

## Features

- MPEG I/II-Layer 3 Hardwired Decoder
  - Stand-alone MP3 Decoder
  - 48, 44.1, 32, 24, 22.05, 16 kHz Sampling Frequency
  - Separated Digital Volume Control on Left and Right Channels (Software Control using 31 Steps)
  - Bass, Medium, and Treble Control (31 Steps)
  - Bass Boost Sound Effect
  - Ancillary Data Extraction
  - CRC Error and MPEG Frame Synchronization Indicators
- Programmable Audio Output for Interfacing with Common Audio DAC
  - PCM Format Compatible
  - I<sup>2</sup>S Format Compatible
- 8-bit MCU C51 Core Based ( $F_{MAX} = 20$  MHz)
- 2304 Bytes of Internal RAM
- 64K Bytes of Code Memory
  - AT89C51SND1C: Flash (100K Erase/Write Cycles)
  - AT83C51SND1C: ROM
- 4K Bytes of Boot Flash Memory (AT89C51SND1C)
  - ISP: Download from USB or UART
- USB Rev 1.1 Controller
  - Full Speed Data Transmission
- Built-in PLL
  - MP3 Audio Clocks
  - USB Clock
- MultiMedia Card<sup>®</sup> Interface Compatibility
- Atmel DataFlash<sup>®</sup> SPI Interface Compatibility
- IDE/ATAPI Interface
- 2 Channels 10-bit ADC, 8 kHz (8-true bit)
  - Battery Voltage Monitoring
  - Voice Recording Controlled by Software
- Up to 44 Bits of General-purpose I/Os
  - 4-bit Interrupt Keyboard Port for a 4 x n Matrix
  - SmartMedia<sup>®</sup> Software Interface
- 2 Standard 16-bit Timers/Counters
- Hardware Watchdog Timer
- Standard Full Duplex UART with Baud Rate Generator
- Two Wire Master and Slave Modes Controller
- SPI Master and Slave Modes Controller
- Power Management
  - Power-on Reset
  - Software Programmable MCU Clock
  - Idle Mode, Power-down Mode
- Operating Conditions:
  - 3V,  $\pm 10\%$ , 25 mA Typical Operating at 25°C
  - Temperature Range: -40°C to +85°C
- Packages
  - TQFP80, BGA81, PLCC84 (Development Board)
  - Dice

## Description

The AT8xC51SND1C are fully integrated stand-alone hardwired MPEG I/II-Layer 3 decoder with a C51 microcontroller core handling data flow and MP3-player control.

The AT89C51SND1C includes 64K Bytes of Flash memory and allows In-System Programming through an embedded 4K Bytes of Boot Flash memory.



## Single-Chip Flash Microcontroller with MP3 Decoder and Human Interface

AT83C51SND1C  
AT89C51SND1C

## Preliminary Summary

Rev. 4109ES-8051-06/03



This is a summary document. A complete document is available on the Atmel web site.

The AT83C51SND1C includes 64K Bytes of ROM memory.

The AT8xC51SND1C include 2304 Bytes of RAM memory.

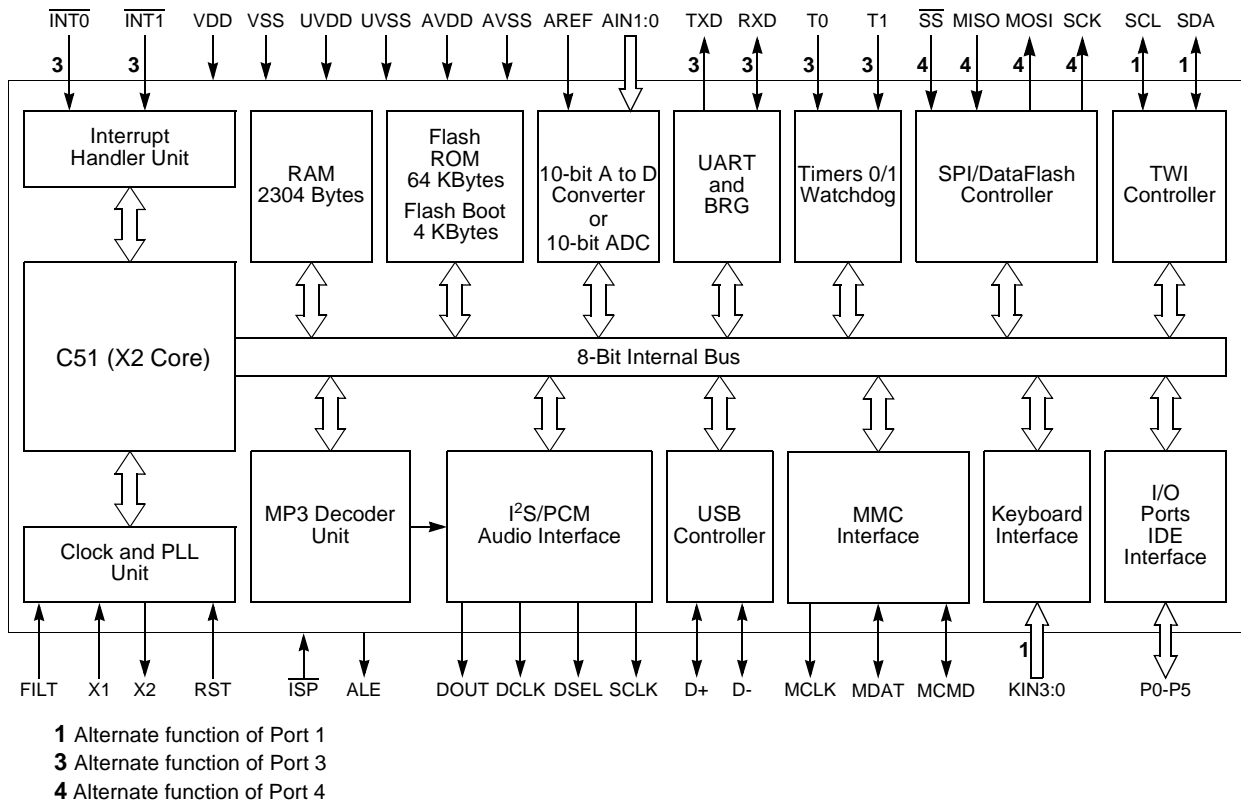
The AT8xC51SND1C provides the necessary features for human interface like timers, keyboard port, serial or parallel interface (USB, TWI, SPI, IDE), ADC input, I<sup>2</sup>S output, and all external memory interface (NAND or NOR Flash, SmartMedia, MultiMedia, DataFlash cards).

## Typical Applications

- MP3-Player
- PDA, Camera, Mobile Phone MP3
- Car Audio/Multimedia MP3
- Home Audio/Multimedia MP3

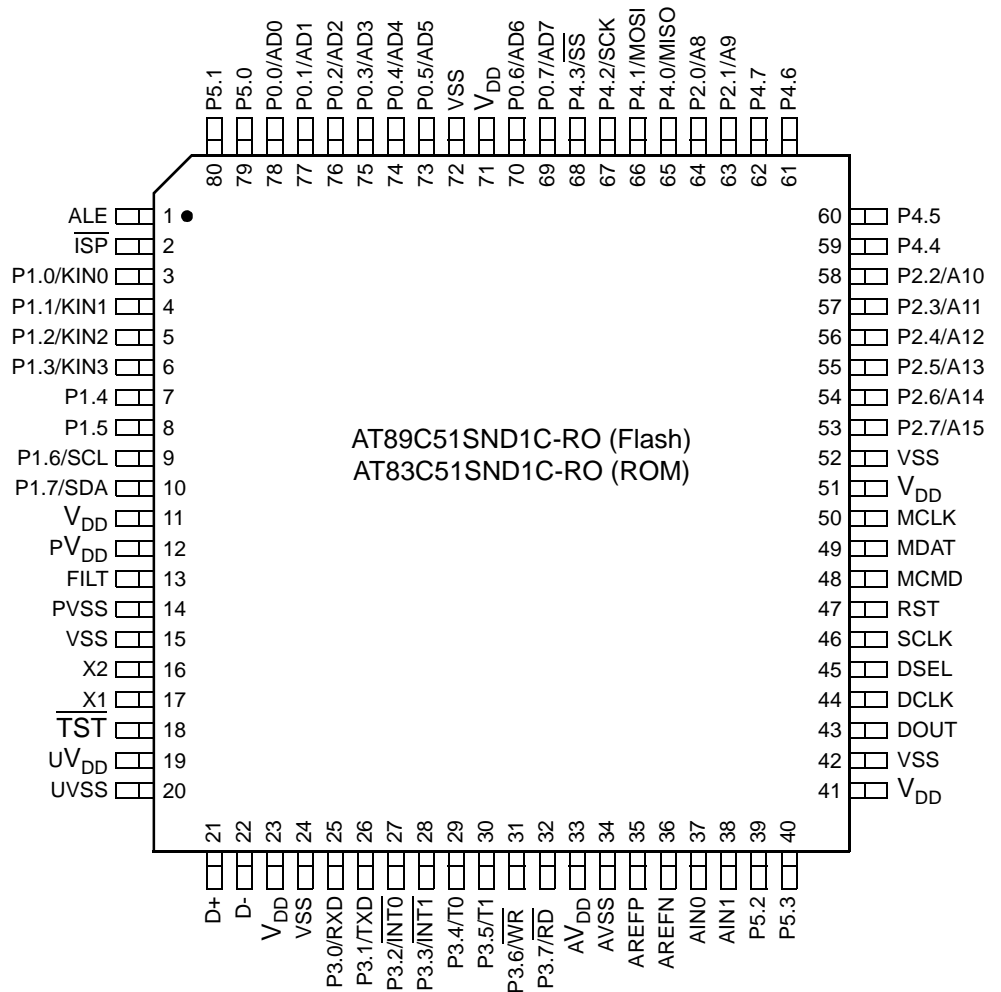
## Block Diagram

Figure 1. AT8xC51SND1C Block Diagram

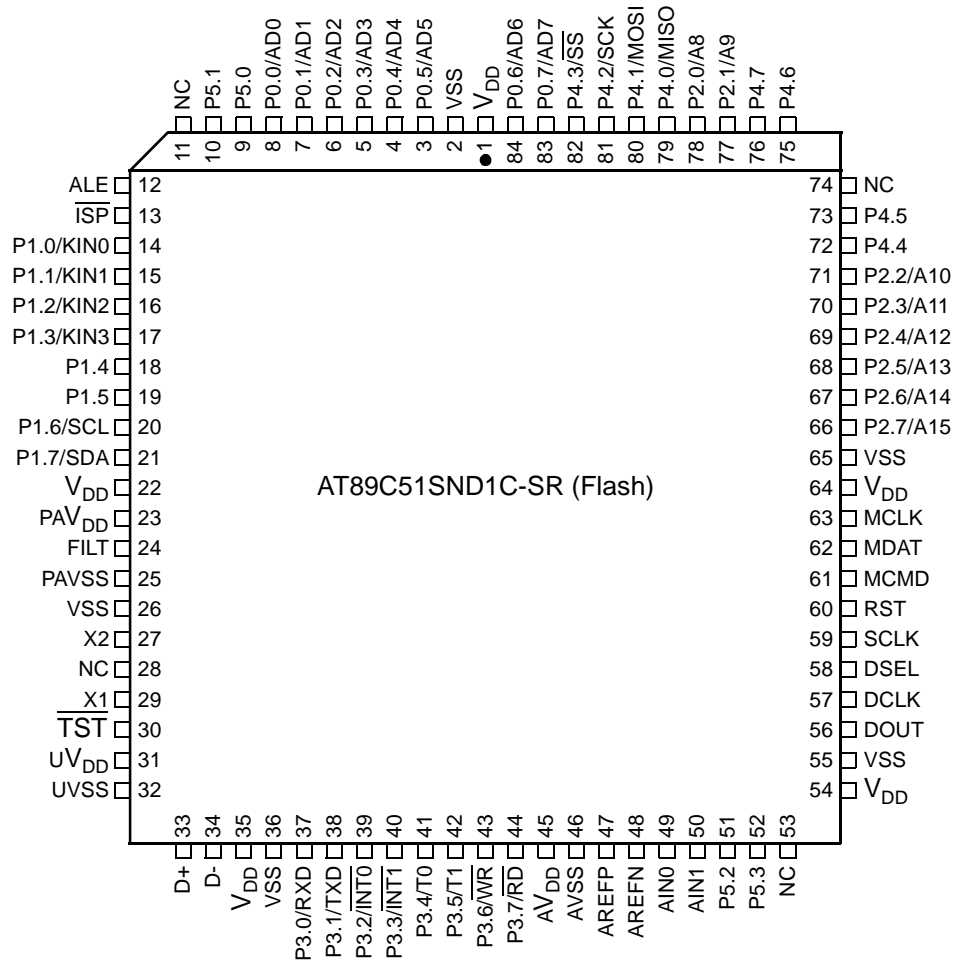


## Pin Descriptions

Figure 2. AT8xC51SND1C, 80-pin TQFP Package



**Figure 3. AT8xC51SND1C 84-pin PLCC Package<sup>(1)</sup>**



Note: 1. Only samples for development board.

## Pin Descriptions

All AT8xC51SND1C signals are detailed by functionality in Table 1 through Table 14.

