ISD18A04

SINGLE-CHIP, SINGLE-MESSAGE

VOICE RECORD/PLAYBACK DEVICE

4- TO 8-SECONDS DURATION

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1. GENERAL DESCRIPTION

Nuvoton's ISD18A04 ChipCorder® is a new device of 4 to 8 seconds with wide operating voltage ranging from 2.4V to 5.5V. It provides high-quality, single chip, single-message, record/playback solution with user-selectable duration. The CMOS devices include an on-chip oscillator (with external control), microphone amplifier, multilevel storage array and speaker amplifier. A minimum record/playback subsystem can be configured with a microphone, a speaker, several passive components, two push buttons, and a power source. Recordings are stored in on-chip nonvolatile memory cells, providing zero-power message storage. This unique, single-chip solution is made possible through Nuvoton's patented multilevel storage technology. Voice and audio signals are stored directly into memory in their natural form, providing high-quality, solid-state voice reproduction.

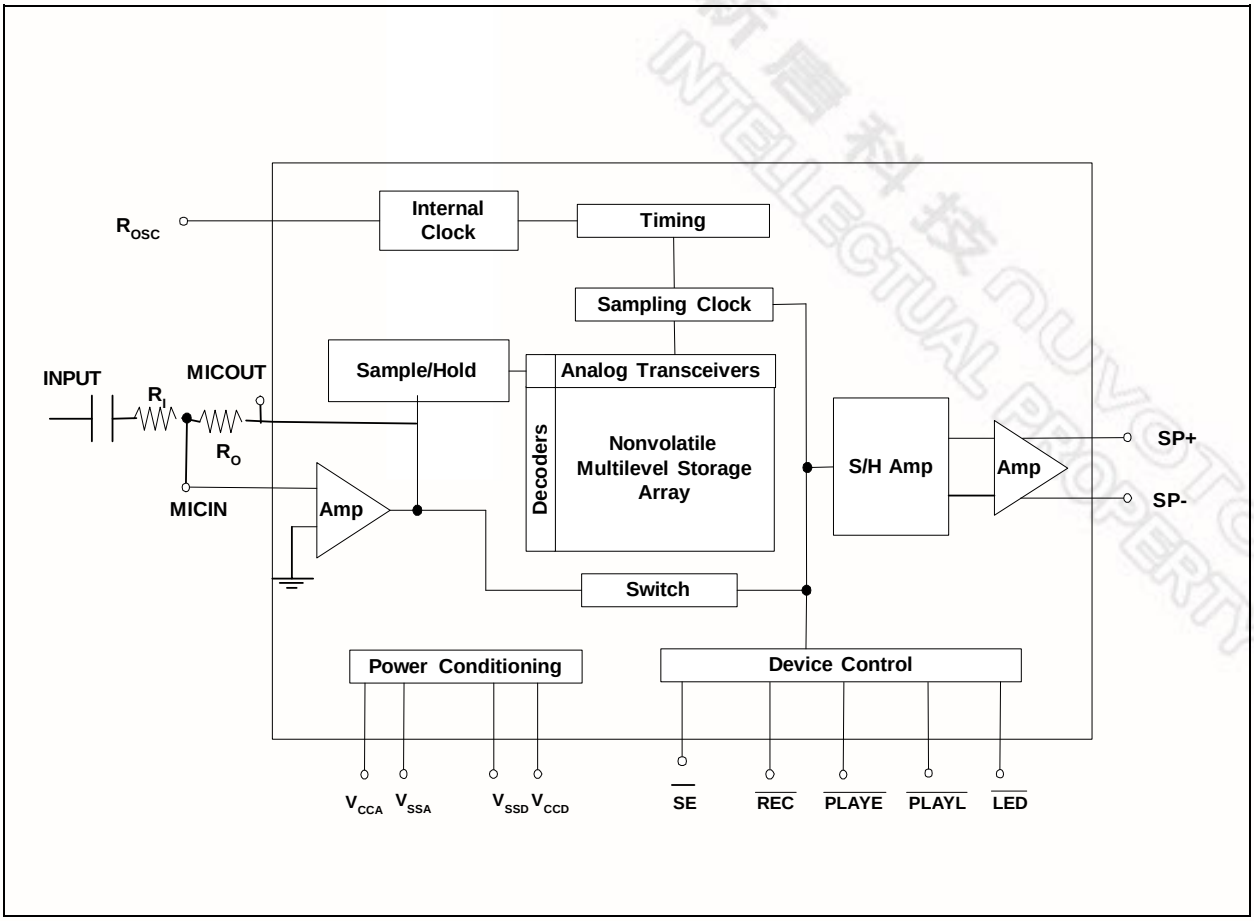
2. FEATURES

- Single power supply : 2.4V to 5.5V
- Easy-to-use single-chip, single-message voice record/playback solution
- Active Low on all control inputs for operations
- High-quality, natural voice/audio reproduction
- Level-hold for recording operation
- Either edge-triggered or level-triggered for playback operation
- Optional beeping sound effects for recording operation
- User-selected variable sampling frequency and duration via external resistor

Sampling Frequency	8 kHz	6.4 kHz	5.3 kHz	4 kHz
Rosc	80 KΩ	100 KΩ	120 KΩ	160 KΩ
Duration	4 secs	5 secs	6 secs	8 secs

- Automatic power-down mode
  - Enters into standby mode immediately after a record or playback cycle
  - 1.0 µA standby current (typical)
- Zero-power message storage
  - Eliminates battery backup circuits
- 100-year message retention (typical)
- 100,000 record cycles (typical)
- On-chip oscillator
- No algorithm development required
- Available in die form

3. BLOCK DIAGRAM



4. PAD DESCRIPTION

PAD NAME	I/O	FUNCTION
V_{SSD}	I	**Digital Ground**: Ground path for digital signals. It is important to have a separate path for each ground signal to minimize the noise.
