

ISD ChipCorder® ISD1600B Series DataSheet

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TABLE OF CONTENTS

1. GENERAL DESCRIPTION	3
2. FEATURES	4
3. BLOCK DIAGRAM	5
4. PIN CONFIGURATION	6
5. PIN DESCRIPTION.....	7
6. FUNCTIONAL DESCRIPTION.....	10
6.1. Detailed Description	10
6.1.1 Audio Quality.....	10
6.1.2 Duration.....	10
6.1.3 Flash Storage.....	10
6.1.4 Basic Operation.....	10
6.1.5 Automatic Power-Down Mode.....	10
6.2. Functional Description Example.....	10
6.2.1. Record a Message	11
6.2.2. Edge-trigger Playback.....	11
6.2.3. Level- trigger Playback.....	11
6.2.4. LED Operation	11
6.2.5. Rosc Operation.....	11
7. TIMING DIAGRAMS	12
8. ABSOLUTE MAXIMUM RATINGS.....	14
8.1 Operating Conditions	15
9. ELECTRICAL CHARACTERISTICS	16
9.1. DC Parameters	16
9.2. AC Parameters.....	18
10. TYPICAL APPLICATION CIRCUIT	19
11. PACKAGE DRAWING AND DIMENSIONS	20
11.1. 16-Lead 150mil Small Outline Integrated Circuit Package	20
12. ORDERING INFORMATION.....	22
13. REVISION HISTORY	24
IMPORTANT NOTICE	25

1. GENERAL DESCRIPTION

The Nuvoton® ISD1600B ChipCorder® Series is a high quality, fully integrated, single-chip single-message voice record and playback device ideally suited to a variety of electronic systems. The message duration is user selectable in ranges from 6.6 seconds to 40 seconds, depending on the specific device. The sampling frequency of each device can also be adjusted from 4 kHz to 12 kHz with an external resistor, giving the user greater flexibility in duration versus recording quality for each application. Operating voltage spans a range from 2.4 V to 5.5 V to ensure that the ISD1600B devices are optimized for a wide range of battery or line-powered applications.

The devices include an on-chip oscillator (with external resistor control), microphone preamplifier with Automatic Gain Control (AGC), anti-aliasing filter, Multi-Level Storage (MLS) array, smoothing filter, Pulse Width Modulation (PWM) Class D speaker driver, and current output. Voice signals can be fed into the chip through a differential microphone input for recording. The PWM output can directly drive a standard 8 Ω speaker or a typical buzzer, while the separate single-ended current output can drive an external amplifier.

Recordings are stored into the on-chip Flash memory cells, providing zero-power message storage. This unique single-chip solution is made possible through Nuvoton's patented Multi-Level Storage (MLS) technology. Audio data are stored directly in solid-state memory without digital compression, providing superior quality voice and music reproduction.

2. FEATURES

- User-friendly single-chip, single-message voice record & playback devices
- Wide operating voltage: 2.4V to 5.5V
- Push-button interface
 - Record is level-triggered
 - Playback is either edge- or level-triggered
- Selectable sampling frequency controlled by an external oscillator resistor

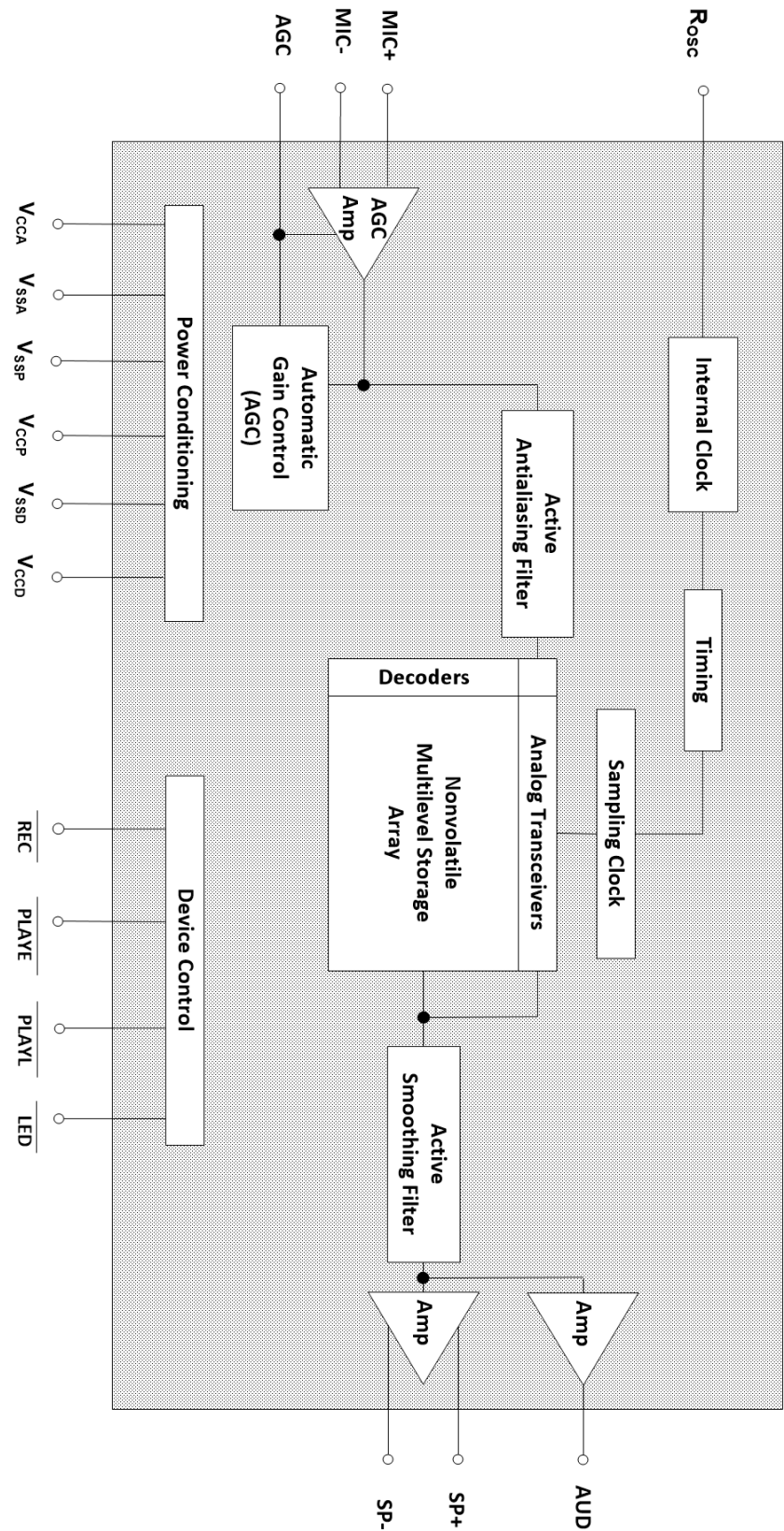
Sampling Frequency	12 kHz	8 kHz	6.4 kHz	5.3 kHz	4 kHz
Rosc	53 k Ω	80 k Ω	100 k Ω	120 k Ω	160 k Ω

