pin Configuration	20/18/16 DIP, 20/18/16 SOP	20/18/16 DIP, 20/18/16 SOP, 16SSOP
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> (RESET) pin of the S3P9658, 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 14-3 below.

Table 17-3. Operating Mode Selection Criteria

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