$\overline{REC}$	I	**Record**: The device starts recording whenever $\overline{REC}$ is Low. This pin must remain Low during recording. A recording cycle is completed when either $\overline{REC}$ returns to High or end of memory is reached, then the device automatically powers down to standby mode. An End-of-Message (EOM) marker is internally generated, enabling a subsequent playback cycle to terminate appropriately. Recording takes precedence over the playback operation. If $\overline{REC}$ is pulled Low during a playback cycle, the playback immediately ceases and recording begins. This pin has an internal pull-up device[1]. Holding this pin at Low after recording will increase standby current. The pin is internally debounced on the falling edge from a push-button switch.
$\overline{PLAYE}$	I	**Edge-Triggered Playback**: A playback operation begins when a Low-going transition occurs on this pin. Playback continues until an End-of-Message (EOM) marker is encountered or the end of memory is reached. Upon completion of the playback cycle, the device automatically powers down into standby mode. Taking $\overline{PLAYE}$ to High during playback will not terminate the current operation. This pin has an internal pull-up device[1]. Holding this pin at Low after playback will increase standby current.
$\overline{PLAYL}$	I	**Level-Triggered Playback**: When this input level is Low, a playback cycle is initiated. Playback stops when $\overline{PLAYL}$ returns to High. If $\overline{PLAYL}$ remains Low constantly, the device will perform a looping playback function. This pin has an internal pull-up device[1].
MICIN		**Microphone Input**: The MICIN transfers input signal to the on-chip microphone amplifier. The input signal should be AC coupled to this pin via a series capacitor. The gain of the microphone amplifier is controlled by two external resistors, R_I and R_O.
MICOUT	O	**Microphone Output**: Output of the microphone amplifier.
SP-	O	**SP-**: The negative signal of the differential speaker outputs. This output together with the SP+ are used to drive an 8Ω speaker differentially.
V_{SSA}	I	**Analog Ground**: Ground path for analog signals. It is important to have a separate path for each ground signal to minimize the noise.
SP+	O	**SP+**: This is the positive signal of the differential speaker outputs. This output together with the SP- act as a differential output to drive an 8Ω speaker directly. The differential output provides output power of up to four times over a single-ended output. Furthermore, when differential output is used, coupling capacitor is not needed. A single-ended output configuration will require an AC-coupling capacitor between the speaker pin and the speaker. The SP+ pin and the SP- pin are internally connected through a 50 KΩ resistance. While not in playback mode, they are floating.