**Table 1. Ports Signal Description**

Signal Name	Type	Description	Alternate Function
P0.7:0	I/O	<b>Port 0</b> P0 is an 8-bit open-drain bi-directional I/O port. Port 0 pins that have 1s written to them float and can be used as high impedance inputs. To avoid any parasitic current consumption, floating P0 inputs must be polarized to $V_{DD}$ or $V_{SS}$ .	AD7:0
P1.7:0	I/O	<b>Port 1</b> P1 is an 8-bit bi-directional I/O port with internal pull-ups.	KIN3:0 SCL SDA

**Table 1. Ports Signal Description (Continued)**

Signal Name	Type	Description	Alternate Function
P2.7:0	I/O	<b>Port 2</b> P2 is an 8-bit bi-directional I/O port with internal pull-ups.	A15:8
P3.7:0	I/O	<b>Port 3</b> P3 is an 8-bit bi-directional I/O port with internal pull-ups.	RXD TXD $\overline{\text{INT0}}$ INT1 T0 T1 $\overline{\text{WR}}$ $\overline{\text{RD}}$
P4.7:0	I/O	<b>Port 4</b> P4 is an 8-bit bi-directional I/O port with internal pull-ups.	MISO MOSI SCK $\overline{\text{SS}}$
P5.3:0	I/O	<b>Port 5</b> P5 is a 4-bit bi-directional I/O port with internal pull-ups.	-

**Table 2. Clock Signal Description**

Signal Name	Type	Description	Alternate Function
X1	I	<b>Input to the on-chip inverting oscillator amplifier</b> To use the internal oscillator, a crystal/resonator circuit is connected to this pin. If an external oscillator is used, its output is connected to this pin. X1 is the clock source for internal timing.	-
X2	O	<b>Output of the on-chip inverting oscillator amplifier</b> To use the internal oscillator, a crystal/resonator circuit is connected to this pin. If an external oscillator is used, leave X2 unconnected.	-
FILT	I	<b>PLL low pass filter input</b> FILT receives the RC network of the PLL low pass filter.	-

**Table 3. Timer 0 and Timer 1 Signal Description**

Signal Name	Type	Description	Alternate Function
$\overline{\text{INT0}}$	I	<b>Timer 0 Gate Input</b> INT0 serves as external run control for timer 0, when selected by GATE0 bit in TCON register. <b>External Interrupt 0</b> INT0 input sets IE0 in the TCON register. If bit IT0 in this register is set, bit IE0 is set by a falling edge on INT0. If bit IT0 is cleared, bit IE0 is set by a low level on INT0.	P3.2
$\overline{\text{INT1}}$	I	<b>Timer 1 Gate Input</b> INT1 serves as external run control for timer 1, when selected by GATE1 bit in TCON register. <b>External Interrupt 1</b> INT1 input sets IE1 in the TCON register. If bit IT1 in this register is set, bit IE1 is set by a falling edge on INT1. If bit IT1 is cleared, bit IE1 is set by a low level on INT1.	P3.3

**Table 3.** Timer 0 and Timer 1 Signal Description (Continued)

Signal Name	Type	Description	Alternate Function
T0	I	<b>Timer 0 External Clock Input</b> When Timer 0 operates as a counter, a falling edge on the T0 pin increments the count.	P3.4
T1	I	<b>Timer 1 External Clock Input</b> When Timer 1 operates as a counter, a falling edge on the T1 pin increments the count.	P3.5

**Table 4.** Audio Interface Signal Description

Signal Name	Type	Description	Alternate Function
DCLK	O	<b>DAC Data Bit Clock</b>	-
DOUT	O	<b>DAC Audio Data</b>	-
DSEL	O	<b>DAC Channel Select Signal</b> DSEL is the sample rate clock output.	-
SCLK	O	<b>DAC System Clock</b> SCLK is the oversampling clock synchronized to the digital audio data (DOUT) and the channel selection signal (DSEL).	-

**Table 5.** USB Controller Signal Description

Signal Name	Type	Description	Alternate Function
D+	I/O	<b>USB Positive Data Upstream Port</b> This pin requires an external 1.5 k $\Omega$ pull-up to $V_{DD}$ for full speed operation.	-
D-	I/O	<b>USB Negative Data Upstream Port</b>	-

**Table 6.** MultiMediaCard Interface Signal Description

Signal Name	Type	Description	Alternate Function
MCLK	O	<b>MMC Clock output</b> Data or command clock transfer.	-
MCMD	I/O	<b>MMC Command line</b> bi-directional command channel used for card initialization and data transfer commands. To avoid any parasitic current consumption, unused MCMD input must be polarized to $V_{DD}$ or $V_{SS}$ .	-
MDAT	I/O	<b>MMC Data line</b> bi-directional data channel. To avoid any parasitic current consumption, unused MDAT input must be polarized to $V_{DD}$ or $V_{SS}$ .	-

**Table 7. UART Signal Description**

Signal Name	Type	Description	Alternate Function
RXD	I/O	<b>Receive Serial Data</b> RXD sends and receives data in serial I/O mode 0 and receives data in serial I/O modes 1, 2 and 3.	P3.0
TXD	O	<b>Transmit Serial Data</b> TXD outputs the shift clock in serial I/O mode 0 and transmits data in serial I/O modes 1, 2 and 3.	P3.1

**Table 8. SPI Controller Signal Description**

Signal Name	Type	Description	Alternate Function
MISO	I/O	<b>SPI Master Input Slave Output Data Line</b> When in master mode, MISO receives data from the slave peripheral. When in slave mode, MISO outputs data to the master controller.	P4.0
MOSI	I/O	<b>SPI Master Output Slave Input Data Line</b> When in master mode, MOSI outputs data to the slave peripheral. When in slave mode, MOSI receives data from the master controller.	P4.1
SCK	I/O	<b>SPI Clock Line</b> When in master mode, SCK outputs clock to the slave peripheral. When in slave mode, SCK receives clock from the master controller.	P4.2
$\overline{SS}$	I	<b>SPI Slave Select Line</b> When in controlled slave mode, $\overline{SS}$ enables the slave mode.	P4.3

**Table 9. TWI Controller Signal Description**

Signal Name	Type	Description	Alternate Function
SCL	I/O	<b>TWI Serial Clock</b> When TWI controller is in master mode, SCL outputs the serial clock to the slave peripherals. When TWI controller is in slave mode, SCL receives clock from the master controller.	P1.6
SDA	I/O	<b>TWI Serial Data</b> SDA is the bi-directional TWI data line.	P1.7

**Table 10. A/D Converter Signal Description**

Signal Name	Type	Description	Alternate Function
AIN1:0	I	<b>A/D Converter Analog Inputs</b>	-
AREFP	I	<b>Analog Positive Voltage Reference Input</b>	-
AREFN	I	<b>Analog Negative Voltage Reference Input</b> This pin is internally connected to AVSS.	-

**Table 11. Keypad Interface Signal Description**

Signal Name	Type	Description	Alternate Function
KIN3:0	I	<b>Keypad Input Lines</b> Holding one of these pins high or low for 24 oscillator periods triggers a keypad interrupt.	P1.3:0

**Table 12. External Access Signal Description**

Signal Name	Type	Description	Alternate Function
A15:8	I/O	<b>Address Lines</b> Upper address lines for the external bus. Multiplexed higher address and data lines for the IDE interface.	P2.7:0
AD7:0	I/O	<b>Address/Data Lines</b> Multiplexed lower address and data lines for the external memory or the IDE interface.	P0.7:0
ALE	O	<b>Address Latch Enable Output</b> ALE signals the start of an external bus cycle and indicates that valid address information is available on lines A7:0. An external latch is used to demultiplex the address from address/data bus.	-
$\overline{\text{ISP}}$	I/O	<b>ISP Enable Input</b> This signal must be held to GND through a pull-down resistor at the falling reset to force execution of the internal bootloader.	-
$\overline{\text{RD}}$	O	<b>Read Signal</b> Read signal asserted during external data memory read operation.	P3.7
$\overline{\text{WR}}$	O	<b>Write Signal</b> Write signal asserted during external data memory write operation.	P3.6

**Table 13. System Signal Description**

Signal Name	Type	Description	Alternate Function
RST	I	<b>Reset Input</b> Holding this pin high for 64 oscillator periods while the oscillator is running resets the device. The Port pins are driven to their reset conditions when a voltage lower than $V_{IL}$ is applied, whether or not the oscillator is running. This pin has an internal pull-down resistor which allows the device to be reset by connecting a capacitor between this pin and $V_{DD}$ . Asserting RST when the chip is in Idle mode or Power-down mode returns the chip to normal operation.	-
$\overline{\text{TST}}$	I	<b>Test Input</b> Test mode entry signal. This pin must be set to $V_{DD}$ .	-



**Table 14.** Power Signal Description

Signal Name	Type	Description	Alternate Function
V <sub>DD</sub>	PWR	<b>Digital Supply Voltage</b> Connect these pins to +3V supply voltage.	-
VSS	GND	<b>Circuit Ground</b> Connect these pins to ground.	-
AV <sub>DD</sub>	PWR	<b>Analog Supply Voltage</b> Connect this pin to +3V supply voltage.	-
AVSS	GND	<b>Analog Ground</b> Connect this pin to ground.	-
PV <sub>DD</sub>	PWR	<b>PLL Supply voltage</b> Connect this pin to +3V supply voltage.	-
PVSS	GND	<b>PLL Circuit Ground</b> Connect this pin to ground.	-
UV <sub>DD</sub>	PWR	<b>USB Supply Voltage</b> Connect this pin to +3V supply voltage.	-
UVSS	GND	<b>USB Ground</b> Connect this pin to ground.	-

## Internal Pin Structure

**Table 15.** Detailed Internal Pin Structure

Circuit <sup>(1)</sup>	Type	Pins
	Input	$\overline{\text{TST}}$
	Input/Output	RST
	Input/Output	P1 <sup>(2)</sup> P2 <sup>(3)</sup> P3 P4 P53:0
	Input/Output	P0 MCMD MDAT $\overline{\text{ISP}}$
	Output	ALE SCLK DCLK DOUT DSEL MCLK
	Input/Output	D+ D-

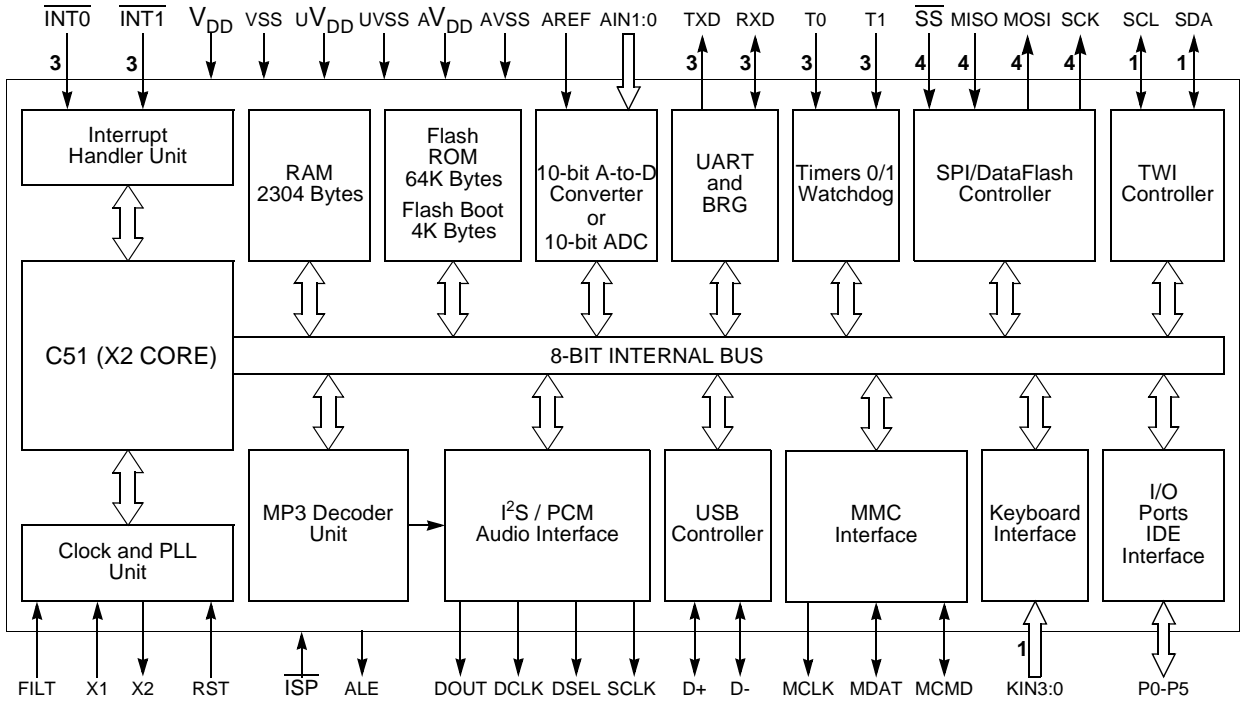
Notes: 1. For information on resistors value, input/output levels, and drive capability, refer to the Section "DC Characteristics", page 24.

2. When the TWI controller is enabled, P<sub>1</sub>, P<sub>2</sub>, and P<sub>3</sub> transistors are disabled allowing pseudo open-drain structure.

