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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: [info@chipsmall.com](mailto:info@chipsmall.com) Web: [www.chipsmall.com](http://www.chipsmall.com)

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



## 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)
  - AT83SND1C: ROM
- 4K Bytes of Boot Flash Memory (AT89C51SND1C)
  - ISP: Download from USB (standard) or UART (option)
- External Code Memory
  - AT80C51SND1C: ROMless
- 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



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

**AT83SND1C**  
**AT89C51SND1C**  
**AT80C51SND1C**



## 1. 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.

The AT83SND1C includes 64K Bytes of ROM memory.

The AT80C51SND1C does not include any code memory.

The AT8xC51SND1C include 2304 Bytes of RAM memory.

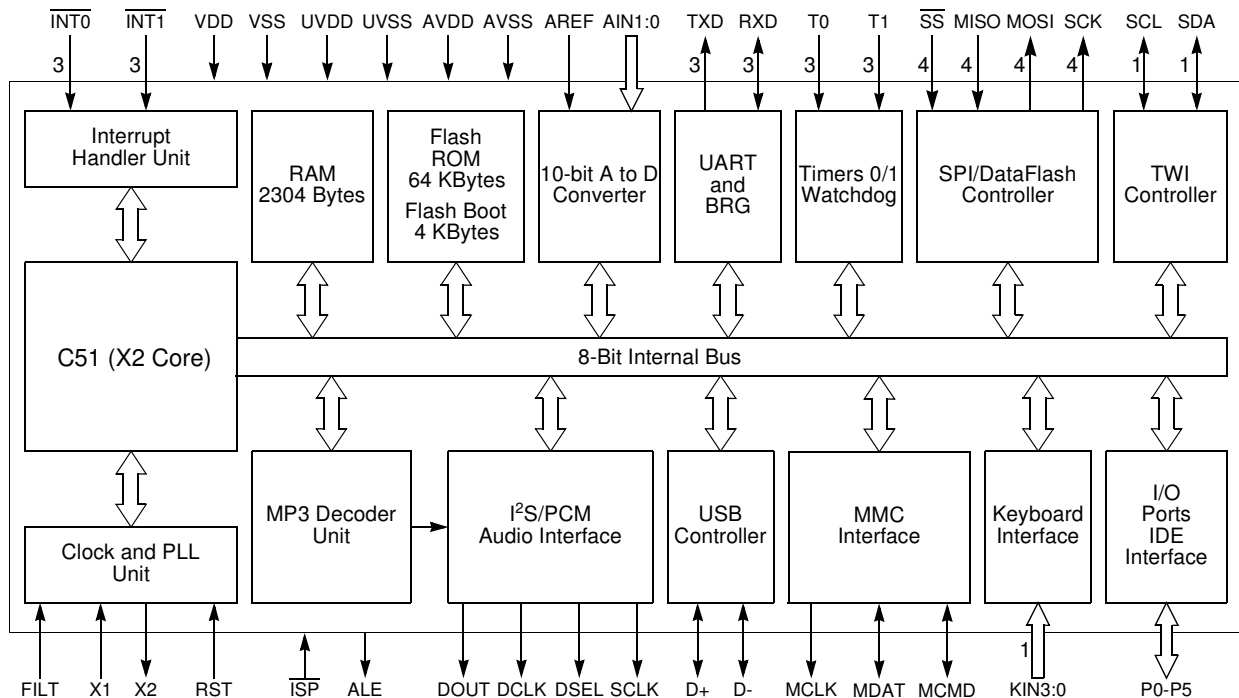
The AT8xC51SND1C provides the necessary features for human interface like timers, keyboard port, serial or parallel interface (USB, TWI, SPI, IDE), ADC input, I<sup>2</sup>S output, and all external memory interface (NAND or NOR Flash, SmartMedia, MultiMedia, DataFlash cards).

## 2. Typical Applications

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

## 3. Block Diagram

Figure 3-1. AT8xC51SND1C Block Diagram



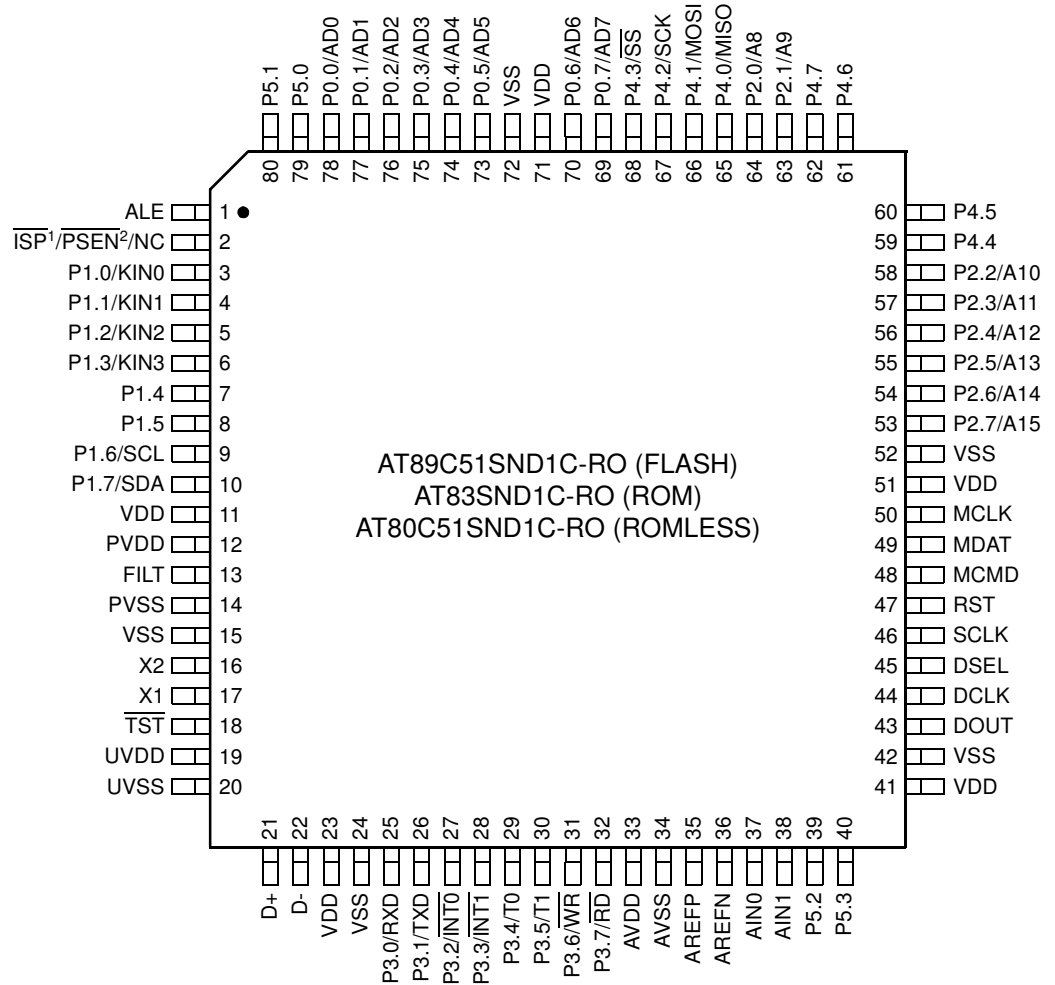
- 1 Alternate function of Port 1  
 3 Alternate function of Port 3  
 4 Alternate function of Port 4