- Variable duration selected by external oscillator resistor

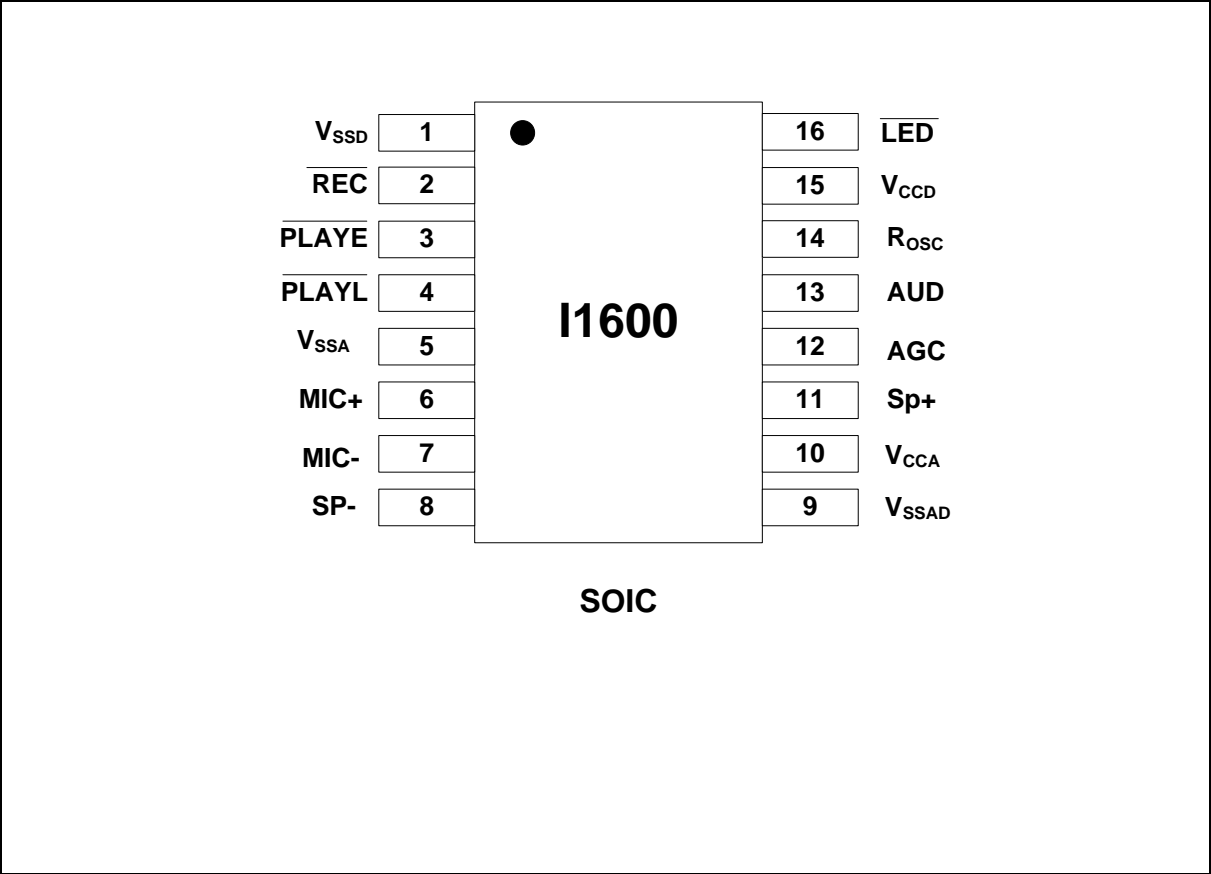
Sample Frequency	12 KHz	8 KHz	6.4 KHz	5.3 KHz	4 HKz
ISD1610B	6.6 secs	10 secs	12.5 secs	15 secs	20 secs
ISD1616B	10.6 secs	16 secs	20 secs	24 secs	32 secs
ISD1620B	13.3 secs	20 secs	25 secs	30 secs	40 secs

- Message and operation indicators
 - LED: stay on during recording, blink during playback operation
- Automatic power-down mode
 - Enters standby mode immediately after a record or playback cycle
 - Standby current: 1 μ A typical and 10 μ A maximum
- Dual output channels
 - PWM Class D speaker amplifier to directly drive an 8 Ω speaker or a typical buzzer
 - AUD single-ended current output to drive external power amplifier
- ChipCorder standard features
 - High-quality, natural voice and audio reproduction
 - Zero-power message storage: Eliminates battery backup circuits
 - 100-year message retention (typical)
 - 100,000 record cycles (typical)
- Package options: DIE / SOP-16
Package is Halogen-free, RoHS-compliant and TSCA-compliant
- Temperature options:
 - Commercial: 0°C ~ +50°C (DIE) / 0°C ~ +70°C (SOP-16)
 - Industrial: -40°C ~ +85°C (SOP-16)