3. In Port 2, P<sub>1</sub> transistor is continuously driven when outputting a high level bit address (A15:8).

# Block Diagram

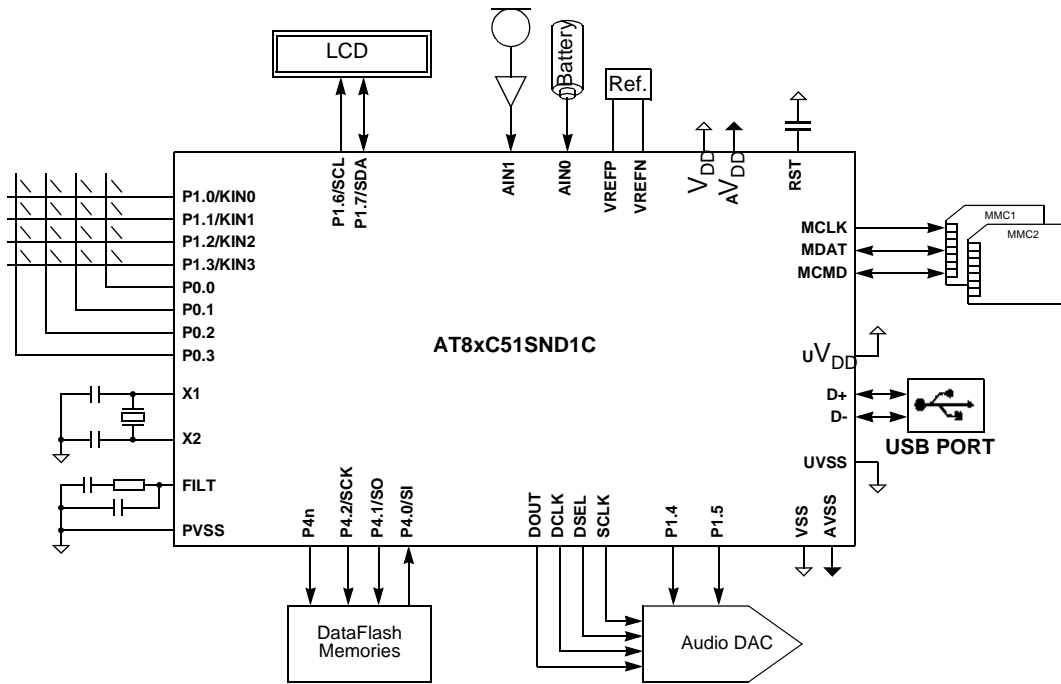
Figure 4. AT8xC51SND1C Block Diagram



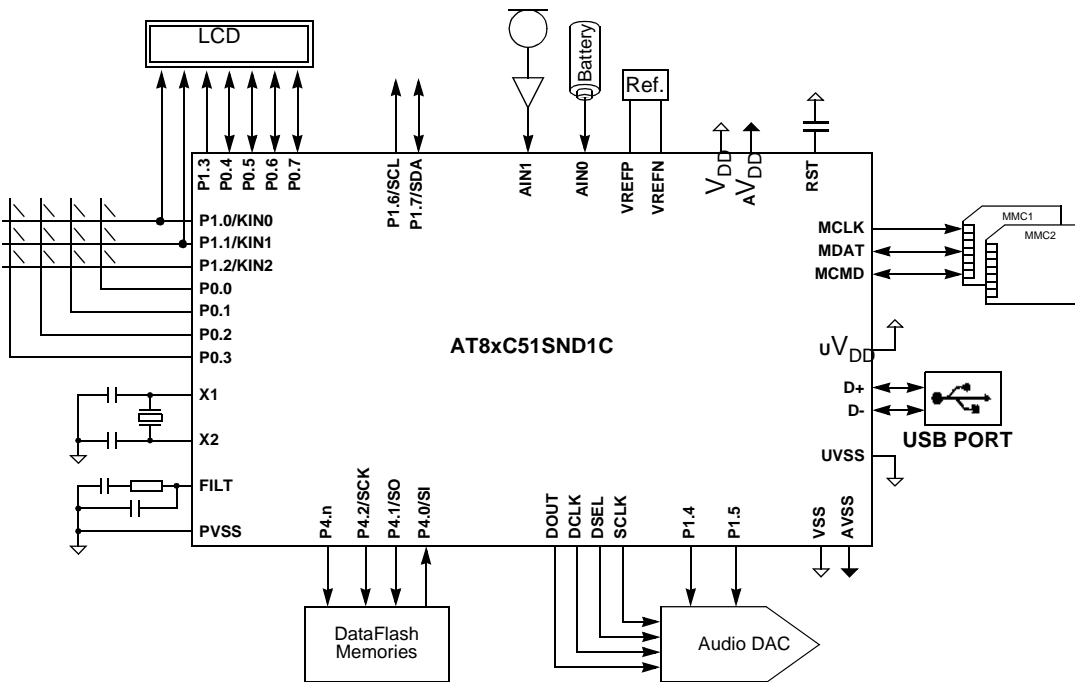
**Note:** 1 Alternate function of Port 1  
 3 Alternate function of Port 3  
 4 Alternate function of Port 4

## Application Information

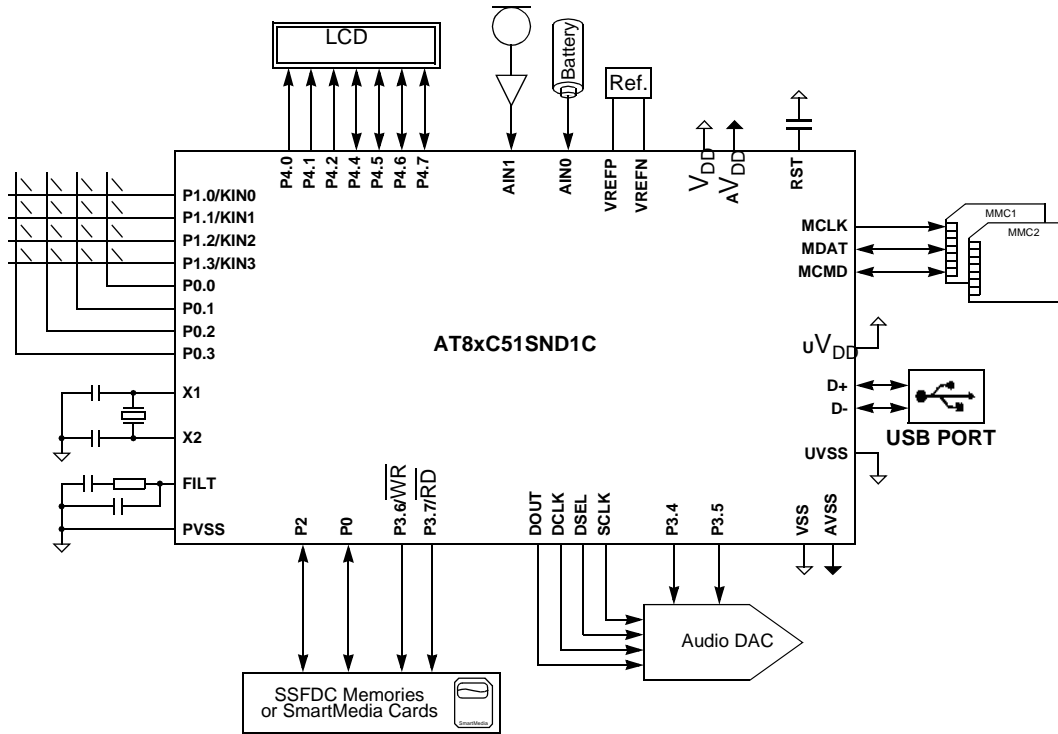
**Figure 5.** AT8xC51SND1C Typical Application with On-board Atmel DataFlash and TWI LCD



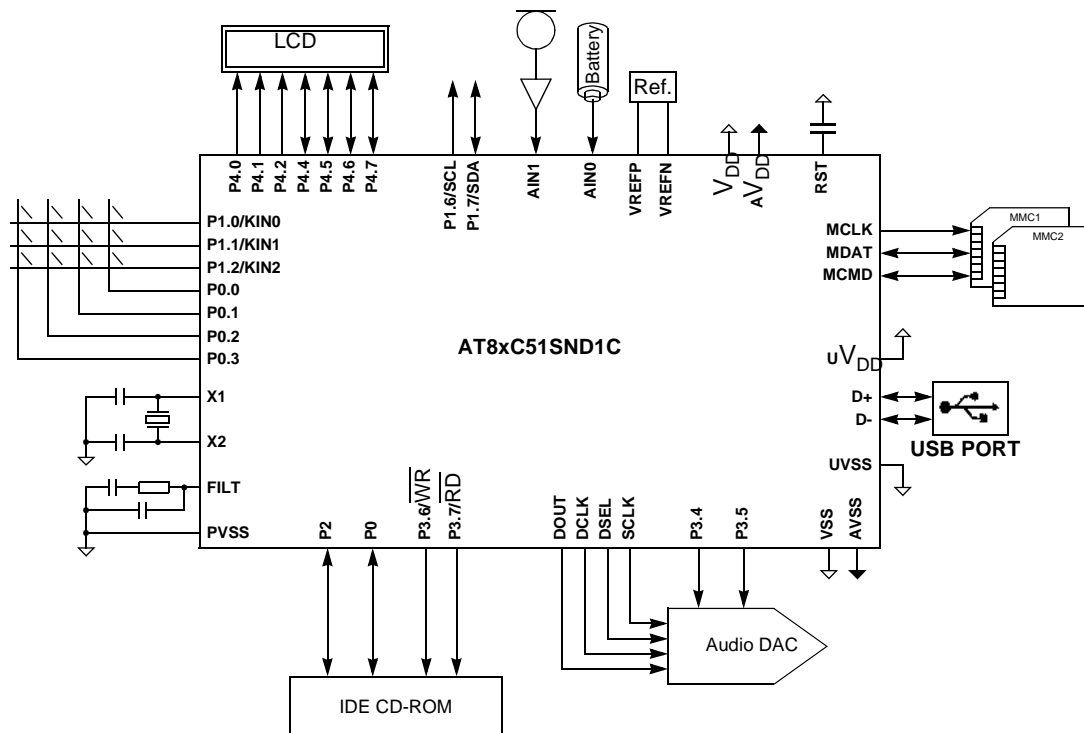
**Figure 6.** AT8xC51SND1C Typical Application with On-board Atmel DataFlash and LCD



**Figure 7.** AT8xC51SND1C Typical Application with On-board SSFDC Flash



**Figure 8.** AT8xC51SND1C Typical Application with IDE CD-ROM Drive



## Address Spaces

The AT8xC51SND1C derivatives implement four different address spaces:

- Program/Code Memory
- Boot Memory
- Data Memory
- Special Function Registers (SFRs)

## Code Memory

The AT89C51SND1C and AT83C51SND1C implement 64K Bytes of on-chip program/code memory. The AT83C51SND1C product provides the internal program/code memory in ROM technology while the AT89C51SND1C product provides it in Flash technology.

The Flash memory increases ROM functionality by enabling in-circuit electrical erasure and programming. Thanks to the internal charge pump, the high voltage needed for programming or erasing Flash cells is generated on-chip using the standard  $V_{DD}$  voltage. Thus, the AT89C51SND1C can be programmed using only one voltage and allows in application software programming commonly known as IAP. Hardware programming mode is also available using specific programming tools.

## Boot Memory

The AT89C51SND1C implements 4K Bytes of on-chip boot memory provided in Flash technology. This boot memory is delivered programmed with a standard bootloader software allowing In-system Programming commonly known as ISP. It also contains some Application Programming Interfaces routines commonly known as API allowing user to develop his own bootloader.

## Data Memory

The T89C51CC01 derivatives implement 2304 Bytes of on-chip data RAM. This memory is divided in two separate areas:

- 256 Bytes of on-chip RAM memory (standard C51 memory).
- 2048 Bytes of on-chip expanded RAM memory (ERAM accessible via MOVX instructions).

## Special Function Registers

The AT8xC51SND1C derivatives implement a 128 Bytes of Special Function Registers (SRFs) area containing the peripherals registers. This area is divided in two separate areas:

- up to 16 bit and byte-addressable registers
- up to 112 byte-addressable registers

## Peripherals

### Clock Generator System

The AT8xC51SND1C internal clocks are extracted from an on-chip PLL fed by an on-chip oscillator. Four clocks are generated respectively for the C51 core, the MP3 decoder, the audio interface, and the other peripherals. The C51 and peripheral clocks are derived from the oscillator clock. The MP3 decoder clock is generated by dividing the PLL output clock. The audio interface sample rates are also obtained by dividing the PLL output clock.

### Ports

The AT8xC51SND1C implement five 8-bit ports (P0 - P4) and one 4-bit port (P5). In addition to performing general-purpose I/Os, some ports are capable of external data memory operations; others allow for alternate functions. All I/O Ports are bi-directional. Each Port contains a latch, an output driver and an input buffer. Port 0 and Port 2 output drivers and input buffers facilitate external memory operations. Some Port 1, Port 3 and Port 4 pins serve for both general-purpose I/Os and alternate functions.

### Timers/Counters

The AT8xC51SND1C implement the two general-purpose, 16-bit Timers/Counters of a standard C51. They are identified as Timer 0, Timer 1, and can independently be configured each to operate in a variety of modes as a Timer or as an event Counter. When operating as a Timer, a Timer/Counter runs for a programmed length of time, then issues an interrupt request. When operating as a Counter, a Timer/Counter counts negative transitions on an external pin. After a preset number of counts, the Counter issues an interrupt request.