## 4. Pin Description

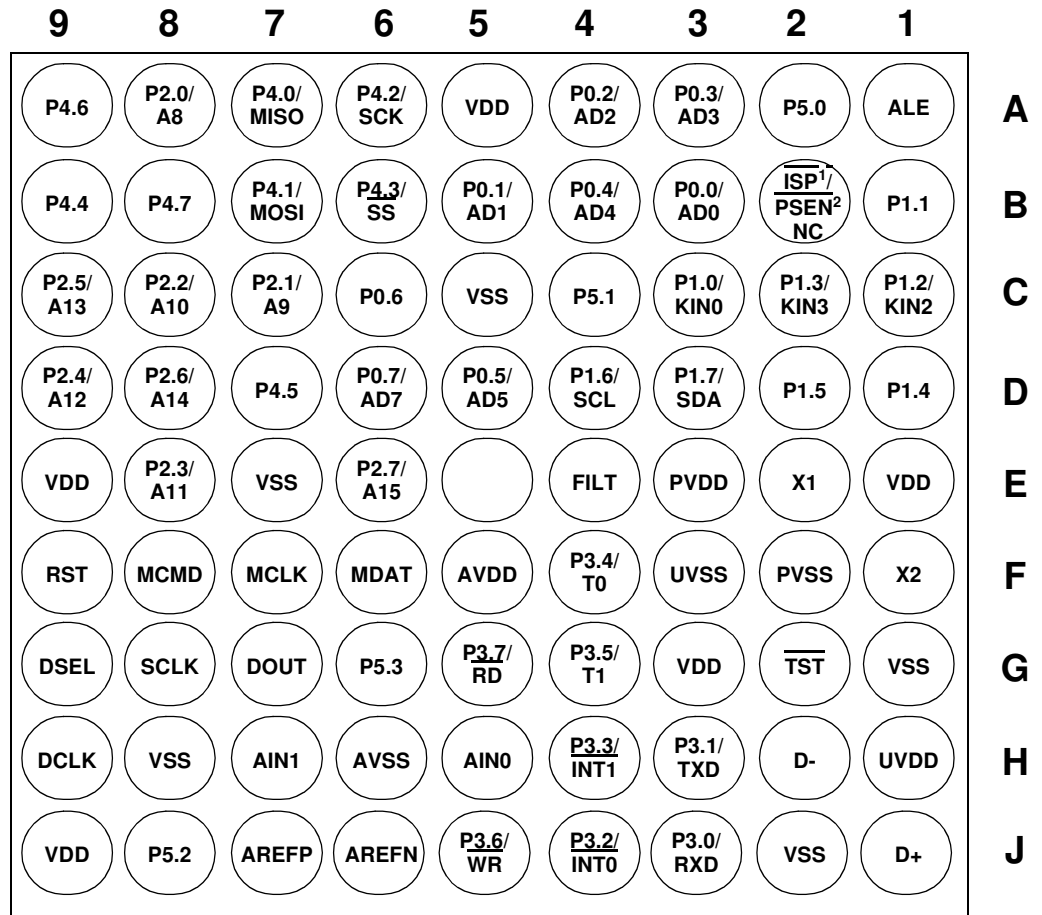
### 4.1 Pinouts

Figure 4-1. AT8xC51SND1C 80-pin QFP Package



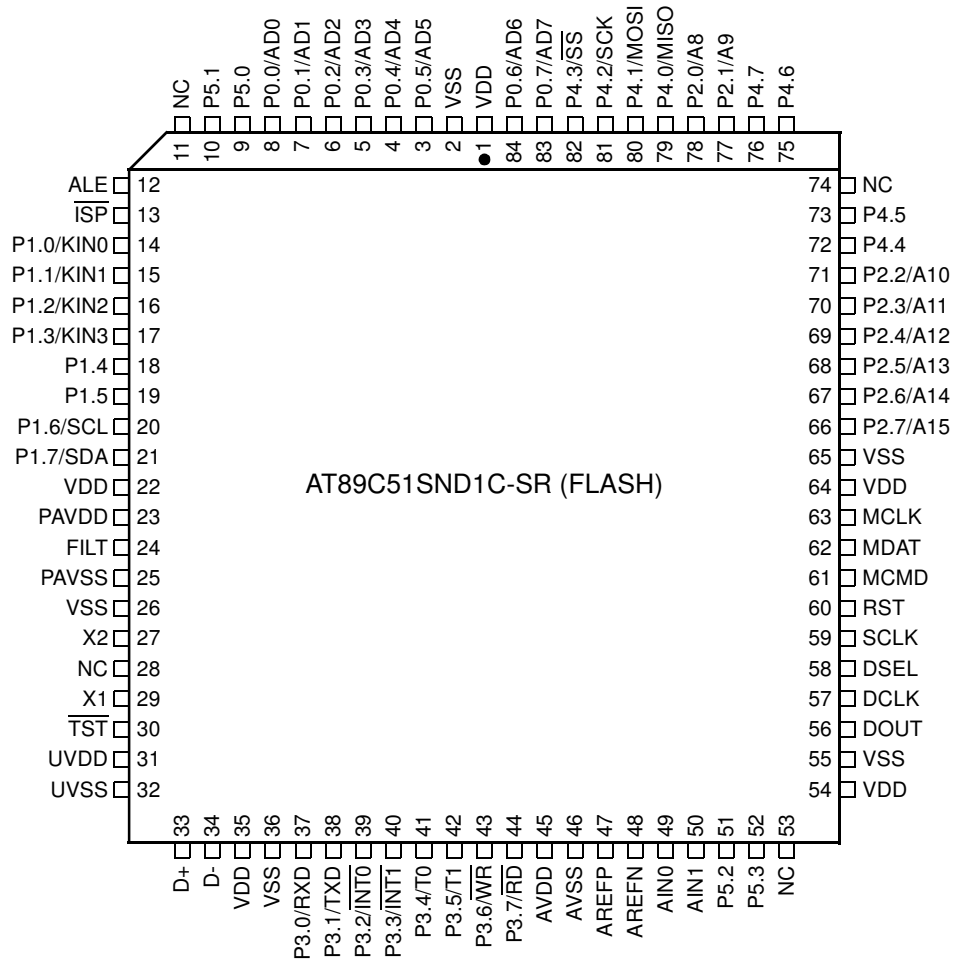
- Notes:
1.  $\overline{\text{ISP}}$  pin is only available in AT89C51SND1C product.  
Do not connect this pin on AT83SND1C product.
  2.  $\overline{\text{PSEN}}$  pin is only available in AT80C51SND1C product.

**Figure 4-2.** AT8xC51SND1C 81-pin BGA Package



- Notes:
1.  $\overline{\text{ISP}}$  pin is only available in AT89C51SND1C product.  
Do not connect this pin on AT83SND1C and AT80C51SND1C product.
  2. PSEN pin is only available in AT80C51SND1C product.

**Figure 4-3.** AT8xC51SND1C 84-pin PLCC Package



## 4.2 Signals

All the AT8xC51SND1C signals are detailed by functionality in Table 1 to 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 bidirectional 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 <sub>DD</sub> or V <sub>SS</sub> .	AD7:0
P1.7:0	I/O	<b>Port 1</b> P1 is an 8-bit bidirectional I/O port with internal pull-ups.	KIN3:0 SCL SDA
P2.7:0	I/O	<b>Port 2</b> P2 is an 8-bit bidirectional I/O port with internal pull-ups.	A15:8

Signal Name	Type	Description	Alternate Function
P3.7:0	I/O	<b>Port 3</b> P3 is an 8-bit bidirectional I/O port with internal pull-ups.	RXD TXD $\overline{\text{INT0}}$ $\overline{\text{INT1}}$ T0 T1 $\overline{\text{WR}}$ $\overline{\text{RD}}$
P4.7:0	I/O	<b>Port 4</b> P4 is an 8-bit bidirectional 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 bidirectional 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> $\overline{\text{INT0}}$ serves as external run control for timer 0, when selected by GATE0 bit in TCON register. <b>External Interrupt 0</b> $\overline{\text{INT0}}$ input sets IE0 in the TCON register. If bit IT0 in this register is set, bit IE0 is set by a falling edge on $\overline{\text{INT0}}$ . If bit IT0 is cleared, bit IE0 is set by a low level on $\overline{\text{INT0}}$ .	P3.2