V_{CCA}	I	**Analog Power Supply**: Analog power supply provides power to the analog circuits inside the device. This power bus is brought out to an independent pad to minimize noise on the chip. It is important that the decoupling capacitors should be as close to the device as possible.
ROSC	I	**Oscillator Resistor**: An external resistor must be connected between this pin and $V_{SSA.}$ The value of this external resistor determines the sampling frequency and the duration of the device. Refer to the table in Duration Section for details.
$\overline{SE}$	I	**Sound Effect**: As activated, beeping feature is enabled for record operation. During recording, one-beep sound indicates the start of recording, and two-beep sound indicates the end of recording. Linking $\overline{SE}$ to V_{CCD} disables the beeping feature. This pin has an internal pull-up device[2].
V_{CCD}	I	**Digital Power Supply**: Digital power supply provides power to the digital circuits inside the device. This power bus is brought out to an independent pad to minimize noise on the chip. It is important that the decoupling capacitors should be as close to the device as possible.
$\overline{LED}$	O	**LED output**: During recording, this output is Low. It can be used to drive an LED to show that recording is in progress. Also, $\overline{LED}$ pulses Low momentarily when an EOM or end of memory is encountered during playback.

Note: [1] The internal pull-up device is ~40kΩ typically.

[2] The internal pull-up device is ~80kΩ typically.

5. FUNCTIONAL DESCRIPTION

5.1. DETAILED DESCRIPTION

Speech/Sound Quality

Nuvoton's patented ChipCorder® technology provides natural record and playback. The input voice signals are stored directly in nonvolatile cells and are reproduced without the synthetic effect often heard with digital solid-state speech solutions. A complete sample is stored in a single cell, minimizing the memory necessary to store a single message.

Duration

The ISD18A04 device offers 4 to 8 seconds duration depending upon the sampling frequency selected. Sampling frequency and duration are determined by an external resistor connected to the ROSC pin. The below table shows the relationship between sampling frequency, ROSC and duration.

Sampling Frequency	8 kHz	6.4 kHz	5.3 kHz	4 kHz
ROSC	80 KΩ	100 KΩ	120 KΩ	160 KΩ
Duration	4 secs	5 secs	6 secs	8 secs

Non-Volatile Storage

The ISD18A04 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.

Basic Operation

The ISD18A04 device performs record operation via the $\overline{REC}$ pin, and playback operaton via either $\overline{PLAYE}$ or $\overline{PLAYL}$ pins for edge-triggered and level-triggered playback, respectively. Playback looping can be performed via the control of $\overline{PLAYL}$. Beeping function for recording can be activated via the control of $\overline{SE}$. Feed-through mode is controlled by both the $\overline{PLAYE}$ and $\overline{PLAYL}$ pins. Hence, the ISD18A04 device can be easily configured for design simplicity in a single-message application.

Automatic Power-Down Mode

At the end of a playback or record cycle, the ISD18A04 device automatically returns to a low-power standby mode, consuming typically 1μA, provided that $\overline{REC}$, $\overline{PLAYE}$, $\overline{PLAYL}$ and $\overline{SE}$ pins are at High state. After playback, the device powers down automatically at the end of the message. For recording, the device powers down immediately when $\overline{REC}$ returns to High or end of memory is reached.

5.2. FUNCTIONAL DESCRIPTION

The following operating sequences illustrate the functionality of the ISD18A04 device.

Record a message

Pulling the $\overline{REC}$ Low initiates a record cycle from beginning of the memory. Recording ceases and the device will automatically power down after $\overline{REC}$ returns to High or when end of memory is reached. An EOM marker is written at the end of message. A debounce time is required.