### Watchdog Timer

The AT8xC51SND1C implement a hardware Watchdog Timer that automatically resets the chip if it is allowed to time out. The WDT provides a means of recovering from routines that do not complete successfully due to software or hardware malfunctions.

### MP3 Decoder

The AT8xC51SND1C implements a MPEG I/II audio layer 3 decoder (MP3 decoder).

In MPEG I (ISO 11172-3) three layers of compression have been standardized supporting three sampling frequencies: 48, 44.1, and 32 kHz. Among these layers, layer 3 allows highest compression rate of about 12:1 while still maintaining CD audio quality. For example, 3 minutes of CD audio (16-bit PCM, 44.1 kHz) data, which needs about 32M bytes of storage, can be encoded into only 2.7 MBytes of MPEG I audio layer 3 data.

In MPEG II (ISO 13818-3), three additional sampling frequencies: 24, 22.05, and 16 kHz are supported for low bit rates applications.

The AT8xC51SND1C can decode in real-time the MPEG I audio layer 3 encoded data into a PCM audio data, and also supports MPEG II audio layer 3 additional frequencies.

Additional features are supported by the AT8xC51SND1C MP3 decoder such as volume, bass, medium, and treble controls, bass boost effect and ancillary data extraction.

### Audio Output Interface

The AT8xC51SND1C implements an audio output interface allowing the decoded audio bitstream to be output in various formats. It is compatible with right and left justification PCM and I<sup>2</sup>S formats and the on-chip PLL (see Section "Clock Generator System") allows connection of almost all of the commercial audio DAC families available on the market.

## Universal Serial Bus Interface

The AT8xC51SND1C implement a full-speed USB Interface. It can be used for the following purposes:

- Download of MP3 encoded audio files by supporting the USB mass storage class.
- In-System Programming by supporting the USB firmware upgrade class.

## MultiMedia Card Interface

The AT8xC51SND1C implement a MultiMedia Card (MMC) interface compliant to the V2.2 specification in MultiMedia Card mode. The MMC allows storage of MP3 encoded audio files in removable Flash memory cards that can be easily plugged to, or removed from the application. It can also be used for In-System Programming.

## IDE/ATAPI Interface

The AT8xC51SND1C provide an IDE/ATAPI interface allowing connection of devices such as CD-ROM reader, CompactFlash™ cards, Hard Disk Drive, etc. It consists of a 16-bit bi-directional bus part of the low-level ANSI ATA/ATAPI specification. It is provided for mass storage interfaces but could be used for In-System Programming using CD-ROM.

## Serial I/O Interface

The AT8xC51SND1C implement a serial port with its own baud rate generator providing one single synchronous communication mode and three full-duplex Universal Asynchronous Receiver Transmitter (UART) communication modes. It is provided for the following purposes:

- In-System Programming.
- Remote control of the AT8xC51SND1C by a host.

## Serial Peripheral Interface

The AT8xC51SND1C implement a Serial Peripheral Interface (SPI) supporting master and slave modes. It is provided for the following purposes:

- Interfacing DataFlash memory and DataFlash cards for MP3 encoded audio files storage
- Remote control of the AT8xC51SND1C by a host
- In-System Programming

## TWI Controller

The AT8xC51SND1C implements a TWI controller supporting the four standard master and slave modes with multimaster capability. It is provided for the following purposes:

- Connection of slave devices like LCD controller, audio DAC...
- Remote control of the AT8xC51SND1C by a host
- In-System Programming

## A/D Controller

The AT8xC51SND1C implements a 2-channel 10-bit (8 true bits) analog-to-digital converter (ADC). It is provided for the following purposes:

- Battery monitoring
- Voice recording
- Corded remote control

## Keyboard Interface

The AT8xC51SND1C implement a keyboard interface allowing connection of 4 x n matrix keyboard. It is based on 4 inputs with programmable interrupt capability on both high or low level. These inputs are available as an alternate function of P1.3:0 and allow exit from idle and power-down modes.





## Electrical Characteristics

### Absolute Maximum Rating

Storage Temperature .....	-65 to +150°C	<b>*NOTICE:</b> Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. These are stress ratings only. Operation beyond the “operating conditions” is not recommended and extended exposure beyond the “Operating Conditions” may affect device reliability.
Voltage on any other Pin to $V_{SS}$ .....	-0.3 to +4.0 V	
$I_{OL}$ per I/O Pin .....	5 mA	
Power Dissipation .....	1 W	
Operating Conditions		
Ambient Temperature Under Bias.....	-40 to +85°C	
$V_{DD}$ .....	2.7 to 3.3V	

### DC Characteristics

#### Digital Logic

**Table 1.** Digital DC Characteristics  $V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Typ <sup>(1)</sup>	Max	Units	Test Conditions
$V_{IL}$	Input Low Voltage	-0.5		$0.2 \cdot V_{DD} - 0.1$	V	
$V_{IH1}^{(2)}$	Input High Voltage (except RST, X1)	$0.2 \cdot V_{DD} + 1.1$		$V_{DD}$	V	
$V_{IH2}$	Input High Voltage (RST, X1)	$0.7 \cdot V_{DD}$		$V_{DD} + 0.5$	V	
$V_{OL1}$	Output Low Voltage (except P0, ALE, MCMD, MDAT, MCLK, SCLK, DCLK, DSEL, DOUT)			0.45	V	$I_{OL} = 1.6$ mA
$V_{OL2}$	Output Low Voltage (P0, ALE, MCMD, MDAT, MCLK, SCLK, DCLK, DSEL, DOUT)			0.45	V	$I_{OL} = 3.2$ mA
$V_{OH1}$	Output High Voltage (P1, P2, P3, P4 and P5)	$V_{DD} - 0.7$			V	$I_{OH} = -30$ $\mu\text{A}$
$V_{OH2}$	Output High Voltage (P0, P2 address mode, ALE, MCMD, MDAT, MCLK, SCLK, DCLK, DSEL, DOUT, D+, D-)	$V_{DD} - 0.7$			V	$I_{OH} = -3.2$ mA
$I_{IL}$	Logical 0 Input Current (P1, P2, P3, P4 and P5)			-50	$\mu\text{A}$	$V_{in} = 0.45$ V
$I_{LI}$	Input Leakage Current (P0, ALE, MCMD, MDAT, MCLK, SCLK, DCLK, DSEL, DOUT)			10	$\mu\text{A}$	$0.45 < V_{IN} < V_{DD}$
$I_{TL}$	Logical 1 to 0 Transition Current (P1, P2, P3, P4 and P5)			-650	$\mu\text{A}$	$V_{in} = 2.0$ V
$R_{RST}$	Pull-Down Resistor	50	90	200	k $\Omega$	
$C_{IO}$	Pin Capacitance		10		pF	$T_A = 25^\circ\text{C}$
$V_{RET}$	$V_{DD}$ Data Retention Limit			1.8	V	

**Table 1. Digital DC Characteristics VDD = 2.7 to 3.3 V, TA = -40 to +85°C**

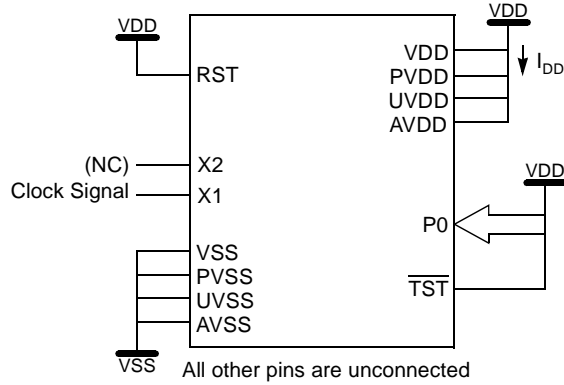
Symbol	Parameter	Min	Typ <sup>(1)</sup>	Max	Units	Test Conditions
I <sub>DD</sub>	AT89C51SND1C Operating Current		(3)	X1 / X2 mode 6.5 / 10.5 8 / 13.5 9.5 / 17	mA	V <sub>DD</sub> < 3.3 V 12 MHz 16 MHz 20 MHz
	AT83C51SND1C Operating Current		TBD	TBD	mA	V <sub>DD</sub> < 3.3 V 12 MHz 16 MHz 20 MHz
I <sub>DL</sub>	AT89C51SND1C Idle Mode Current		(3)	X1 / X2 mode 5.3 / 8.1 6.4 / 10.3 7.5 / 13	mA	V <sub>DD</sub> < 3.3 V 12 MHz 16 MHz 20 MHz
	AT83C51SND1C Idle Mode Current		TBD	TBD	mA	V <sub>DD</sub> < 3.3 V 12 MHz 16 MHz 20 MHz
I <sub>PD</sub>	AT89C51SND1C Power-Down Mode Current		20	500	μA	V <sub>RET</sub> < V <sub>DD</sub> < 3.3 V
	AT83C51SND1C Power-Down Mode Current		TBD	TBD	μA	V <sub>RET</sub> < V <sub>DD</sub> < 3.3 V
I <sub>FP</sub>	AT89C51SND1C Flash Programming Current			15	mA	V <sub>DD</sub> < 3.3 V

- Notes: 1. Typical values are obtained using V<sub>DD</sub>= 3 V and T<sub>A</sub>= 25°C. They are not tested and there is no guarantee on these values.  
 2. Flash retention is guaranteed with the same formula for V<sub>DD</sub> min down to 0V.  
 3. See Table 2 for typical consumption in player mode.

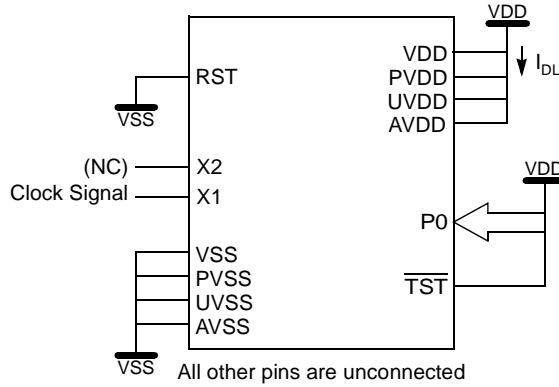
**Table 2. Typical Reference Design Power Consumption**

Player Mode	I <sub>DD</sub>	Test Conditions
Stop	10 mA	AT89C51SND1C at 16 MHz, X2 mode, V <sub>DD</sub> = 3 V No song playing
Playing	30 mA	AT89C51SND1C at 16 MHz, X2 mode, V <sub>DD</sub> = 3 V MP3 Song with Fs= 44.1 KHz, at any bit rates (Variable Bit Rate)

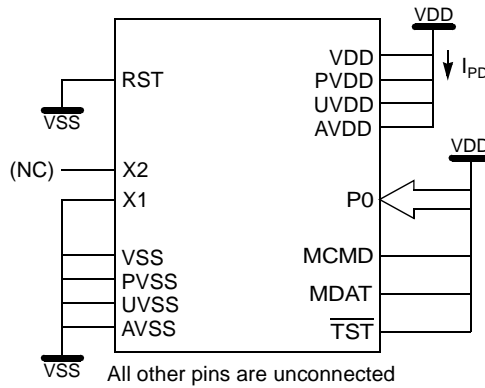
**Figure 9.**  $I_{DD}$  Test Condition, Active Mode



**Figure 10.**  $I_{DL}$  Test Condition, Idle Mode



**Figure 11.**  $I_{PD}$  Test Condition, Power-Down Mode



## A to D Converter

**Table 3.** A to D Converter DC Characteristics

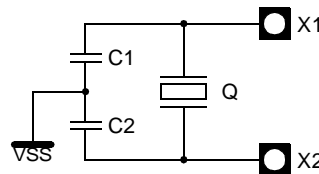
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
$AV_{DD}$	Analog Supply Voltage	2.7		3.3	V	
$AI_{DD}$	Analog Operating Supply Current			600	$\mu\text{A}$	$AV_{DD} = 3.3\text{V}$ $AIN1:0 = 0$ to $AV_{DD}$ $ADEN = 1$
$AI_{PD}$	Analog Standby Current			2	$\mu\text{A}$	$AV_{DD} = 3.3\text{V}$ $ADEN = 0$ or $PD = 1$
$AV_{IN}$	Analog Input Voltage	$AV_{SS}$		$AV_{DD}$	V	
$AV_{REF}$	Reference Voltage $A_{REFN}$ $A_{REFP}$	$AV_{SS}$ 2.4		$AV_{DD}$	V	
$R_{REF}$	AREF Input Resistance	10		30	$\text{K}\Omega$	$T_A = 25^\circ\text{C}$
$C_{IA}$	Analog Input capacitance			10	pF	$T_A = 25^\circ\text{C}$

## Oscillator & Crystal

### Schematic

**Figure 12.** Crystal Connection



Note: For operation with most standard crystals, no external components are needed on X1 and X2. It may be necessary to add external capacitors on X1 and X2 to ground in special cases (max 10 pF). X1 and X2 may not be used to drive other circuits.