$\overline{\text{INT1}}$	I	<b>Timer 1 Gate Input</b> $\overline{\text{INT1}}$ serves as external run control for timer 1, when selected by GATE1 bit in TCON register. <b>External Interrupt 1</b> $\overline{\text{INT1}}$ input sets IE1 in the TCON register. If bit IT1 in this register is set, bit IE1 is set by a falling edge on $\overline{\text{INT1}}$ . If bit IT1 is cleared, bit IE1 is set by a low level on $\overline{\text{INT1}}$ .	P3.3

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 <sub>DD</sub> 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> Bidirectional command channel used for card initialization and data transfer commands. To avoid any parasitic current consumption, unused MCMD input must be polarized to V <sub>DD</sub> or V <sub>SS</sub> .	-
MDAT	I/O	<b>MMC Data line</b> Bidirectional data channel. To avoid any parasitic current consumption, unused MDAT input must be polarized to V <sub>DD</sub> or V <sub>SS</sub> .	-



**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 bidirectional Two Wire 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.	-
$\overline{\text{PSEN}}$	I/O	<b>Program Store Enable Output (AT80C51SND1C Only)</b> This signal is active low during external code fetch or external code read (MOVC instruction).	-
$\overline{\text{ISP}}$	I/O	<b>ISP Enable Input (AT89C51SND1C Only)</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
$\overline{\text{EA}}^{(1)(2)}$	I	<b>External Access Enable (Dice Only)</b> $\overline{\text{EA}}$ must be externally held low to enable the device to fetch code from external program memory locations 0000h to FFFFh.	-

Notes: 1. For ROM/Flash Dice product versions: pad  $\overline{\text{EA}}$  must be connected to VCC.  
2. For ROMless Dice product versions: pad  $\overline{\text{EA}}$  must be connected to VSS.