3. BLOCK DIAGRAM



4. PIN CONFIGURATION



5. PIN DESCRIPTION

PIN NAME	SOIC / PDIP	FUNCTIONS
	PIN NO.	
V _{SSD}	1	Digital Ground: V _{SSD} is the ground for digital circuits. It is important to have a separate path for each ground back to the system ground terminal to minimize noise.
$\overline{\text{REC}}$	2	Record: The device starts recording whenever $\overline{\text{REC}}$ transits from High to Low and stays at Low. Recording stops when the signal returns to High. This pin has an internal pull-up resistor ^[1] and an internal debounce on falling edge.
$\overline{\text{PLAYE}}$	3	Edge-trigger Playback: A playback operation starts when this input detects a low going signal exceeding the specified debounced time. This pin has an internal pull-up resistor ^[1] and an internal debounce on both falling & rising edge.
$\overline{\text{PLAYL}}$	4	Level-trigger Playback: A playback operation begins when this input detects a low going signal and remains at Low. Playback stops when the signal returns to High. This pin has an internal pull-up resistor ^[1] and an internal debounce on falling edge.
V _{SSA}	5	Analog Ground: V _{SSA} is the ground for analog circuits. It is important to have a separate path for each ground back to the system ground terminal to minimize noise.
MIC+	6	Microphone Positive Input: The input transfers the signal to the preamplifier. The internal Automatic Gain Control (AGC) circuit controls the gain of the preamplifier. An external microphone should be AC coupled to this pin via a series capacitor. The capacitor value, together with an internal 10 K Ω resistance on this pin, determines the low-frequency cutoff for the ISD1600B passband.
MIC-	7	Microphone Negative Input: This is the inverting input to the microphone preamplifier. It provides input noise-cancellation, or common-mode rejection, when the microphone is connected differentially to the device.

PIN NAME	SOIC / PDIP	FUNCTIONS
	PIN NO.	
SP-	8	Speaker Negative : The SP-, Class D PWM output, provides a differential output with SP+ pin to drive 8Ω speaker or buzzer. During power down or recording, this pin is tri-stated.
V _{SSP}	9	PWM Ground : V _{SSP} is the ground for PWM speaker driver. It is important to have a separate path for each ground back to the system ground terminal to minimize noise.
V _{CCA}	10	Analog power supply : It is important to have a separate path for each power back to the power terminal to minimize the noises. Decoupling capacitors to V _{SSA} should be as close to the device as possible.
V _{CCP}	10	V_{CCP} : Power supply for PWM speaker drivers. It is important to have a separate path for each power back to the power terminal to minimize noise. Decoupling capacitors to V _{SSP} should be as close to the device as possible.
SP+	11	Speaker Positive : The SP+, Class D PWM output, provide a differential output with SP- pin to drive an 8Ω speaker or buzzer directly. During power down or recording, this pin is tri-stated.
AGC	12	Automatic Gain Control : The AGC dynamically adjusts the gain of the preamplifier to compensate the wide range of microphone input levels. The AGC allows the full range of signal to be recorded with minimal distortion. Nominal values of 4.7 μF give satisfactory results in most cases. Connecting this pin to ground provides maximum gain to the preamplifier circuitry. Conversely, connecting this pin to power supply provides minimum gain to the preamplifier circuitry.
AUD	13	AUD : The AUD provides a single-ended current output to drive an external amplifier. During standby or recording, this pin is tri-stated.

PIN NAME	SOIC / PDIP	FUNCTIONS
	PIN NO.	
Rosc	14	Oscillator Resistor: This enables the user to vary the record and/or playback duration of the device. A resistor connected between the Rosc pin and V _{SSA} determines the sample frequency for the ISD1600B device. Please refer to the Duration Section in Section 6.1.
V _{CCD}	15	Digital power supply: It is important to have a separate path for each power back to the power terminal to minimize noise. Decoupling capacitors should be as close to the device as possible.
$\overline{\text{LED}}$	16	LED output: This pin is Low during a record cycle and blinks during playback cycle. It can be used to drive an LED to indicate either a record or playback cycle is in progress.

Note: ^[1] 600k Ω (typical).

6. FUNCTIONAL DESCRIPTION

6.1. DETAILED DESCRIPTION

6.1.1 Audio Quality

Nuvoton's patented ChipCorder® MLS technology provides natural high quality record and playback solution on a single chip. The input audio signals are stored directly into the non-volatile memory and are reproduced in its natural form without any compression artifacts caused by the digital speech solutions. A complete sample is stored in a single cell, minimizing the memory needed to store a single message.

6.1.2 Duration

The ISD1600B series offer single-chip solution with record & playback duration from 6.6 seconds to 40 seconds. Sampling frequency and duration are determined by an external resistor connected to the Rosc pin.

Sampling Frequency	Rosc	ISD1610B	ISD1616B	ISD1620B
12 KHz	53 kΩ	6.6 secs	10.6 secs	13.3 secs
8 KHz	80 kΩ	10 secs	16 secs	20 secs
6.4 KHz	100 kΩ	12.5 secs	20 secs	25 secs
5.3 KHz	120 kΩ	15 secs	24 secs	30 secs
4 KHz	160 kΩ	20 secs	32 secs	40 secs

6.1.3 Flash Storage

The ISD1600B product utilizes the on-chip Flash memory providing zero-power message storage. The message is retained for up to 100 years without power. In addition, the device can be re-recorded typically over 100,000 times.

6.1.4 Basic Operation

The ISD1600B ChipCorder® device is controlled by either the $\overline{\text{REC}}$, or one of the two playback modes, $\overline{\text{PLAYE}}$ and $\overline{\text{PLAYL}}$. The ISD1600B parts are configured for simple design in single-message application. Detailed operations are explained in Section 6.2.

6.1.5 Automatic Power-Down Mode

At the end of a playback or record cycle, the ISD1600B device automatically enters into a low-power mode, consuming typically 1μA, provided that $\overline{\text{PLAYE}}$, $\overline{\text{PLAYL}}$ and $\overline{\text{REC}}$ are High (see DC parameters Section). During a playback cycle, the device powers down automatically at the end of the message. During a record cycle, the device powers down immediately after $\overline{\text{REC}}$ is released to High.

6.2. FUNCTIONAL DESCRIPTION EXAMPLE

The following example operating sequences demonstrate the functionality of the ISD1600B series.

6.2.1. Record a Message

The device starts recording from the beginning of the memory when $\overline{\text{REC}}$ transits from High to Low and stays at Low. A record cycle is completed when $\overline{\text{REC}}$ is pulled to High or entire memory is filled up. Then an End-of-Message (EOM) marker is written at the end of message, enabling a subsequent playback cycle to terminate appropriately. Hence, the device automatically enters into standby mode.

Record takes precedence over playback operation. If $\overline{\text{REC}}$ is pulled Low during a playback cycle, the playback immediately halts and recording starts from the beginning of the memory.

Holding $\overline{\text{REC}}$ Low after recording will increase standby current consumption.