### Parameters

**Table 4.** Oscillator & Crystal Characteristics

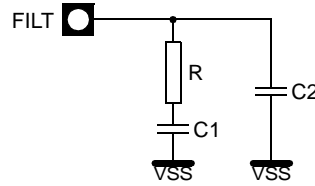
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
$C_{X1}$	Internal Capacitance (X1 - VSS)		10		pF
$C_{X2}$	Internal Capacitance (X2 - VSS)		10		pF
$C_L$	Equivalent Load Capacitance (X1 - X2)		5		pF
DL	Drive Level			50	$\mu\text{W}$
F	Crystal Frequency			20	MHz
RS	Crystal Series Resistance			40	$\Omega$
CS	Crystal Shunt Capacitance			6	pF

## Phase Lock Loop

### Schematic

**Figure 13.** PLL Filter Connection



### Parameters

**Table 5.** PLL Filter Characteristics

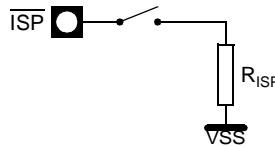
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
R	Filter Resistor		100		$\Omega$
C1	Filter Capacitance 1		10		nF
C2	Filter Capacitance 2		2.2		nF

## In System Programming

### Schematic

**Figure 14.** ISP Pull-Down Connection



### Parameters

**Table 6.** ISP Pull-Down Characteristics

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
$R_{ISP}$	ISP Pull-Down Resistor		2.2		K $\Omega$

## AC Characteristics

### External 8-bit Bus Cycles

#### Definition of Symbols

**Table 7.** External 8-bit Bus Cycles Timing Symbol Definitions

Signals		Conditions	
A	Address	H	High
D	Data In	L	Low
L	ALE	V	Valid
Q	Data Out	X	No Longer Valid
R	$\overline{RD}$	Z	Floating
W	$\overline{WR}$		

#### Timings

Test conditions: capacitive load on all pins= 50 pF.

**Table 8.** External 8-bit Bus Cycle - Data Read AC Timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Variable Clock Standard Mode		Variable Clock X2 Mode		Unit
		Min	Max	Min	Max	
$T_{CLCL}$	Clock Period	50		50		ns
$T_{LHLL}$	ALE Pulse Width	$2 \cdot T_{CLCL} - 15$		$T_{CLCL} - 15$		ns
$T_{AVLL}$	Address Valid to ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLAX}$	Address hold after ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLRL}$	ALE Low to $\overline{RD}$ Low	$3 \cdot T_{CLCL} - 30$		$1.5 \cdot T_{CLCL} - 30$		ns
$T_{RLRH}$	$\overline{RD}$ Pulse Width	$6 \cdot T_{CLCL} - 25$		$3 \cdot T_{CLCL} - 25$		ns
$T_{RHLH}$	$\overline{RD}$ high to ALE High	$T_{CLCL} - 20$	$T_{CLCL} + 20$	$0.5 \cdot T_{CLCL} - 20$	$0.5 \cdot T_{CLCL} + 20$	ns
$T_{AVDV}$	Address Valid to Valid Data In		$9 \cdot T_{CLCL} - 65$		$4.5 \cdot T_{CLCL} - 65$	ns
$T_{AVRL}$	Address Valid to $\overline{RD}$ Low	$4 \cdot T_{CLCL} - 30$		$2 \cdot T_{CLCL} - 30$		ns
$T_{RLDV}$	$\overline{RD}$ Low to Valid Data		$5 \cdot T_{CLCL} - 30$		$2.5 \cdot T_{CLCL} - 30$	ns
$T_{RLAZ}$	$\overline{RD}$ Low to Address Float		0		0	ns
$T_{RHDX}$	Data Hold After $\overline{RD}$ High	0		0		ns
$T_{RHDZ}$	Instruction Float After $\overline{RD}$ High		$2 \cdot T_{CLCL} - 25$		$T_{CLCL} - 25$	ns

**Table 9.** External 8-bit Bus Cycle - Data Write AC Timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Variable Clock Standard Mode		Variable Clock X2 Mode		Unit
		Min	Max	Min	Max	
$T_{CLCL}$	Clock Period	50		50		ns
$T_{LHLL}$	ALE Pulse Width	$2 \cdot T_{CLCL} - 15$		$T_{CLCL} - 15$		ns
$T_{AVLL}$	Address Valid to ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLAX}$	Address hold after ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLWL}$	ALE Low to $\overline{WR}$ Low	$3 \cdot T_{CLCL} - 30$		$1.5 \cdot T_{CLCL} - 30$		ns
$T_{WLWH}$	$\overline{WR}$ Pulse Width	$6 \cdot T_{CLCL} - 25$		$3 \cdot T_{CLCL} - 25$		ns
$T_{WHLH}$	$\overline{WR}$ High to ALE High	$T_{CLCL} - 20$	$T_{CLCL} + 20$	$0.5 \cdot T_{CLCL} - 20$	$0.5 \cdot T_{CLCL} + 20$	ns
$T_{AVWL}$	Address Valid to $\overline{WR}$ Low	$4 \cdot T_{CLCL} - 30$		$2 \cdot T_{CLCL} - 30$		ns
$T_{QVWH}$	Data Valid to $\overline{WR}$ High	$7 \cdot T_{CLCL} - 20$		$3.5 \cdot T_{CLCL} - 20$		ns
$T_{WHQX}$	Data Hold after $\overline{WR}$ High	$T_{CLCL} - 15$		$0.5 \cdot T_{CLCL} - 15$		ns

Waveforms

**Figure 15.** External 8-bit Bus Cycle - Data Read Waveforms

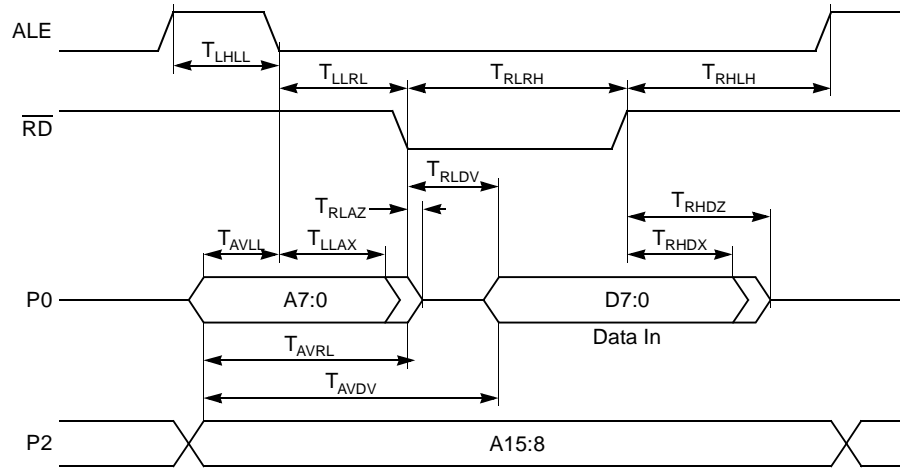
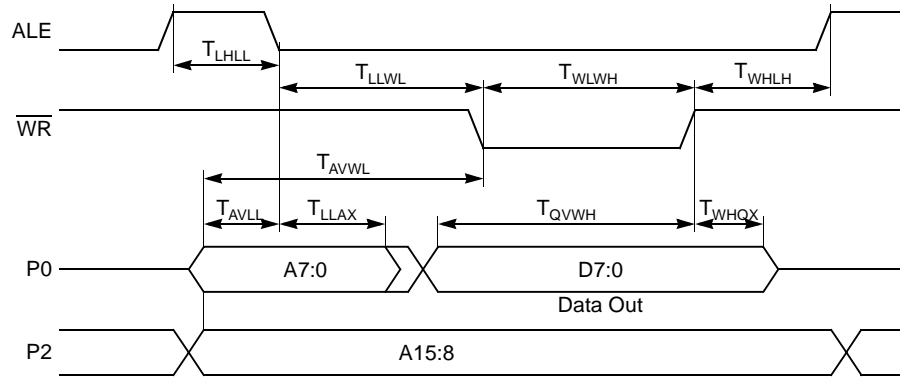


Figure 16. External 8-bit Bus Cycle - Data Write Waveforms



External IDE 16-bit Bus Cycles

Definition of Symbols

Table 10. External IDE 16-bit Bus Cycles Timing Symbol Definitions

Signals	
A	Address
D	Data In
L	ALE
Q	Data Out
R	$\overline{RD}$
W	$\overline{WR}$

Conditions	
H	High
L	Low
V	Valid
X	No Longer Valid
Z	Floating



Test conditions: capacitive load on all pins= 50 pF.

**Table 11.** External IDE 16-bit Bus Cycle - Data Read AC Timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Variable Clock Standard Mode		Variable Clock X2 Mode		Unit
		Min	Max	Min	Max	
$T_{CLCL}$	Clock Period	50		50		ns
$T_{LHLL}$	ALE Pulse Width	$2 \cdot T_{CLCL} - 15$		$T_{CLCL} - 15$		ns
$T_{AVLL}$	Address Valid to ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLAX}$	Address hold after ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLRL}$	ALE Low to $\overline{RD}$ Low	$3 \cdot T_{CLCL} - 30$		$1.5 \cdot T_{CLCL} - 30$		ns
$T_{RLRH}$	$\overline{RD}$ Pulse Width	$6 \cdot T_{CLCL} - 25$		$3 \cdot T_{CLCL} - 25$		ns
$T_{RHLH}$	$\overline{RD}$ high to ALE High	$T_{CLCL} - 20$	$T_{CLCL} + 20$	$0.5 \cdot T_{CLCL} - 20$	$0.5 \cdot T_{CLCL} + 20$	ns
$T_{AVDV}$	Address Valid to Valid Data In		$9 \cdot T_{CLCL} - 65$		$4.5 \cdot T_{CLCL} - 65$	ns
$T_{AVRL}$	Address Valid to $\overline{RD}$ Low	$4 \cdot T_{CLCL} - 30$		$2 \cdot T_{CLCL} - 30$		ns
$T_{RLDV}$	$\overline{RD}$ Low to Valid Data		$5 \cdot T_{CLCL} - 30$		$2.5 \cdot T_{CLCL} - 30$	ns
$T_{RLAZ}$	$\overline{RD}$ Low to Address Float		0		0	ns
$T_{RHDX}$	Data Hold After $\overline{RD}$ High	0		0		ns
$T_{RHDZ}$	Instruction Float After $\overline{RD}$ High		$2 \cdot T_{CLCL} - 25$		$T_{CLCL} - 25$	ns

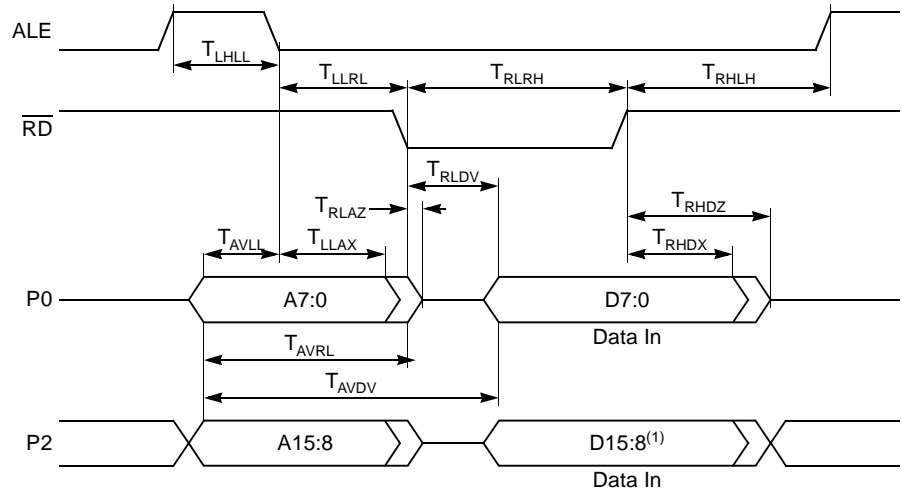
**Table 12.** External IDE 16-bit Bus Cycle - Data Write AC Timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Variable Clock Standard Mode		Variable Clock X2 Mode		Unit
		Min	Max	Min	Max	
$T_{CLCL}$	Clock Period	50		50		ns
$T_{LHLL}$	ALE Pulse Width	$2 \cdot T_{CLCL} - 15$		$T_{CLCL} - 15$		ns
$T_{AVLL}$	Address Valid to ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLAX}$	Address hold after ALE Low	$T_{CLCL} - 20$		$0.5 \cdot T_{CLCL} - 20$		ns
$T_{LLWL}$	ALE Low to $\overline{WR}$ Low	$3 \cdot T_{CLCL} - 30$		$1.5 \cdot T_{CLCL} - 30$		ns
$T_{WLWH}$	$\overline{WR}$ Pulse Width	$6 \cdot T_{CLCL} - 25$		$3 \cdot T_{CLCL} - 25$		ns
$T_{WHLH}$	$\overline{WR}$ High to ALE High	$T_{CLCL} - 20$	$T_{CLCL} + 20$	$0.5 \cdot T_{CLCL} - 20$	$0.5 \cdot T_{CLCL} + 20$	ns
$T_{AVWL}$	Address Valid to $\overline{WR}$ Low	$4 \cdot T_{CLCL} - 30$		$2 \cdot T_{CLCL} - 30$		ns
$T_{QVWH}$	Data Valid to $\overline{WR}$ High	$7 \cdot T_{CLCL} - 20$		$3.5 \cdot T_{CLCL} - 20$		ns
$T_{WHQX}$	Data Hold after $\overline{WR}$ High	$T_{CLCL} - 15$		$0.5 \cdot T_{CLCL} - 15$		ns

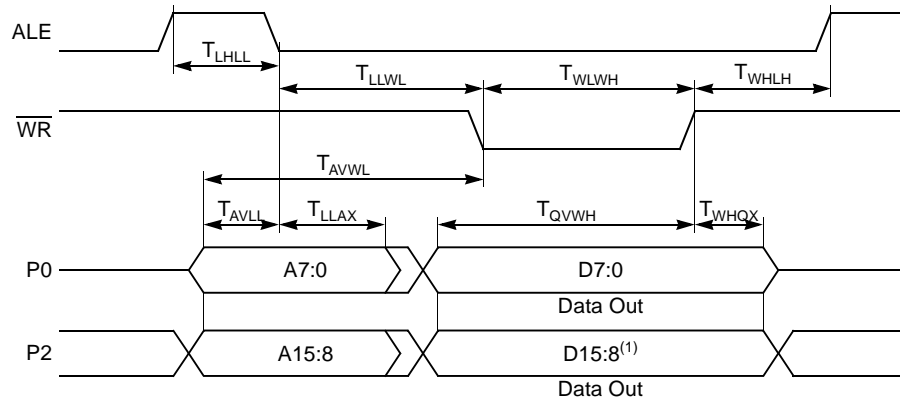
## Waveforms

**Figure 17.** External IDE 16-bit Bus Cycle - Data Read Waveforms



Note: 1. D15:8 is written in DAT16H SFR.