**Table 13.** System Signal Description

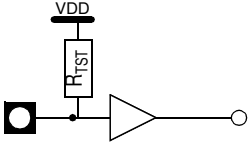
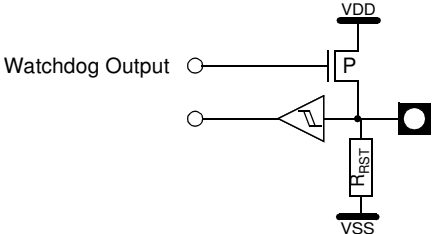
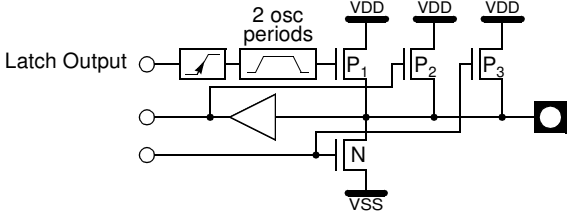
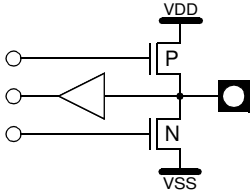
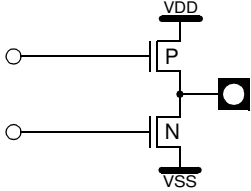
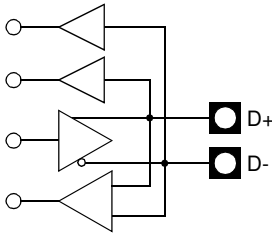
Signal Name	Type	Description	Alternate Function
RST	I	<b>Reset Input</b> Holding this pin high for 64 oscillator periods while the oscillator is running resets the device. The Port pins are driven to their reset conditions when a voltage lower than $V_{IL}$ is applied, whether or not the oscillator is 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
VDD	PWR	<b>Digital Supply Voltage</b> Connect these pins to +3V supply voltage.	-
VSS	GND	<b>Circuit Ground</b> Connect these pins to ground.	-
AVDD	PWR	<b>Analog Supply Voltage</b> Connect this pin to +3V supply voltage.	-
AVSS	GND	<b>Analog Ground</b> Connect this pin to ground.	-
PVDD	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.	-
UVDD	PWR	<b>USB Supply Voltage</b> Connect this pin to +3V supply voltage.	-
UVSS	GND	<b>USB Ground</b> Connect this pin to ground.	-

## 4.3 Internal Pin Structure

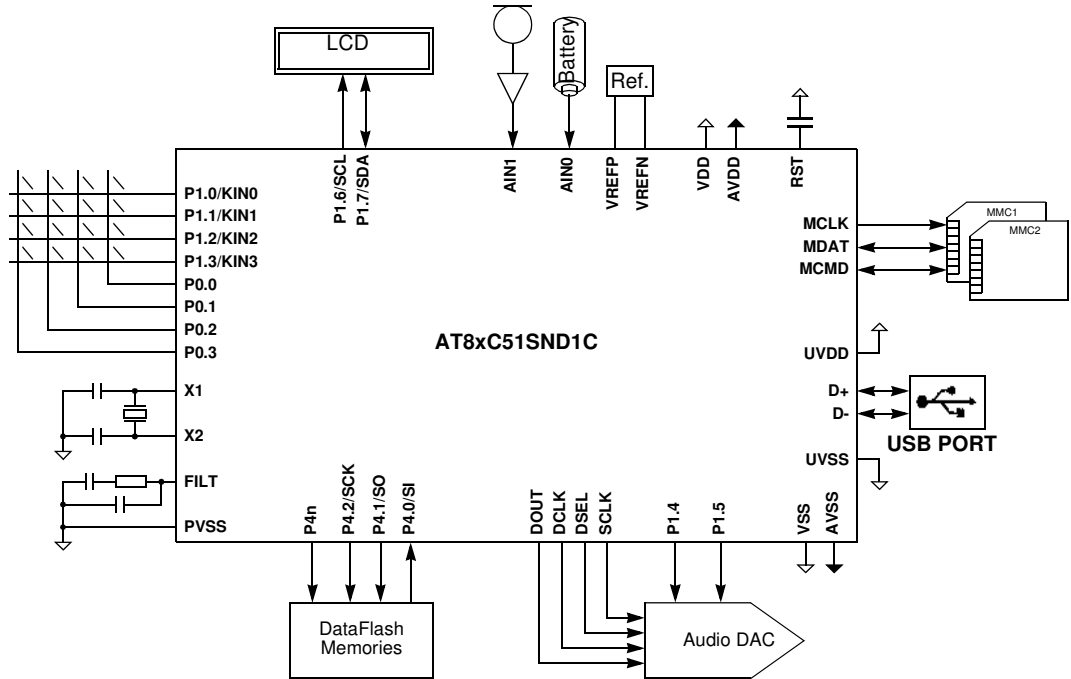
Table 15. Detailed Internal Pin Structure

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 $\overline{\text{ISP}}$ $\overline{\text{PSEN}}$
	Output	ALE SCLK DCLK DOUT DSEL MCLK
	Input/Output	D+ D-