6.2.2. Edge-trigger Playback

A playback operation starts from the beginning of the memory when $\overline{\text{PLAYE}}$ detects a low going signal exceeding the specified debounced time. Playback continues until an EOM marker is encountered. Upon completion of a playback cycle, the device automatically enters into standby mode.

During playback, a subsequent low going signal will terminate the current playback operation.

Holding this pin Low after playback operation will increase standby current consumption.

6.2.3. Level- trigger Playback

When $\overline{\text{PLAYL}}$ switches from High to Low and stays at Low, a playback starts from the beginning of the memory until either an EOM marker is reached, then it automatically powers down.

If $\overline{\text{PLAYL}}$ is pulled High at any time during playback, the playback operation stops immediately and the device enters into the power-down mode.

6.2.4. LED Operation

The $\overline{\text{LED}}$ is Low during recording, which turns on an LED as a recording indicator. However, during playback, the LED blinks a few times per second to indicate a playback operation. It returns to a High when operation stops.

6.2.5. Rosc Operation

The duration can be varied by changing the value of R_{osc} . This means the designer has the flexibility to choose different sampling frequency, up to 12 KHz, depending upon the needs.

This feature allows frequency shifting where a recorded audio can be played back faster or slower than normal for special sound effects.

Another feature is a "Pause" function that can be activated by taking the R_{osc} resistor to V_{CC} to stop playback momentarily, and to resume when the resistor is switched back to ground.