**Figure 18.** External IDE 16-bit Bus Cycle - Data Write Waveforms



Note: 1. D15:8 is the content of DAT16H SFR.

## SPI Interface

### Definition of Symbols

**Table 13.** SPI Interface Timing Symbol Definitions

Signals	
C	Clock
I	Data In
O	Data Out

Conditions	
H	High
L	Low
V	Valid
X	No Longer Valid
Z	Floating

Test conditions: capacitive load on all pins= 100 pF.

**Table 14.** SPI Interface Master AC Timing

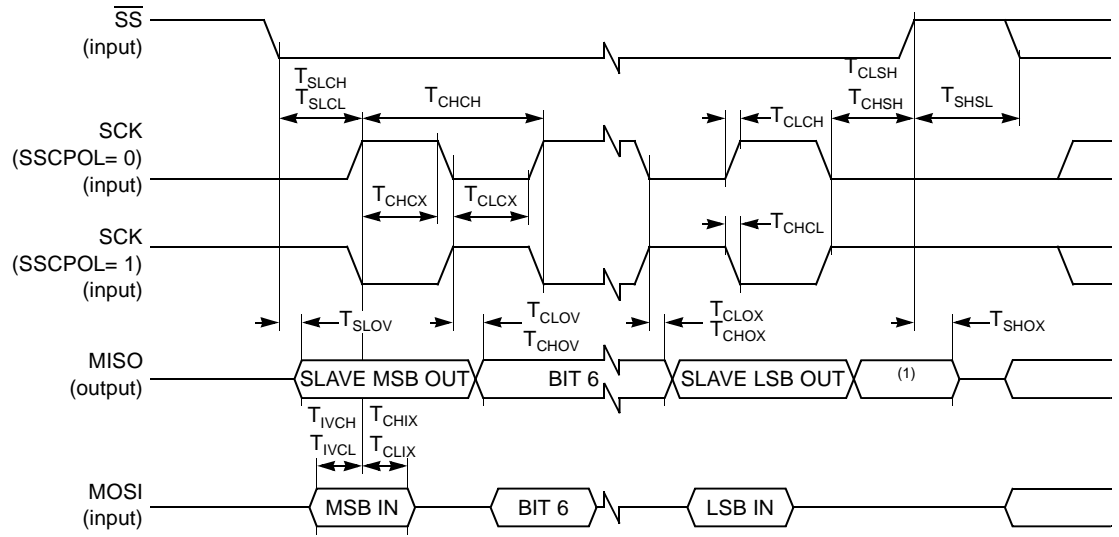
$V_{DD} = 2.7 \text{ to } 3.3 \text{ V}$ ,  $T_A = -40 \text{ to } +85^\circ\text{C}$

Symbol	Parameter	Min	Max	Unit
<b>Slave Mode</b>				
$T_{CHCH}$	Clock Period	8		$T_{OSC}$
$T_{CHCX}$	Clock High Time	3.2		$T_{OSC}$
$T_{CLCX}$	Clock Low Time	3.2		$T_{OSC}$
$T_{SLCH}, T_{SLCL}$	$\overline{SS}$ Low to Clock edge	200		ns
$T_{IVCL}, T_{IVCH}$	Input Data Valid to Clock Edge	100		ns
$T_{CLIX}, T_{CHIX}$	Input Data Hold after Clock Edge	100		ns
$T_{CLOV}, T_{CHOV}$	Output Data Valid after Clock Edge		100	ns
$T_{CLOX}, T_{CHOX}$	Output Data Hold Time after Clock Edge	0		ns
$T_{CLSH}, T_{CHSH}$	$\overline{SS}$ High after Clock Edge	0		ns
$T_{IVCL}, T_{IVCH}$	Input Data Valid to Clock Edge	100		ns
$T_{CLIX}, T_{CHIX}$	Input Data Hold after Clock Edge	100		ns
$T_{SLOV}$	$\overline{SS}$ Low to Output Data Valid		130	ns
$T_{SHOX}$	Output Data Hold after $\overline{SS}$ High		130	ns
$T_{SHSL}$	$\overline{SS}$ High to $\overline{SS}$ Low	(1)		
$T_{ILIH}$	Input Rise Time		2	$\mu\text{s}$
$T_{IHIL}$	Input Fall Time		2	$\mu\text{s}$
$T_{OLOH}$	Output Rise time		100	ns
$T_{OHOL}$	Output Fall Time		100	ns
<b>Master Mode</b>				
$T_{CHCH}$	Clock Period	4		$T_{OSC}$
$T_{CHCX}$	Clock High Time	1.6		$T_{OSC}$
$T_{CLCX}$	Clock Low Time	1.6		$T_{OSC}$
$T_{IVCL}, T_{IVCH}$	Input Data Valid to Clock Edge	50		ns
$T_{CLIX}, T_{CHIX}$	Input Data Hold after Clock Edge	50		ns
$T_{CLOV}, T_{CHOV}$	Output Data Valid after Clock Edge		65	ns
$T_{CLOX}, T_{CHOX}$	Output Data Hold Time after Clock Edge	0		ns
$T_{ILIH}$	Input Data Rise Time		2	$\mu\text{s}$
$T_{IHIL}$	Input Data Fall Time		2	$\mu\text{s}$
$T_{OLOH}$	Output Data Rise time		50	ns
$T_{OHOL}$	Output Data Fall Time		50	ns

Note: 1. Value of this parameter depends on software.

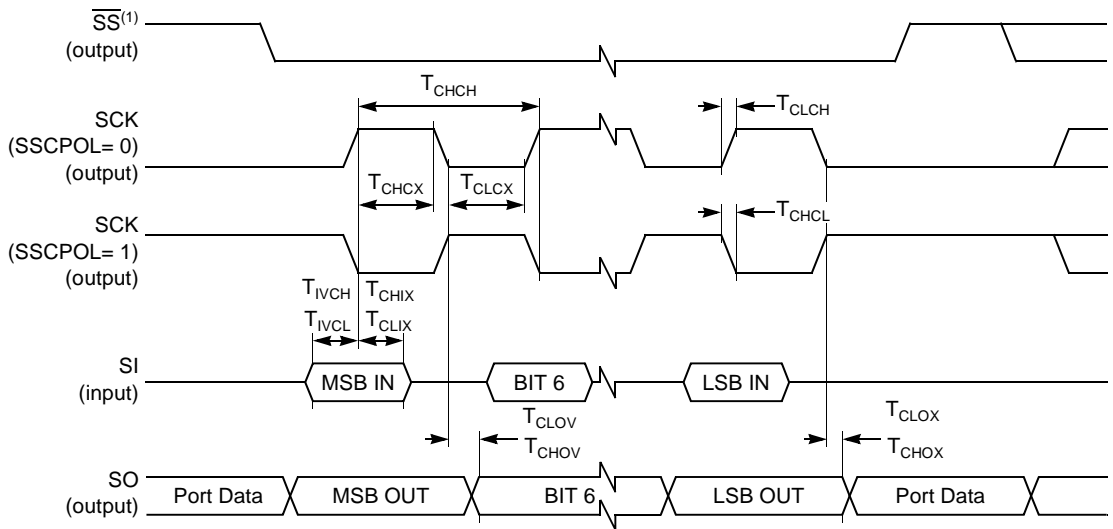
Waveforms

Figure 19. SPI Slave Waveforms (SSCPHA= 0)



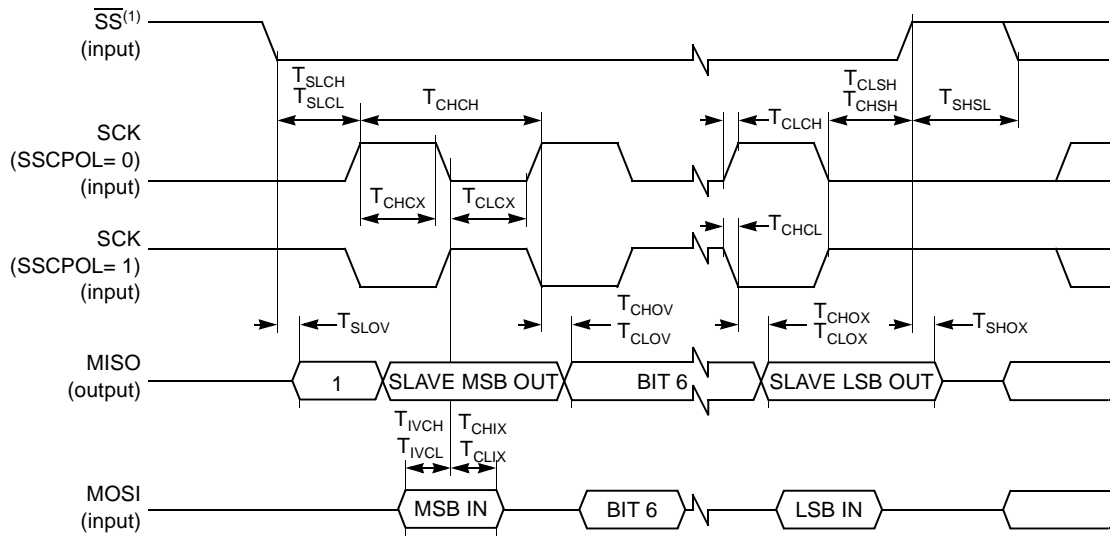
Note: 1. Not Defined but generally the MSB of the character which has just been received.

Figure 20. SPI Slave Waveforms (SSCPHA= 1)



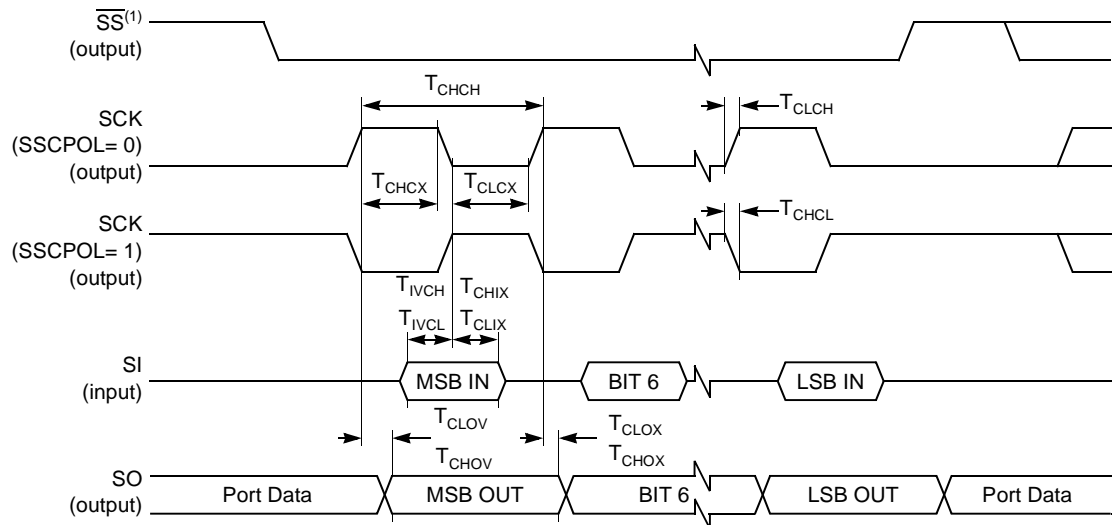
Note: 1. Not Defined but generally the LSB of the character which has just been received.

**Figure 21. SPI Master Waveforms (SSCPHA= 0)**



Note: 1.  $\overline{SS}$  handled by software using general purpose port pin.

**Figure 22. SPI Master Waveforms (SSCPHA= 1)**



Note: 1.  $\overline{SS}$  handled by software using general purpose port pin.