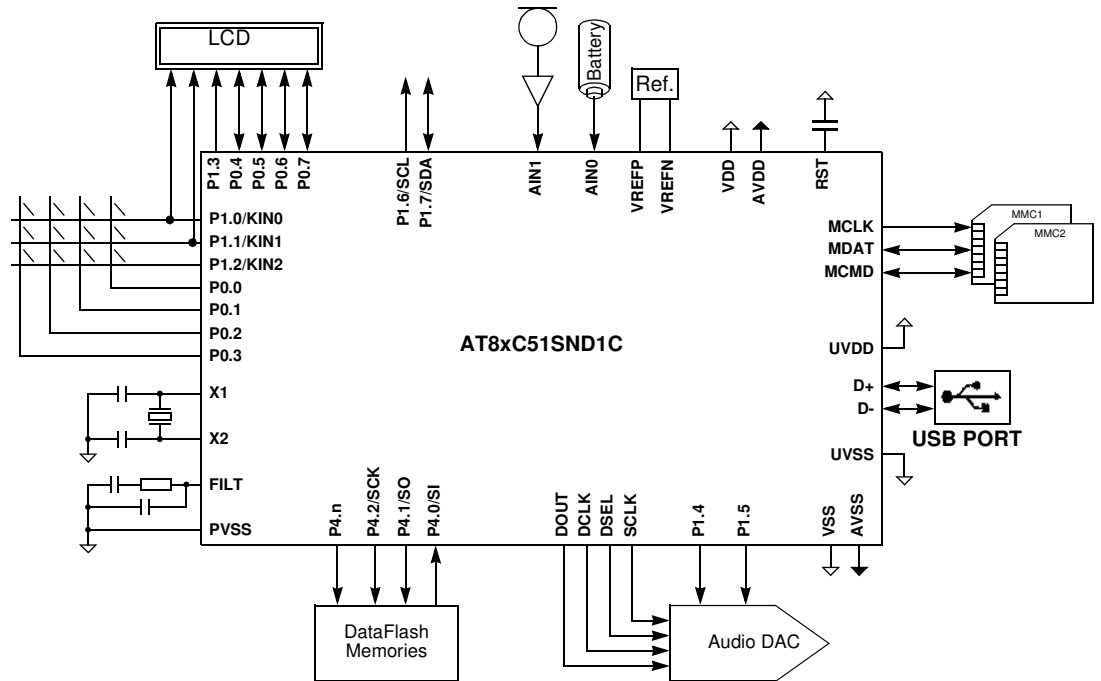
- Notes:
- For information on resistors value, input/output levels, and drive capability, refer to the Section "DC Characteristics", page 18.
  - When the Two Wire controller is enabled, P<sub>1</sub>, P<sub>2</sub>, and P<sub>3</sub> transistors are disabled allowing pseudo open-drain structure.
  - In Port 2, P<sub>1</sub> transistor is continuously driven when outputting a high level bit address (A15:8).

## 5. Application Information

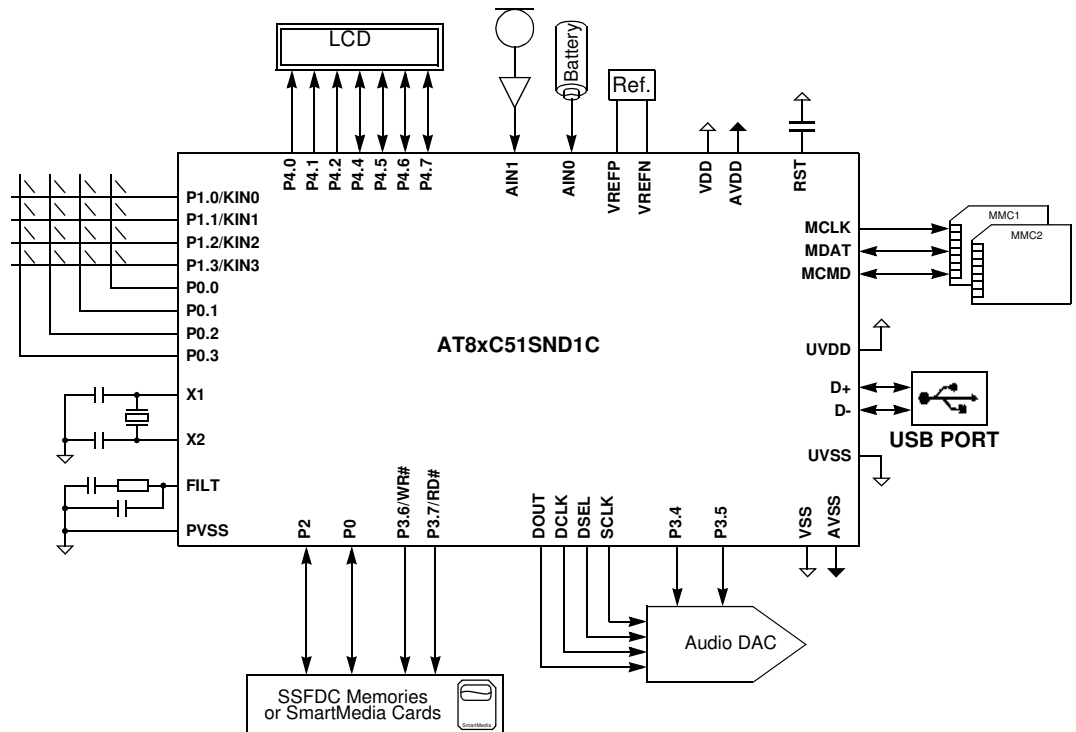
**Figure 5-1.** AT8xC51SND1C Typical Application with On-Board Atmel DataFlash and 2-wire LCD