7. TIMING DIAGRAMS

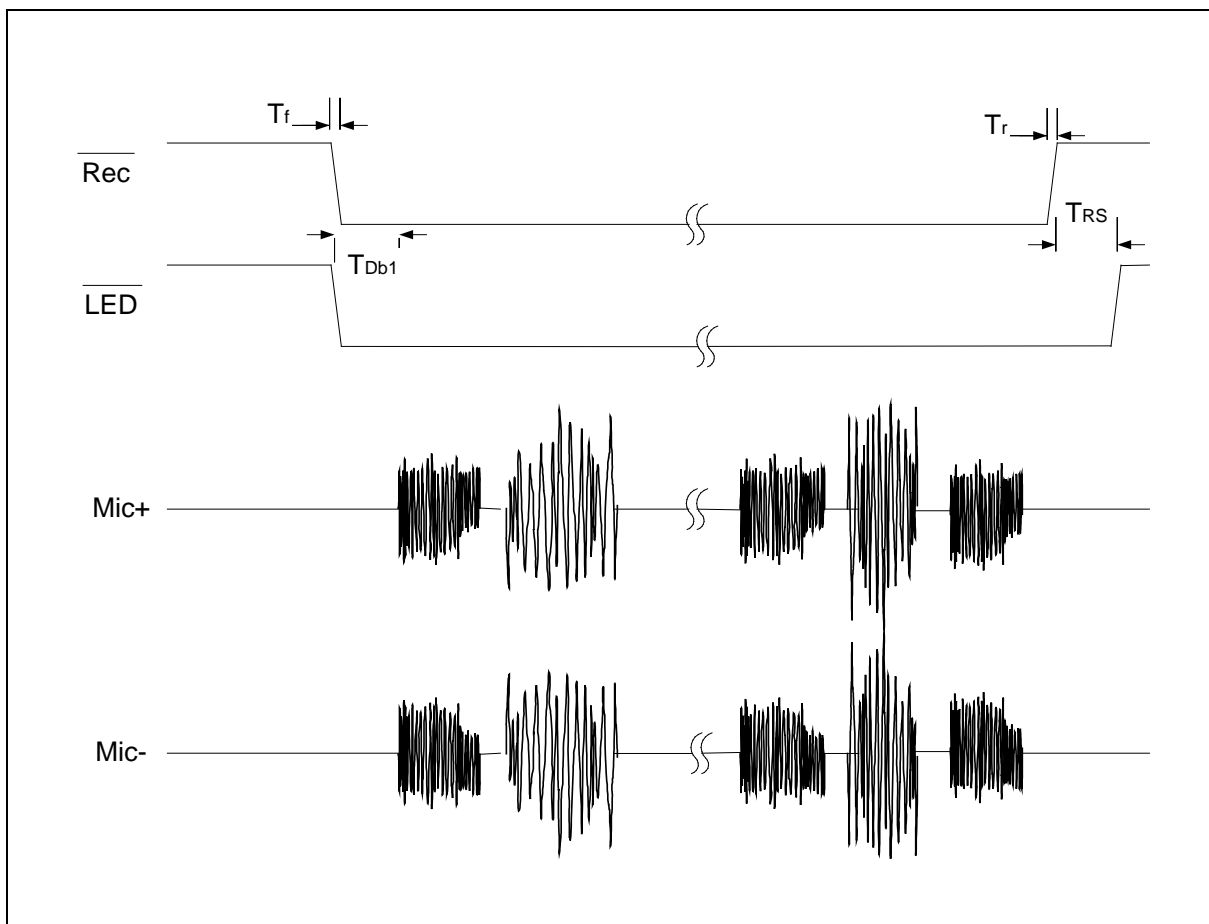


FIGURE 1: RECORD OPERATION

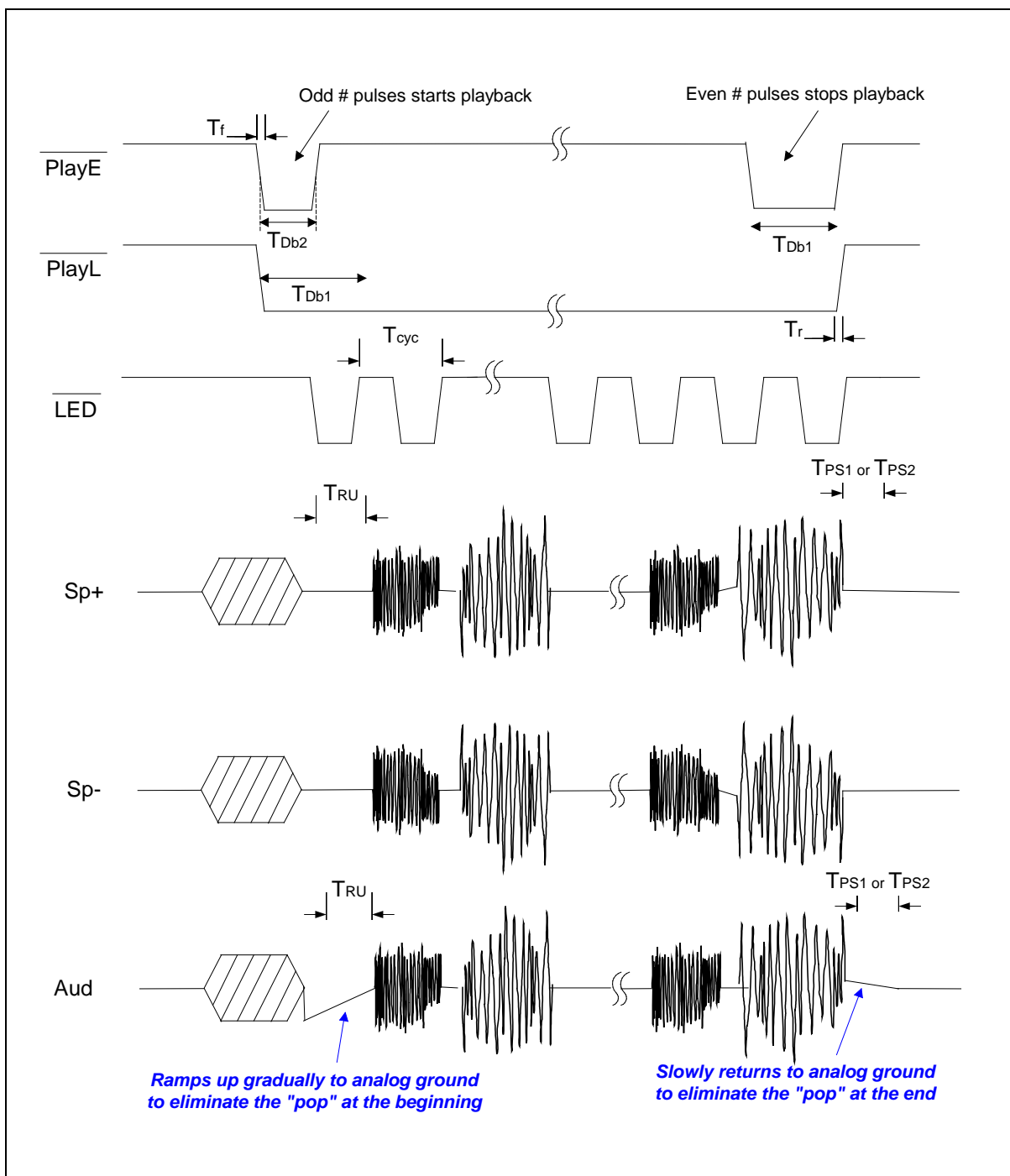


FIGURE 2: PLAYBACK OPERATION

8. ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS (DIE)

CONDITIONS ^[1]	VALUES
Junction temperature	150°C
Storage temperature range	-65°C to +150°C
Voltage applied to all pins	(V _{SS} –0.3V) to (V _{DD} +0.3V)
Power supply voltage to ground potential	-0.3V to +7.0V

ABSOLUTE MAXIMUM RATINGS (PACKAGED PARTS)

CONDITIONS ^[1]	VALUES
Junction temperature	150°C
Storage temperature range	-65°C to +150°C
Voltage applied to all pins	(V _{SS} –0.3V) to (V _{DD} +0.3V)
Lead temperature (Soldering – 10 sec)	300°C
Power supply voltage to ground potential	-0.3V to +7.0V

^[1] Stresses above those listed may cause permanent damage to the device. Exposure to the absolute maximum ratings may affect device reliability and performance. Functional operation is not implied at these conditions.

8.1 OPERATING CONDITIONS

OPERATING CONDITIONS (DIE)

CONDITIONS	VALUES
Operating temperature range	0°C to +50°C
Supply voltage (V_{DD}) ^[1]	+2.4V to +5.5V
Ground voltage (V_{SS}) ^[2]	0V
Input voltage (V_{DD}) ^[1]	0V to 5.5V
Voltage applied to any pins	($V_{SS} - 0.3V$) to ($V_{DD} + 0.3V$)

OPERATING CONDITIONS (PACKAGED PARTS)

CONDITIONS	VALUES
Operating temperature range (Case temperature)	-40°C to +85°C
Supply voltage (V_{DD}) ^[1]	+2.4V to +5.5V
Ground voltage (V_{SS}) ^[2]	0V
Input voltage (V_{DD}) ^[1]	0V to 5.5V
Voltage applied to any pins	($V_{SS} - 0.3V$) to ($V_{DD} + 0.3V$)

^[1] $V_{DD} = V_{CCA} = V_{CCD} = V_{CCP}$

^[2] $V_{SS} = V_{SSA} = V_{SSD} = V_{SSP}$

9. ELECTRICAL CHARACTERISTICS

9.1. DC PARAMETERS

PARAMETER		SYMBOL	MIN	TYP [1]	MAX	UNITS	CONDITIONS		
Supply Voltage		V _{DD}	2.4		5.5	V			
Input Low Voltage		V _{IL}	V _{SS} -0.3		0.3xV _D _D	V			
Input High Voltage		V _{IH}	0.7xV _D _D		V _{DD}	V			
Output Low Voltage		V _{OL}	V _{SS} -0.3		0.3xV _D _D	V	I _{OL} = 4.0 mA ^[2]		
Output High Voltage		V _{OH}	0.7xV _D _D		V _{DD}	V	I _{OH} = -1.6 mA ^[2]		
Record Current		I _{DD_Record}			20	mA	V _{DD} = 5.5V, No load, Sampling freq = 12 kHz		
Playback Current		I _{DD_Playback}			20	mA			
Standby Current		I _{SB}		1	10	μA	[3] [4]		
Input Leakage Current		I _{ILPD1}			±1	μA	Force V _{DD} ^[5]		
Input Current HIGH		I _{ILPD2}	-3		-10	μA	Force V _{SS} ^[5]		
Preamplifier Input Resistance		R _{MIC+} , R _{MIC-}		20		KΩ	Across both pins		
MIC Input Voltage		V _{IN}			15	300	mV	Peak-to-Peak ^[6]	
Gain from MIC to SP+/-		A _{MSP}	6		40	dB	V _{IN} = 15 to 300mV, AGC = 4.7μF, V _{DD} = 2.4V to 5.5V		
Output Load Impedance		R _{EXT}	8			Ω	Speaker Load		
	Speaker Output Power		P _{out}		670		mW	V _{DD} = 5.5V	15mVp-p 1kHz freq sinewave, R _{EXT} = 8Ω;
					313		mW	V _{DD} = 4.4V	
					117		mW	V _{DD} = 3V	
					49		mW	V _{DD} = 2.4V	
	Speaker Output Voltage		V _{out}		V _{DD}		V	R _{EXT} = 8Ω (Speaker), typical buzzer	
AUD		I _{AUD}		-3.0		mA	V _{DD} =4.5V, R _{EXT} = 390Ω		