Edge-triggered playback

Pulling the $\overline{PLAYE}$ Low starts a playback cycle from the beginning of the memory. When the device reaches the EOM marker, $\overline{LED}$ blinks once, playback stops and device will automatically power down. A subsequent falling edge on $\overline{PLAYE}$ initiates a new playback cycle. During playback, any falling edge on $\overline{PLAYE}$ has no effect on current playback operation.

Level- triggered playback

Holding the $\overline{PLAYL}$ Low initiates a playback cycle from the beginning of the message. When $\overline{PLAYL}$ returns to High, playback operation stops immediately and the device automatically powers down. A subsequent low level on $\overline{PLAYL}$ triggers a new playback cycle.

If $\overline{PLAYL}$ is held Low constantly, the playback operation will start from the beginning of memory through the end of memory, then loop the playback again and again, until $\overline{PLAYL}$ is back to High.

Beeping feature

When $\overline{SE}$ is active, beeping sound effect can be audible to signify the begin and end of record operation. One-beep sound indicates the start of recording and two-beep sound indicates the end of recording. To disable beeping, connect this pin to Vcc.

Microphone amplifier gain

Two external resistosr, R_I and R_O, are used to adjust the microphone amplifier gain for the incoming signal. The value of R_O is limited to the range of 100kΩ to 1MΩ. In order to avoid distortion, the gain ratio (=R_O/ R_I) must be between 1 and 100.

Record (supersedes playback)

The recording takes precedence over playback operation. During playback, holding $\overline{REC}$ at Low will stop playback operation immediately and begin a new record operation from the beginning of the memory. While doing that, even though beep feature is enabled, there is no beep for the start of recording. However, device still plays double-beep at the end of recording.

Feed-Through mode

Holding both $\overline{\text{PLAYL}}$ and $\overline{\text{PLAYE}}$ Low simultaneously will enable the Feed-Through mode. During this mode, the input signal from MICIN will transmit to the speaker output.

$\overline{\text{LED}}$ operation

The $\overline{\text{LED}}$ output provides an active Low signal during recording, which can be used to drive an LED as a "record-in-progress" indicator. It returns to a High state when recording halts. This output also pulses Low at the end of playback to indicate the end of message (EOM) occurs.

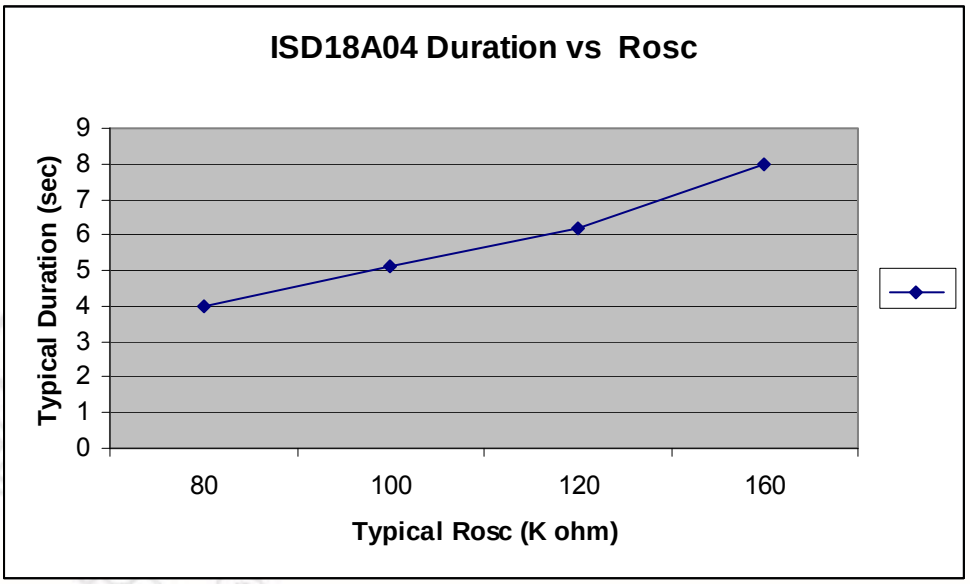
ROSC operation

When the R_{OSC} varies from 80 KΩ to 160 KΩ, the duration changes from 4 to 8 seconds. See the chart below for typical durations. If precision on duration is required over a wide range of operating conditions, resistor with 1% accuracy is recommended.