## Two-wire Interface

### Timings

**Table 15.** TWI Interface AC Timing

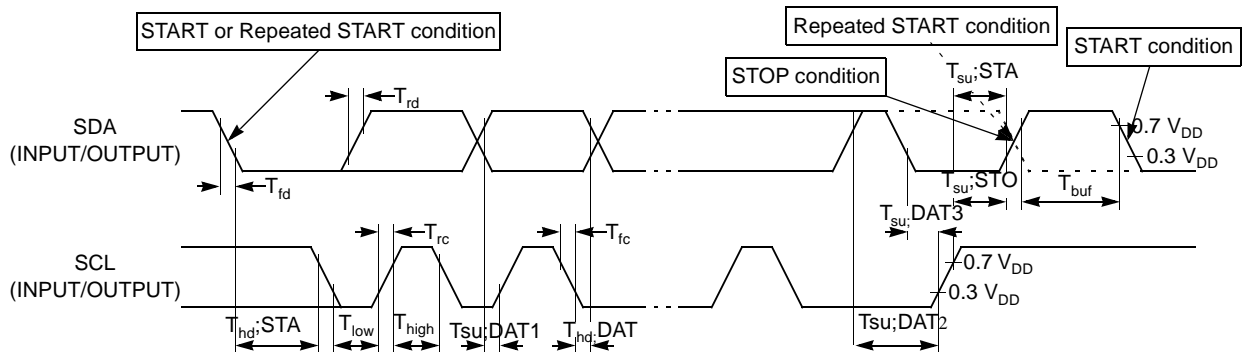
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	INPUT Min Max	OUTPUT Min Max
$T_{HD}; STA$	Start condition hold time	$14 \cdot T_{CLCL}^{(4)}$	$4.0 \mu\text{s}^{(1)}$
$T_{LOW}$	SCL low time	$16 \cdot T_{CLCL}^{(4)}$	$4.7 \mu\text{s}^{(1)}$
$T_{HIGH}$	SCL high time	$14 \cdot T_{CLCL}^{(4)}$	$4.0 \mu\text{s}^{(1)}$
$T_{RC}$	SCL rise time	$1 \mu\text{s}$	$_{(2)}$
$T_{FC}$	SCL fall time	$0.3 \mu\text{s}$	$0.3 \mu\text{s}^{(3)}$
$T_{SU}; DAT1$	Data set-up time	$250 \text{ ns}$	$20 \cdot T_{CLCL}^{(4)} - T_{RD}$
$T_{SU}; DAT2$	SDA set-up time (before repeated START condition)	$250 \text{ ns}$	$1 \mu\text{s}^{(1)}$
$T_{SU}; DAT3$	SDA set-up time (before STOP condition)	$250 \text{ ns}$	$8 \cdot T_{CLCL}^{(4)}$
$T_{HD}; DAT$	Data hold time	$0 \text{ ns}$	$8 \cdot T_{CLCL}^{(4)} - T_{FC}$
$T_{SU}; STA$	Repeated START set-up time	$14 \cdot T_{CLCL}^{(4)}$	$4.7 \mu\text{s}^{(1)}$
$T_{SU}; STO$	STOP condition set-up time	$14 \cdot T_{CLCL}^{(4)}$	$4.0 \mu\text{s}^{(1)}$
$T_{BUF}$	Bus free time	$14 \cdot T_{CLCL}^{(4)}$	$4.7 \mu\text{s}^{(1)}$
$T_{RD}$	SDA rise time	$1 \mu\text{s}$	$_{(2)}$
$T_{FD}$	SDA fall time	$0.3 \mu\text{s}$	$0.3 \mu\text{s}^{(3)}$

- Notes:
1. At 100 kbit/s. At other bit-rates this value is inversely proportional to the bit-rate of 100 kbit/s.
  2. Determined by the external bus-line capacitance and the external bus-line pull-up resistor, this must be  $< 1 \mu\text{s}$ .
  3. Spikes on the SDA and SCL lines with a duration of less than  $3 \cdot T_{CLCL}$  will be filtered out. Maximum capacitance on bus-lines SDA and SCL = 400 pF.
  4.  $T_{CLCL} = T_{OSC} =$  one oscillator clock period.

### Waveforms

**Figure 23.** Two Wire Waveforms



## MMC Interface

### Definition of symbols

**Table 16.** MMC Interface Timing Symbol Definitions

Signals	
C	Clock
D	Data In
O	Data Out

Conditions	
H	High
L	Low
V	Valid
X	No Longer Valid

### Timings

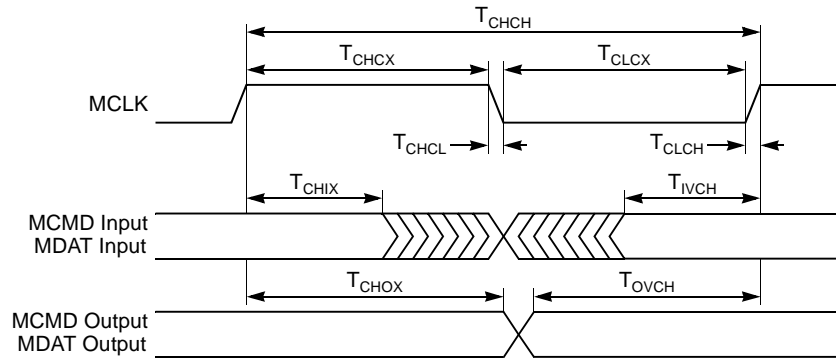
**Table 17.** MMC Interface AC timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$ ,  $C_L \leq 100\text{pF}$  (10 cards)

Symbol	Parameter	Min	Max	Unit
$T_{CHCH}$	Clock Period	50		ns
$T_{CHCX}$	Clock High Time	10		ns
$T_{CLCX}$	Clock Low Time	10		ns
$T_{CLCH}$	Clock Rise Time		10	ns
$T_{CHCL}$	Clock Fall Time		10	ns
$T_{DVCH}$	Input Data Valid to Clock High	3		ns
$T_{CHDX}$	Input Data Hold after Clock High	3		ns
$T_{CHOX}$	Output Data Hold after Clock High	5		ns
$T_{OVCH}$	Output Data Valid to Clock High	5		ns

### Waveforms

**Figure 24.** MMC Input-Output Waveforms



## Audio Interface

### Definition of symbols

**Table 18.** Audio Interface Timing Symbol Definitions

Signals	
C	Clock
O	Data Out
S	Data Select

Conditions	
H	High
L	Low
V	Valid
X	No Longer Valid

### Timings

**Table 19.** Audio Interface AC timings

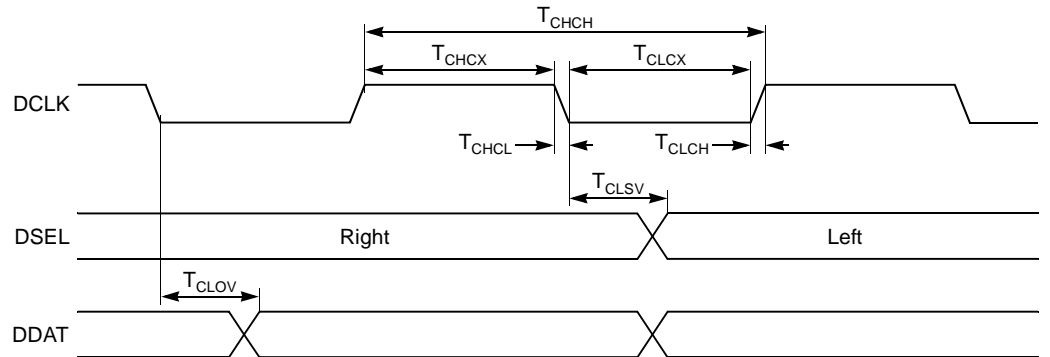
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$ ,  $C_L \leq 30\text{pF}$

Symbol	Parameter	Min	Max	Unit
$T_{CHCH}$	Clock Period		325.5 <sup>(1)</sup>	ns
$T_{CHCX}$	Clock High Time	30		ns
$T_{CLCX}$	Clock Low Time	30		ns
$T_{CLCH}$	Clock Rise Time		10	ns
$T_{CHCL}$	Clock Fall Time		10	ns
$T_{CLSV}$	Clock Low to Select Valid		10	ns
$T_{CLOV}$	Clock Low to Data Valid		10	ns

Note: 1. 32-bit format with  $F_s = 48$  KHz.

### Waveforms

**Figure 25.** Audio Interface Waveforms





## Analog to Digital Converter

### Definition of symbols

**Table 20.** Analog to Digital Converter Timing Symbol Definitions

Signals		Conditions	
C	Clock	H	High
E	Enable (ADEN bit)	L	Low
S	Start Conversion (ADSST bit)		

### Characteristics

**Table 21.** Analog to Digital Converter AC Characteristics

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

Symbol	Parameter	Min	Max	Unit
$T_{CLCL}$	Clock Period	4		$\mu\text{s}$
$T_{EHS}$	Start-up Time		4	$\mu\text{s}$
$T_{SHSL}$	Conversion Time		$11 \cdot T_{CLCL}$	$\mu\text{s}$
DLe	Differential non-linearity error <sup>(1)(2)</sup>		1	LSB
ILe	Integral non-linearity error <sup>(1)(3)</sup>		2	LSB
OSe	Offset error <sup>(1)(4)</sup>		4	LSB
Ge	Gain error <sup>(1)(5)</sup>		4	LSB

- Notes:
- $AV_{DD} = AV_{REFP} = 3.0$  V,  $AV_{SS} = AV_{REFN} = 0$  V. ADC is monotonic with no missing code.
  - The differential non-linearity is the difference between the actual step width and the ideal step width (see Figure 27).
  - The integral non-linearity is the peak difference between the center of the actual step and the ideal transfer curve after appropriate adjustment of gain and offset errors (see Figure 27).
  - The offset error is the absolute difference between the straight line which fits the actual transfer curve (after removing of gain error), and the straight line which fits the ideal transfer curve (see Figure 27).
  - The gain error is the relative difference in percent between the straight line which fits the actual transfer curve (after removing of offset error), and the straight line which fits the ideal transfer curve (see Figure 27).

### Waveforms

**Figure 26.** Analog to Digital Converter Internal Waveforms

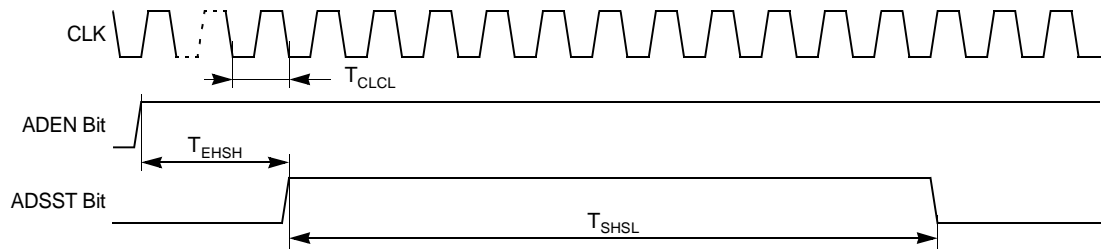
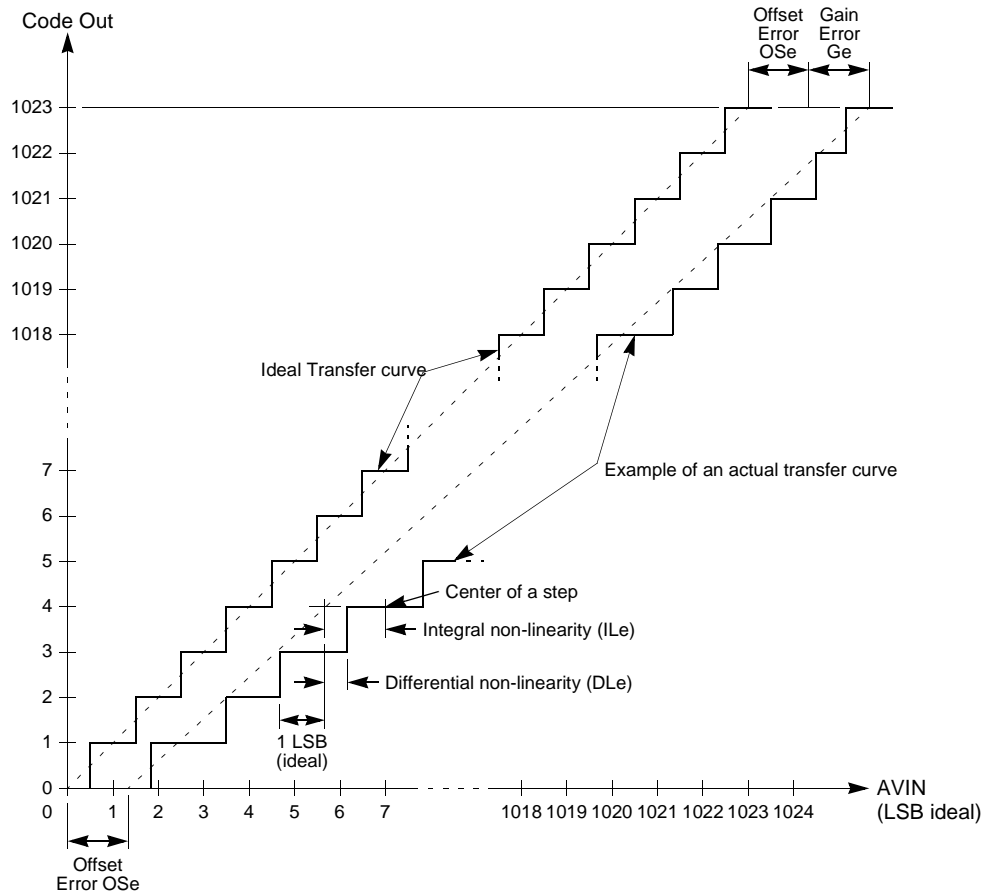