Total Harmonic Distortion	THD		1		%	15mV p-p 1KHz sinewave, Cmessage weighted
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- Notes:
- [1] Conditions: $V_{CC} = 4.5V$, 8kHz sampling frequency and $T_A = 25^{\circ}C$, unless otherwise stated.
 - [2] LED output during Record operation.
 - [3] V_{CCA} , V_{CCD} and V_{CCP} are connected together. V_{SSA} , V_{SSP} and V_{SSD} are connected together.
 - [4] \overline{REC} , \overline{PLAYE} and \overline{PLAYL} must be at V_{CCD} .
 - [5] \overline{REC} , \overline{PLAYE} and \overline{PLAYL} are forced to specified condition.
 - [6] Balanced input signal applied between MIC and MIC REF as shown in the applications example. Single-ended MIC or MIC REF recommended to be less than 100 mV peak to peak.

9.2. AC PARAMETERS

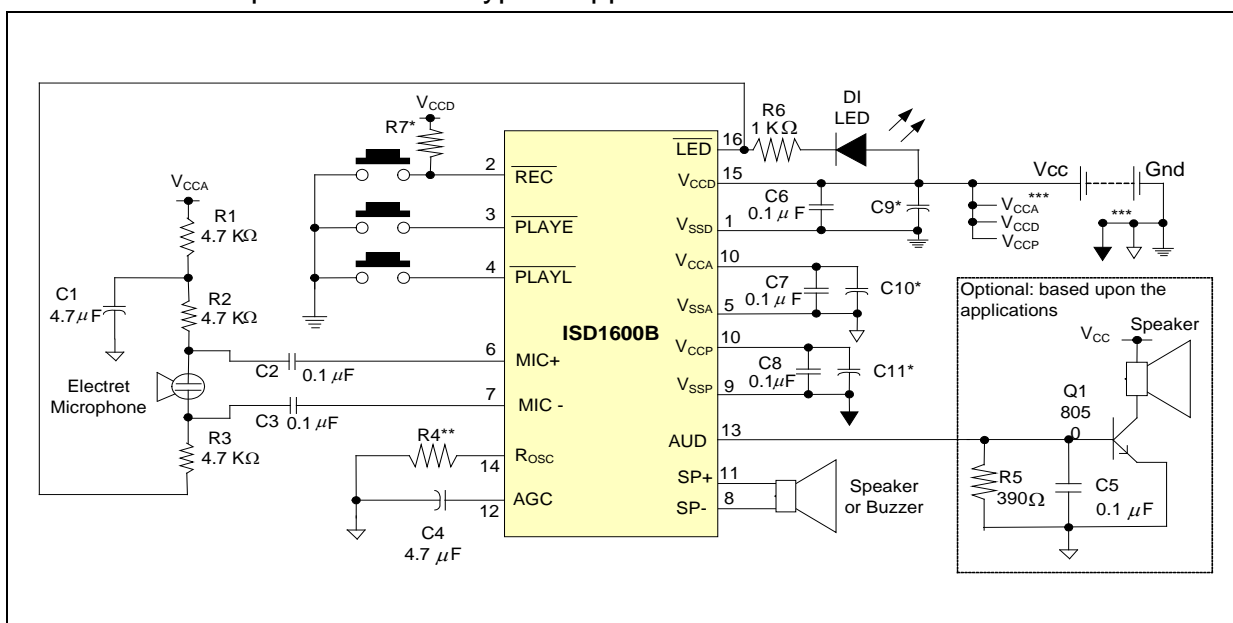
CHARACTERISTIC	SYMBOL	MIN	TYP ^[1]				MAX	UNITS	CONDITIONS	
Sampling Frequency ^[2]	F _s	4					12	KHz	Vcc=2.4V~5.5V	
Duration ^[3]	Dur		I1610B	I1616B	I1620B					Vcc=2.4V~5.5V
			6.6	10.6	13.3			Sec	SF=12kHz	
			10	16	20			Sec	SF=8kHz	
			12.5	20	25			Sec	SF=6.4kHz	
			15	24	30			Sec	SF=5.3kHz	
			20	32	40			Sec	SF=4kHz	
Rising time	T _r	0					100	nsec		
Falling Time	T _f	0					100	nsec		
Debounce Time (Record & PlayL)	T _{Db1}		26.6	26.6	26.6			msec	SF=12kHz	Vcc=2.4V~5.5V
			40	40	40			msec	SF=8kHz	
			50	50	50			msec	SF=6.4kHz	
			60.4	60.4	60.4			msec	SF=5.3kHz	
			80	80	80			msec	SF=4kHz	
Debounce Time (PlayE)	T _{Db2}		13.3	13.3	13.3			msec	SF=12kHz	Vcc=2.4V~5.5V
			20	20	20			msec	SF=8kHz	
			25	25	25			msec	SF=6.4kHz	
			30.2	30.2	30.2			msec	SF=5.3kHz	
			40	40	40			msec	SF=4kHz	
Signal Ramp Up Time	T _{RU}	100						msec	Vcc=2.4V~5.5V	
Record Stop Time	T _{RS}		2 Sample Clock						Vcc=2.4V~5.5V	
PlayL Stop Time	T _{PS1}		T _{Db1}					msec	Vcc=2.4V~5.5V	
PlayE Stop Time	T _{PS2}		2 X T _{Db1}					msec	Vcc=2.4V~5.5V	
LED Cycle frequency	T _{Cyc}	1					6	Hz	Playback at any SF	

Notes:

- ^[1] Typical values : V_{CC} = 4.5V, sampling frequency (SF) = 8 kHz and @ T_A = 25°C, unless otherwise stated.
- ^[2] Sampling Frequency can vary as much as ±2.25 percent over the commercial temperature and voltage ranges, and -6/+4 percent over the industrial temperature and voltage ranges.
- ^[6] Duration can vary as much as ±2.25 percent over the commercial temperature and voltage ranges, and -6/+4 percent over the industrial temperature and voltage ranges.