**Figure 5-2.** AT8xC51SND1C Typical Application with On-Board Atmel DataFlash and // LCD

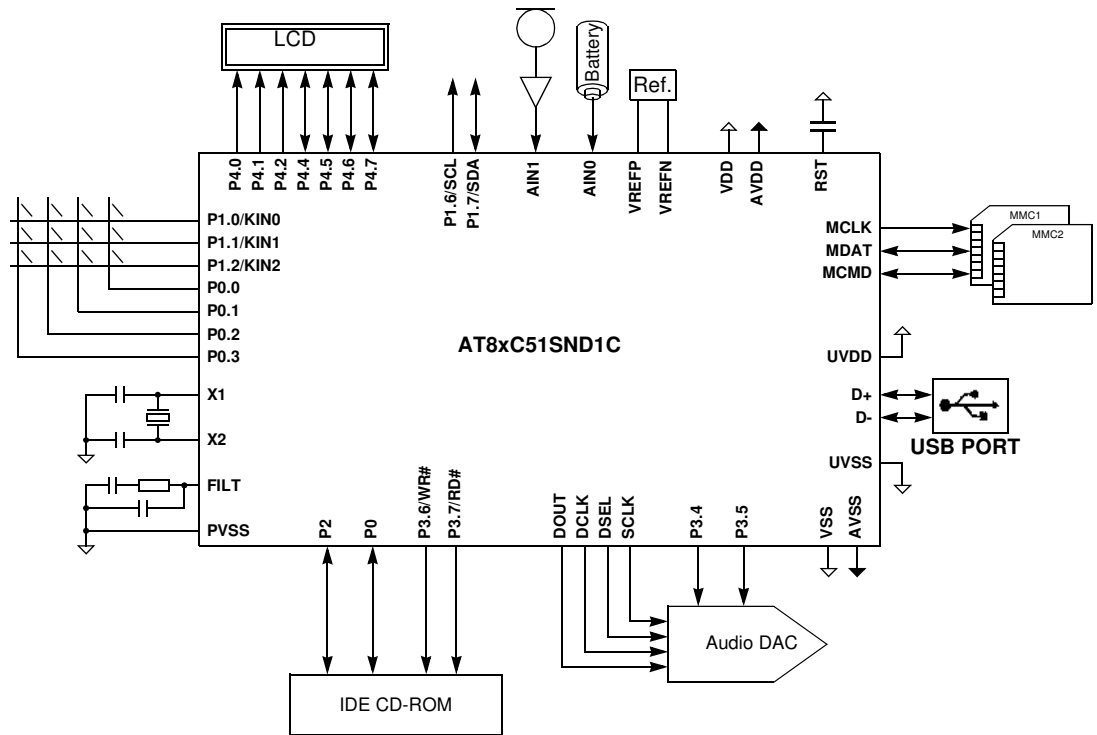


**Figure 5-3.** AT8xC51SND1C Typical Application with On-Board SSFDC Flash





**Figure 5-4.** AT8xC51SND1C Typical Application with IDE CD-ROM Drive



## **6. Peripherals**

The AT8xC51SND1C peripherals are briefly described in the following sections. For further details on how to interface (hardware and software) to these peripherals, please refer to the AT8xC51SND1C design guide.

### **6.1 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.

### **6.2 Ports**

The AT8xC51SND1C implements five 8-bit ports (P0 to P4) and one 4-bit port (P5). In addition to performing general-purpose I/O, some ports are capable of external data memory operations; others allow for alternate functions. All I/O Ports are bidirectional. 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/O and alternate functions.

### **6.3 Timers/Counters**

The AT8xC51SND1C implements 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.

### **6.4 Watchdog Timer**

The AT8xC51SND1C implements 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.

### **6.5 MP3 Decoder**

The AT8xC51SND1C implements a MPEG I/II audio layer 3 decoder (known as 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 32 MBytes 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.

## 6.6 Audio Output Interface

The AT8xC51SND1C implements an audio output interface allowing the decoded audio bit-stream to be output in various formats. It is compatible with right and left justification PCM and I<sup>2</sup>S formats and thanks to the on-chip PLL (see Section 6.1) allows connection of almost all of the commercial audio DAC families available on the market.

## 6.7 Universal Serial Bus Interface

The AT8xC51SND1C implements a full speed Universal Serial Bus 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.

## 6.8 MultiMediaCard Interface

The AT8xC51SND1C implements a MultiMediaCard (MMC) interface compliant to the V2.2 specification in MultiMediaCard Mode. The MMC allows storage of MP3 encoded audio files in removable flash memory cards that can be easily plugged or removed from the application. It can also be used for In System Programming.

## 6.9 IDE/ATAPI interface

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

## 6.10 Serial I/O Interface

The AT8xC51SND1C implements 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.

## 6.11 Serial Peripheral Interface

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

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

## 6.12 2-wire Controller

The AT8xC51SND1C implements a 2-wire 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.

### **6.13 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.

### **6.14 Keyboard Interface**

The AT8xC51SND1C implements 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 alternate function of P1.3:0 and allow exit from idle and power down modes.