Figure 27. Analog to Digital Converter Characteristics



Flash Memory

Definition of symbols

Table 22. Flash Memory Timing Symbol Definitions

Signals	
S	$\overline{\text{ISP}}$
R	RST
B	FBUSY flag

Conditions	
L	Low
V	Valid
X	No Longer Valid

Timings

Table 23. Flash Memory AC Timing

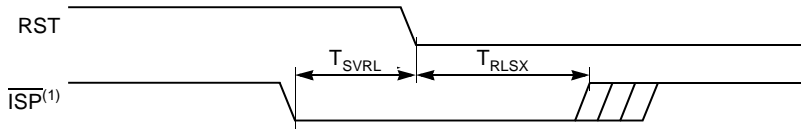
$V_{DD} = 2.7 \text{ to } 3.3 \text{ V}, T_A = -40 \text{ to } +85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
$T_{SVRL}$	Input $\overline{\text{ISP}}$ Valid to RST Edge	50			ns
$T_{RLSX}$	Input $\overline{\text{ISP}}$ Hold after RST Edge	50			ns
$T_{BHBL}$	FLASH Internal Busy (Programming) Time		10		ms
$N_{FCY}$	Number of Flash Write Cycles	100K			Cycle
$T_{FDR}$	Flash Data Retention Time	10			Years



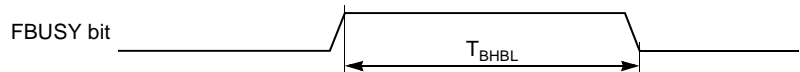
Waveforms

**Figure 28.** FLASH Memory - ISP Waveforms



Note: 1.  $\overline{\text{ISP}}$  must be driven through a pull-down resistor (see Section “In System Programming”, page 28).

**Figure 29.** FLASH Memory - Internal Busy Waveforms



External Clock Drive and Logic Level References

Definition of symbols

**Table 24.** External Clock Timing Symbol Definitions

Signals	
C	Clock

Conditions	
H	High
L	Low
X	No Longer Valid

Timings

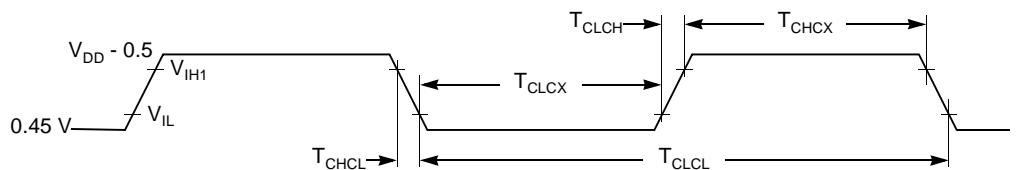
**Table 25.** External Clock AC Timings

$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

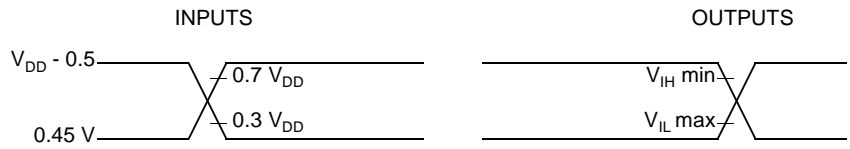
Symbol	Parameter	Min	Max	Unit
$T_{CLCL}$	Clock Period	50		ns
$T_{CHCX}$	High Time	10		ns
$T_{CLCX}$	Low Time	10		ns
$T_{CLCH}$	Rise Time	3		ns
$T_{CHCL}$	Fall Time	3		ns
$T_{CR}$	Cyclic Ratio in X2 mode	40	60	%

Waveforms

**Figure 30.** External Clock Waveform

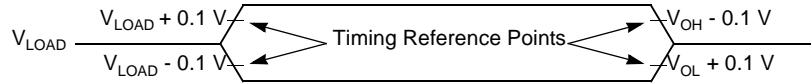


**Figure 31. AC Testing Input/Output Waveforms**



- Note:
1. During AC testing, all inputs are driven at  $V_{DD} - 0.5$  V for a logic 1 and 0.45 V for a logic 0.
  2. Timing measurements are made on all outputs at  $V_{IH}$  min for a logic 1 and  $V_{IL}$  max for a logic 0.

**Figure 32. Float Waveforms**



- Note:
- For timing purposes, a port pin is no longer floating when a 100 mV change from load voltage occurs and begins to float when a 100 mV change from the loading  $V_{OH}/V_{OL}$  level occurs with  $I_{OL}/I_{OH} = \pm 20$  mA.

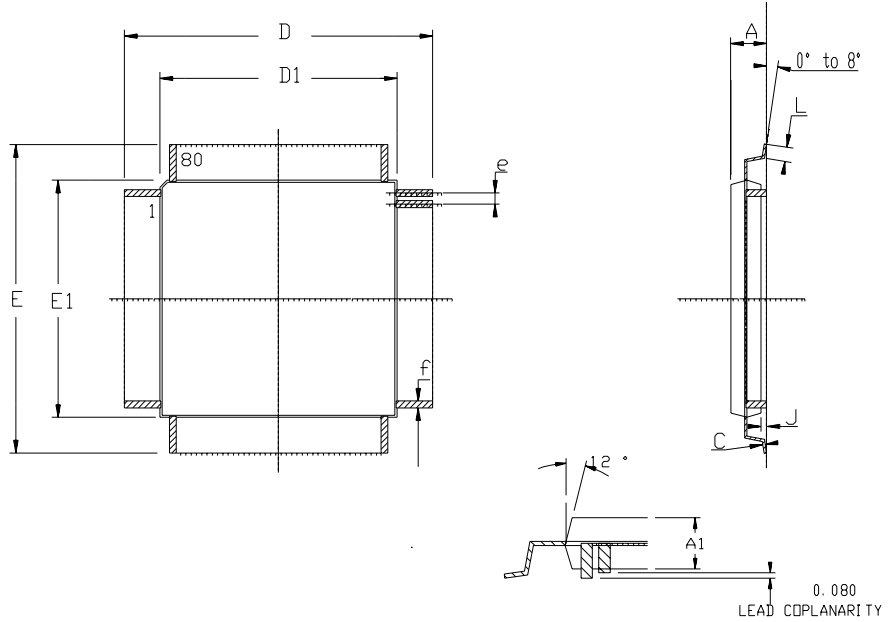
## Ordering Information

Part Number	Memory Size	Supply Voltage	Temperature Range	Max Frequency	Package <sup>(2)</sup>	Packing
AT89C51SND1C-ROTIL	64K Flash	3V	Industrial	40 MHz	TQFP80	Tray
AT89C51SND1C-7HTIL	64K Flash	3V	Industrial	40 MHz	BGA81	Tray
AT83SND1Cxxx <sup>(1)</sup> -ROTIL	64K ROM	3V	Industrial	40 MHz	TQFP80	Tray
AT83SND1Cxxx <sup>(1)</sup> -7HTIL	64K ROM	3V	Industrial	40 MHz	BGA81	Tray
AT80SND1C-ROTIL	ROMless	3V	Industrial	40 MHz	TQFP80	Tray
AT80SND1C-7HTIL	ROMless	3V	Industrial	40 MHz	BGA81	Tray

- Notes:
1. Refers to ROM code.
  2. PLCC84 package only available for development board.

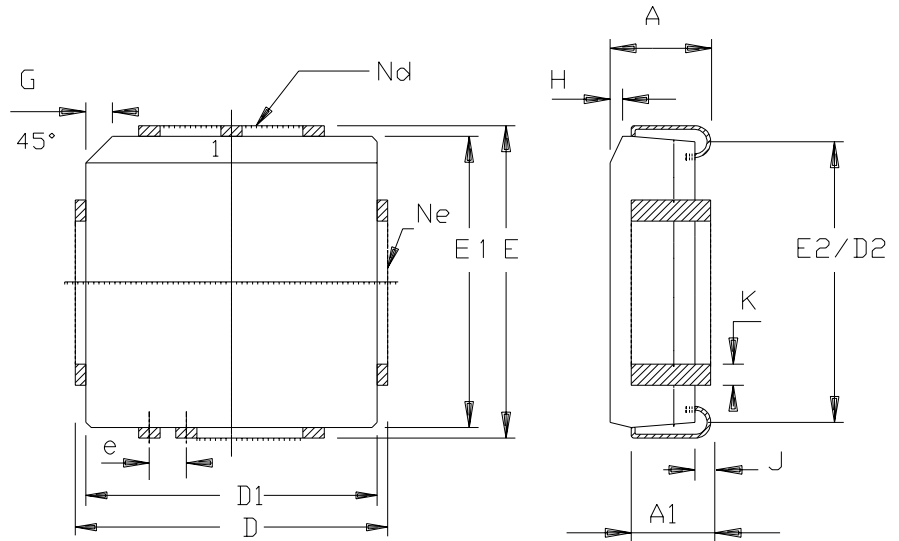
# Package Information

## TQFP80



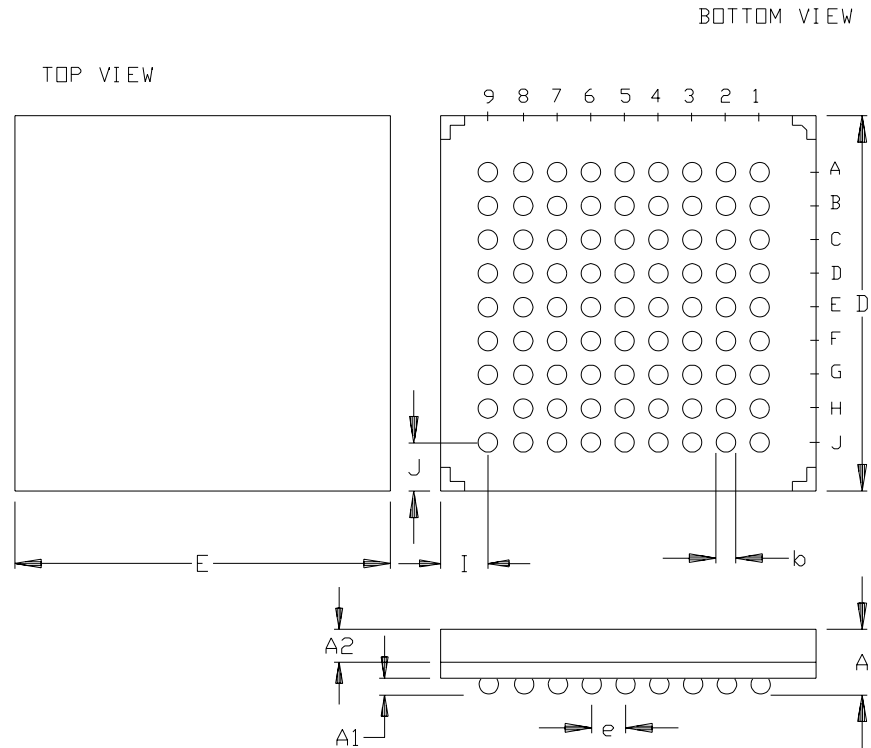
	MM		INCH	
	Min	Max	Min	Max
A	1.40	1.60	.055	.063
A1	1.35	1.45	.053	.057
C	0.17 BSC		.007 BSC	
D	15.80	16.20	.622	.638
D1	13.90	14.10	.547	.555
E	15.80	16.20	.622	.638
E1	13.90	14.10	.547	.555
J	0.05	0.15	.002	.006
L	0.45	0.75	.018	.030
e	0.65 BSC		.0256 BSC	
f	0.30 BSC		.012 BSC	

PLCC84



	MM		INCH	
	A	4.20	5.08	.165
A1	2.29	3.30	.090	.130
D	30.10	30.35	1.185	1.195
D1	29.21	29.41	1.150	1.158
D2	27.69	28.70	1.090	1.130
E	30.10	30.35	1.185	1.195
E1	29.21	29.41	1.150	1.158
E2	27.69	28.70	1.090	1.130
e	1.27	BSC	.050	BSC
G	1.07	1.22	.042	.048
H	1.07	1.42	.042	.056
J	0.51	-	.020	-
K	0.33	0.53	.013	.021
Nd	21		21	
Ne	21		21	
PKG STD	00			

# BGA81



	mm		
	MIN	NOM	MAX
A	1.30	1.40	1.50
A1	0.31	0.36	0.41
A2	0.65	0.70	0.75
e	0.80 BSC		
b	0.46 TYP		
E/D	8.95	9.00	9.05
I/J	1.30 REF		

Compliant JEDEC MO-205



**Datasheet Change  
Log for  
AT8xC51SND1C****Changes from 4109D-  
10/02 to 4109E-06/03**

1. Additional information on AT83C51SND1C product.
2. Added BGA81 package.
3. Updated AC/DC characteristics for AT89C51SND1C product.
4. Changed the endurance of Flash to 100, 000 Write/Erase cycles.
5. Added note on Flash retention formula for  $V_{IH1}$ , in Section "DC Characteristics", page 181.



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