10. TYPICAL APPLICATION CIRCUIT

The below example illustrates a typical applications of ISD1600B device.



Schematic shows both speaker and AUD outputs

Notes:

- * These components may be needed in order to optimize for the best voice quality and system performance, which is also dependent upon the layout of the PCB. Pending upon system requirement, Cx can be 10 μ F, 4.7 μ F or other values. For R7, 1k Ω gives satisfactory result fro most cases.
- ** For Sampling Freq at 8 kHz, R4 = 80 K Ω
- *** It is important to have a separate path for each ground and power back to related terminal to minimize the noise. Also, the power supplies should be decoupled as close to the device as possible.

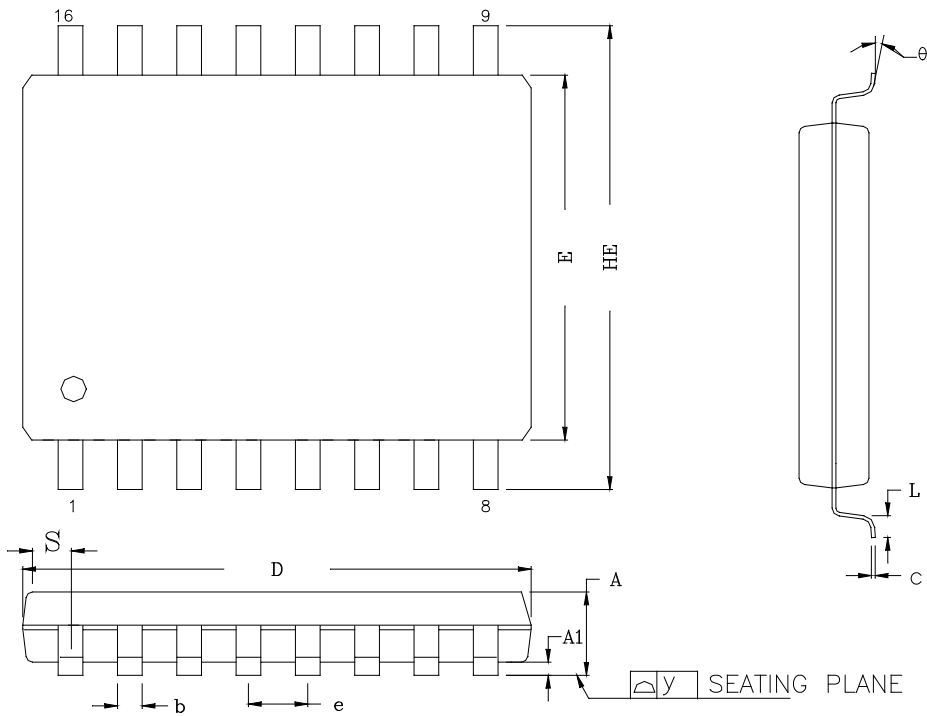
Good Audio Design Practices

Nuvoton's ChipCorder are very high-quality single-chip voice recording and playback devices. To ensure the highest quality voice reproduction, it is important that good audio design practices on layout and power supply decoupling are followed. See Application Information links below for details.

- Design considerations for ISD1600B Series (AN-CC1001.pdf)
- Good Audio Design Practices (apin11.pdf)
- Single-Chip Board Layout Diagrams (apin12.pdf)

11. PACKAGE DRAWING AND DIMENSIONS

11.1. 16-Lead 150mil Small Outline Integrated Circuit Package

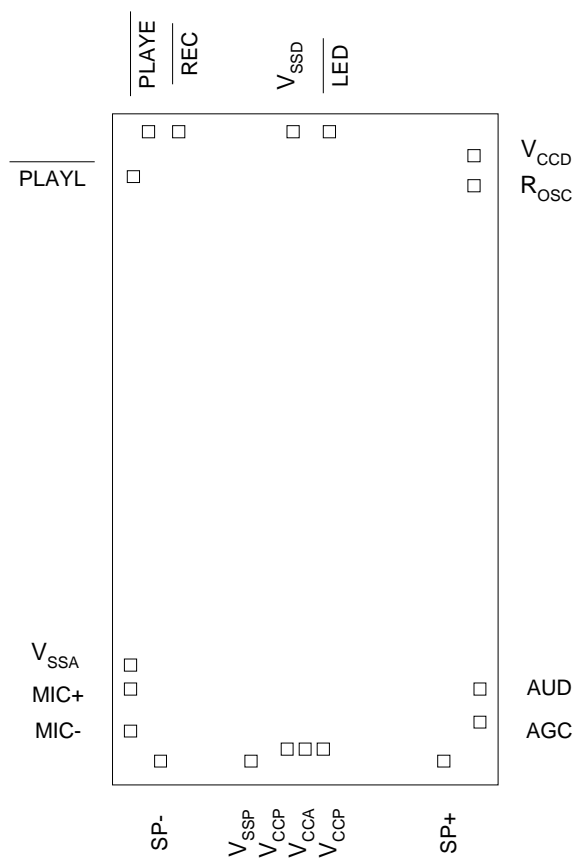


COTROL DIMENSIONS ARE IN MILLIMETERS.

SYMBOL	MILLIMETER			INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	—	1.75	0.053	—	0.069
A1	0.10	—	0.25	0.004	—	0.010
b	0.33	—	0.51	0.013	—	0.020
c	0.19	—	0.25	0.008	—	0.010
D	9.8	—	10.00	0.386	—	0.394
E	3.8	—	4.0	0.150	—	0.157
e	1.27 BASIC			0.050 BASIC		
HE	5.8	—	6.20	0.228	—	0.244
θ	0°	—	8°	0°	—	8°
L	0.40	—	1.27	0.016	—	0.050
S	0.394	—	0.648	0.0155	—	0.0255
y	—	—	0.10	—	—	0.004