## 7. Electrical Characteristics

### 7.1 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	
$V_{DD}$ .....	4.0V	

### 7.2 DC Characteristics

#### 7.2.1 Digital Logic

**Table 16.** 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	$I_{OH} = -30$ $\mu$ 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	$\mu$ A	$V_{IN} = 0.45$ V
$I_{LI}$	Input Leakage Current (P0, ALE, MCMD, MDAT, MCLK, SCLK, DCLK, DSEL, DOUT)			10	$\mu$ A	$0.45 < V_{IN} < V_{DD}$
$I_{TL}$	Logical 1 to 0 Transition Current (P1, P2, P3, P4 and P5)			-650	$\mu$ 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 16.** 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
$I_{DD}$	AT89C51SND1C Operating Current		(3)	X1 / X2 mode 6.5 / 10.5 8 / 13.5 9.5 / 17	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
	AT83SND1C Operating Current			X1 / X2 mode 6.5 / 10.5 8 / 13.5 9.5 / 17	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
	AT80C51SND1C Idle Mode Current			X1 / X2 mode 6.5 / 10.5 8 / 13.5 9.5 / 17	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
$I_{DL}$	AT89C51SND1C Idle Mode Current		(3)	X1 / X2 mode 5.3 / 8.1 6.4 / 10.3 7.5 / 13	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
	AT83SND1C Idle Mode Current			X1 / X2 mode 5.3 / 8.1 6.4 / 10.3 7.5 / 13	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
	AT80C51SND1C Idle Mode Current			X1 / X2 mode 5.3 / 8.1 6.4 / 10.3 7.5 / 13	mA	$V_{DD} < 3.3$ V 12 MHz 16 MHz 20 MHz
$I_{PD}$	AT89C51SND1C Power-Down Mode Current		20	500	$\mu\text{A}$	$V_{RET} < V_{DD} < 3.3$ V
	AT83SND1C Power-Down Mode Current		20	500	$\mu\text{A}$	$V_{RET} < V_{DD} < 3.3$ V
	AT80C51SND1C Power-Down Mode Current		20	500	$\mu\text{A}$	$V_{RET} < V_{DD} < 3.3$ V
$I_{FP}$	AT89C51SND1C Flash Programming Current			15	mA	$V_{DD} < 3.3$ V

Notes: 1. Typical values are obtained using  $V_{DD} = 3$  V and  $T_A = 25^\circ\text{C}$ . They are not tested and there is no guarantee on these values.  
2. Flash retention is guaranteed with the same formula for  $V_{DD}$  min down to 0V.  
3. See Table 17 for typical consumption in player mode.

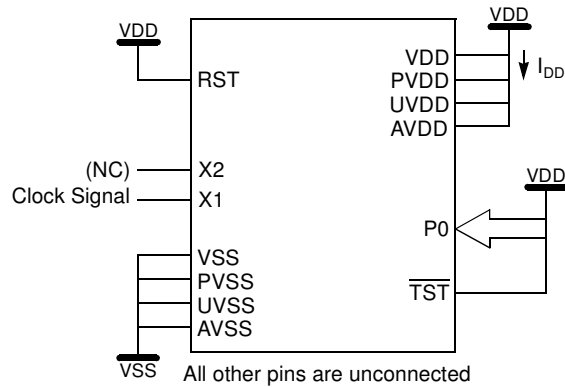
**Table 17.** Typical Reference Design AT89C51SND1C Power Consumption

Player Mode	$I_{DD}$	Test Conditions
Stop	10 mA	AT89C51SND1C at 16 MHz, X2 mode, $V_{DD} = 3$ V No song playing
Playing	30 mA	AT89C51SND1C at 16 MHz, X2 mode, $V_{DD} = 3$ V MP3 Song with $F_s = 44.1$ KHz, at any bit rates (Variable Bit Rate)

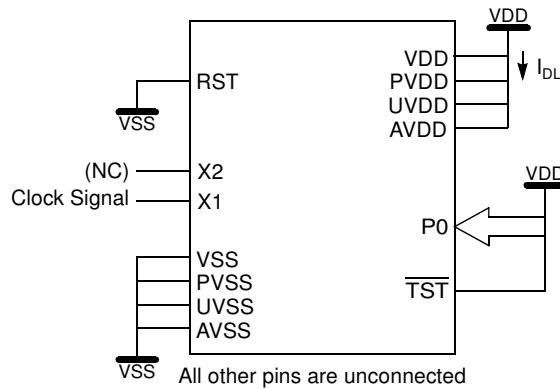


### 7.2.1.1 $I_{DD}$ , $I_{DL}$ and $I_{PD}$ Test Conditions

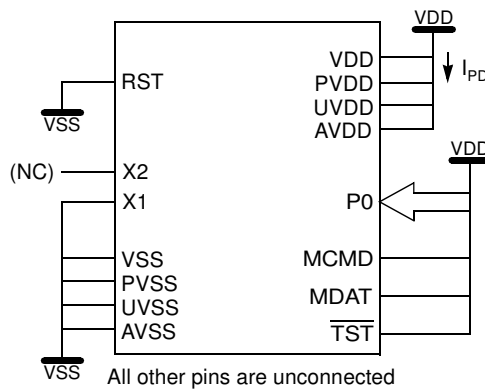
**Figure 7-1.**  $I_{DD}$  Test Condition, Active Mode



**Figure 7-2.**  $I_{DL}$  Test Condition, Idle Mode



**Figure 7-3.**  $I_{PD}$  Test Condition, Power-Down Mode



## 7.2.2 A to D Converter

**Table 18.** A to D Converter DC Characteristics

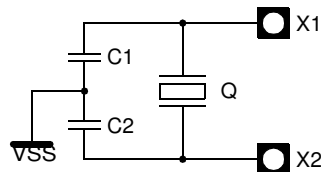
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

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	K $\Omega$	$T_A = 25^\circ\text{C}$
$C_{IA}$	Analog Input capacitance			10	pF	$T_A = 25^\circ\text{C}$

## 7.2.3 Oscillator & Crystal

### 7.2.3.1 Schematic

**Figure 7-4.** 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.

### 7.2.3.2 Parameters

**Table 19.** Oscillator & Crystal Characteristics

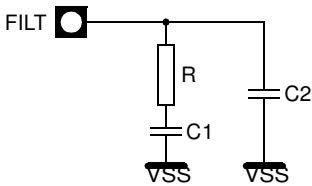
$V_{DD} = 2.7$  to  $3.3$  V,  $T_A = -40$  to  $+85^\circ\text{C}$

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

## 7.2.4 Phase Lock Loop

### 7.2.4.1 Schematic

**Figure 7-5.** PLL Filter Connection



### 7.2.4.2 Parameters

**Table 20.** PLL Filter Characteristics

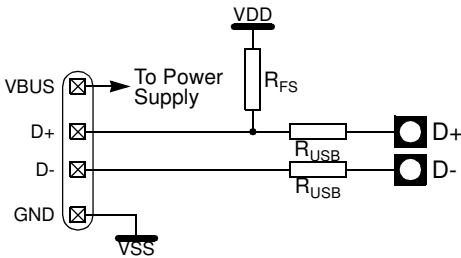
$V_{DD} = 2.7 \text{ to } 3.3 \text{ V}$ ,  $T_A = -40 \text{ to } +85^\circ\text{C}$

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

## 7.2.5 USB Connection

### 7.2.5.1 Schematic

**Figure 7-6.** USB Connection



### 7.2.5.2 Parameters

**Table 21.** USB Characteristics

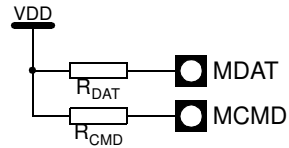
$V_{DD} = 2.7 \text{ to } 3.3 \text{ V}$ ,  $T_A = -40 \text{ to } +85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
$R_{USB}$	USB Termination Resistor		27		$\Omega$
$R_{FS}$	USB Full Speed Resistor		1.5		$K\Omega$

## 7.2.6 MMC Controller

### 7.2.6.1 Schematic

**Figure 7-7.** MMC Connection



### 7.2.6.2 Parameters

**Table 22.** MMC Components Characteristics

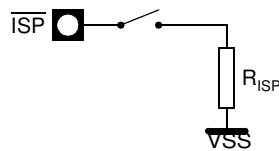
$V_{DD} = 2.7 \text{ to } 3.3 \text{ V}$ ,  $T_A = -40 \text{ to } +85^\circ\text{C}$

Symbol	Parameter	Min	Typ	Max	Unit
R <sub>CMD</sub>	MMC/SD Command Line Pull-Up Resistor		100		K $\Omega$
R <sub>DAT</sub>	MMC/SD Data Line Pull-Up Resistor		10		K $\Omega$

## 7.2.7 In System Programming

### 7.2.7.1 Schematic

**Figure 7-8.** ISP Pull-Down Connection



### 7.2.7.2 Parameters

**Table 23.** ISP Pull-Down Characteristics

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

Symbol	Parameter	Min	Typ	Max	Unit
R <sub>ISP</sub>	ISP Pull-Down Resistor		2.2		K $\Omega$

## 7.3 AC Characteristics

### 7.3.1 External Program Bus Cycles

#### 7.3.1.1 Definition of Symbols

**Table 24.** External Program Bus Cycles Timing Symbol Definitions

Signals		Conditions	
A	Address	H	High
I	Instruction In	L	Low
L	ALE	V	Valid
P	$\overline{\text{PSEN}}$	X	No Longer Valid
		Z	Floating

#### 7.3.1.2 Timings

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

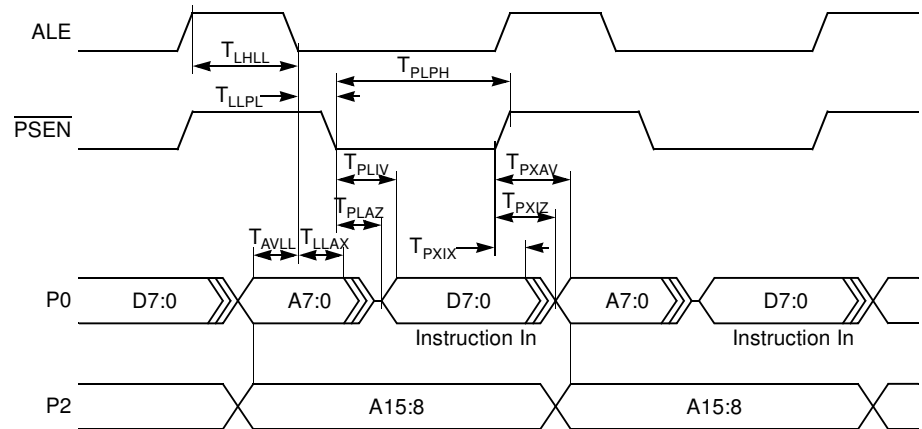
**Table 25.** External Program Bus Cycle - Read AC Timings

$V_{DD} = 2.7$  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
$T_{LLIV}$	ALE Low to Valid Instruction	$4 \cdot T_{CLCL} - 35$		$2 \cdot T_{CLCL} - 35$		ns
$T_{PLPH}$	$\overline{\text{PSEN}}$ Pulse Width	$3 \cdot T_{CLCL} - 25$		$1.5 \cdot T_{CLCL} - 25$		ns
$T_{PLIV}$	$\overline{\text{PSEN}}$ Low to Valid Instruction		$3 \cdot T_{CLCL} - 35$		$1.5 \cdot T_{CLCL} - 35$	ns
$T_{PXIX}$	Instruction Hold After $\overline{\text{PSEN}}$ High	0		0		ns
$T_{PXIZ}$	Instruction Float After $\overline{\text{PSEN}}$ High		$T_{CLCL} - 10$		$0.5 \cdot T_{CLCL} - 10$	ns
$T_{AVIV}$	Address Valid to Valid Instruction		$5 \cdot T_{CLCL} - 35$		$2.5 \cdot T_{CLCL} - 35$	ns
$T_{PLAZ}$	$\overline{\text{PSEN}}$ Low to Address Float		10		10	ns

## 7.3.1.3 Waveforms

**Figure 7-9.** External Program Bus Cycle - Read Waveforms



## 7.3.2 External Data 8-bit Bus Cycles

### 7.3.2.1 Definition of Symbols

**Table 26.** External Data 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	$\overline{WR}$		

### 7.3.2.2 Timings

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

**Table 27.** External Data 8-bit Bus Cycle - 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