11.2. Die Physical Layout

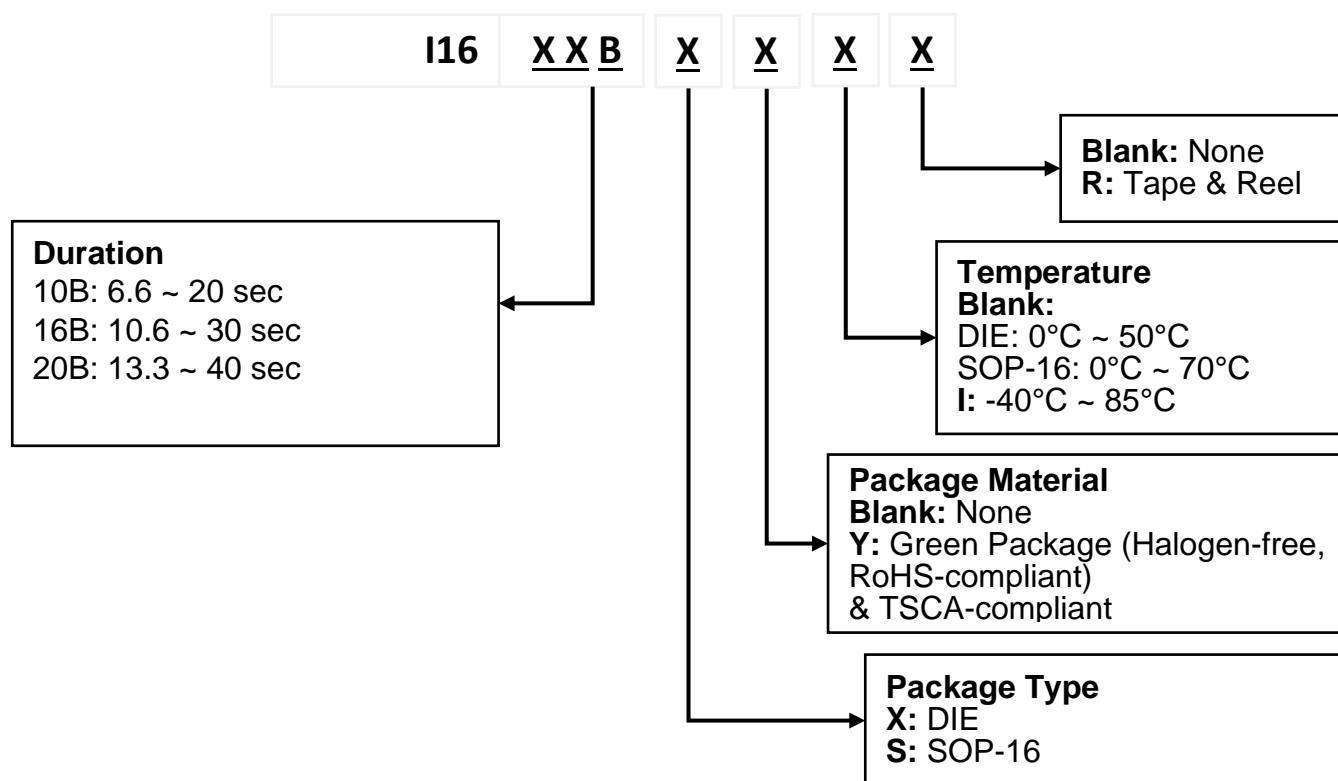
ISD1610B / 1616B / 1620B



Notes:

1. The backside of die is internally connected to V_{SSA} . It **MUST NOT** be connected to any other potential or damage may occur.
2. For package, V_{CCA} and V_{CCP} pads are bonded together to one pin.

12. ORDERING INFORMATION



Package Number	Part Number	Ordering Number	Duration	Package	Temperature	Notes
ISD1610BX	ISD1610BX	I1610BX	6.6 ~ 20 sec	DIE	0°C ~ 50°C	
ISD1610BSY	ISD1610BSY	I1610BSY	6.6 ~ 20 sec	SOP-16	0°C ~ 70°C	
ISD1610BSYR	ISD1610BSYR	I1610BSYR	6.6 ~ 20 sec	SOP-16 Tape & Reel	0°C ~ 70°C	
ISD1610BSYI	ISD1610BSYI	I1610BSYI	6.6 ~ 20 sec	SOP-16	-40°C ~ 85°C	
ISD1610BSYIR	ISD1610BSYIR	I1610BSYIR	6.6 ~ 20 sec	SOP-16 Tape & Reel	-40°C ~ 85°C	
ISD1616BX	ISD1616BX	I1616BX	10.6 ~ 30 sec	DIE	0°C ~ 50°C	
ISD1616BSY	ISD1616BSY	I1616BSY	10.6 ~ 30 sec	SOP-16	0°C ~ 70°C	
ISD1616BSYR	ISD1616BSYR	I1616BSYR	10.6 ~ 30 sec	SOP-16 Tape & Reel	0°C ~ 70°C	
ISD1616BSYI	ISD1616BSYI	I1616BSYI	10.6 ~ 30 sec	SOP-16	-40°C ~ 85°C	

ISD1616BSYIR	ISD1616BSYIR	I1616BSYIR	10.6 ~ 30 sec	SOP-16 Tape & Reel	-40°C ~ 85°C	
ISD1620BX	ISD1620BX	I1620BX	13.3 ~ 40 sec	DIE	0°C ~ 50°C	
ISD1620BSY	ISD1620BSY	I1620BSY	13.3 ~ 40 sec	SOP-16	0°C ~ 70°C	
ISD1620BSYR	ISD1620BSYR	I1620BSYR	13.3 ~ 40 sec	SOP-16 Tape & Reel	0°C ~ 70°C	
ISD1620BSYI	ISD1620BSYI	I1620BSYI	13.3 ~ 40 sec	SOP-16	-40°C ~ 85°C	
ISD1620BSYIR	ISD1620BSYIR	I1620BSYIR	13.3 ~ 40 sec	SOP-16 Tape & Reel	-40°C ~ 85°C	

13. REVISION HISTORY

REVISION	DATE	DESCRIPTION
1.0	Jan 2006	Initial Release
1.1	Apr 2006	Update application diagram
1.2	Dec 2008	Update Rosc resistor value Revise automatic power down mode Update standby current parameter Revise die physical layout section Update Application Circuit in Section 10 Remove PDIP package information Change to Nuvoton Logo Remove vAlert feature
1.3	Apr 1, 2020	Update Document Format
1.4	Apr 27, 2020	Update Product Selection Information
1.5	Jun 28, 2021	Update Ordering Information
1.6	Feb 1, 2023	Update Halogen-free, RoHS-compliant and TSCA-compliant description

IMPORTANT NOTICE

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.

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