By varying the R_{OSC} resistor value spontaneously during playback, the tone of a recorded voice can be changed to either faster or slower for special effect purpose, . For example, use a 100 KΩ resistor to perform the recording and playback with either an 80 KΩ resistor for faster "chipmunk" talk or with a 120 KΩ resistor for a slower voice.

Another feature is a "Pause" function that can be implemented by taking the R_{OSC} resistor to V_{CC} to stop the playback operation momentarily, then resuming when the resistor is connected back to ground. It is not recommended to pause during the record mode.

Chart 1: ISD Duration Versus R_{OSC} at T_A = 25°C and V_{CC} = 3.0V



6. TIMING DIAGRAMS

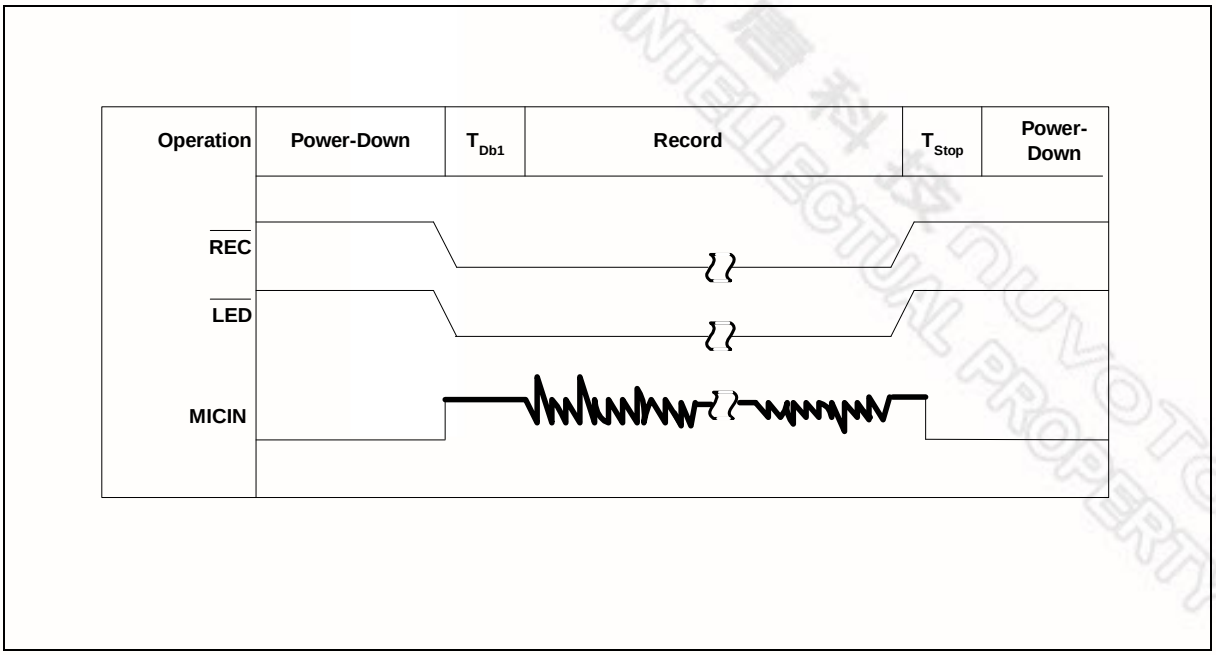


FIGURE 1: RECORD MESSAGE UNTIL $\overline{REC}$ GOES HIGH WITHOUT BEEP FEATURE

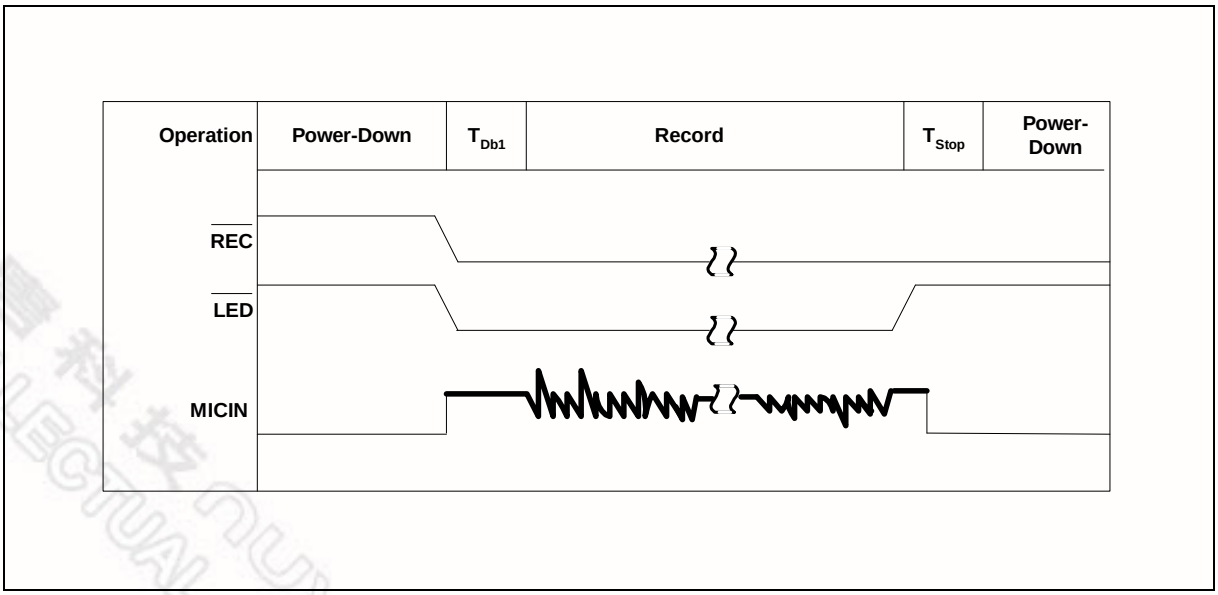


FIGURE 2: RECORD MESSAGE UNTIL ARRAY IS FULL WITHOUT BEEP FEATURE

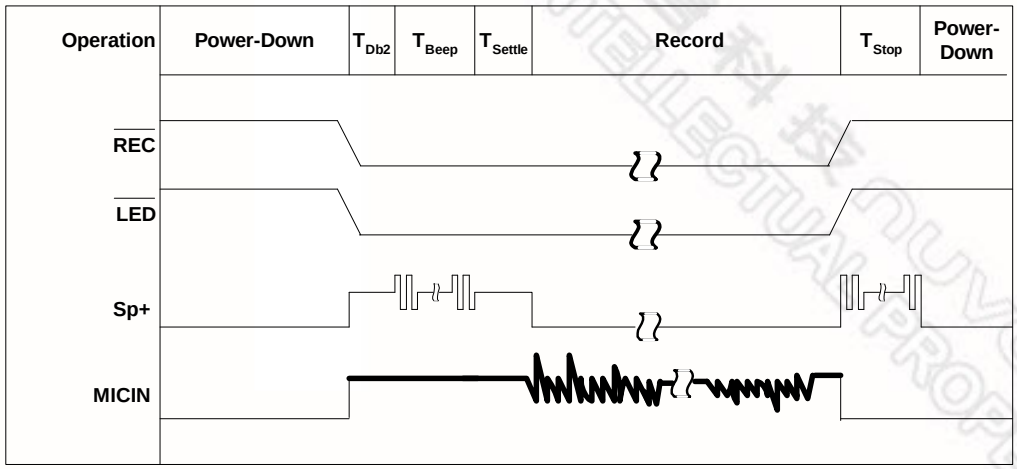


FIGURE 3: RECORD MESSAGE UNTIL $\overline{\text{REC}}$ GOES HIGH WITH BEEP FEATURE

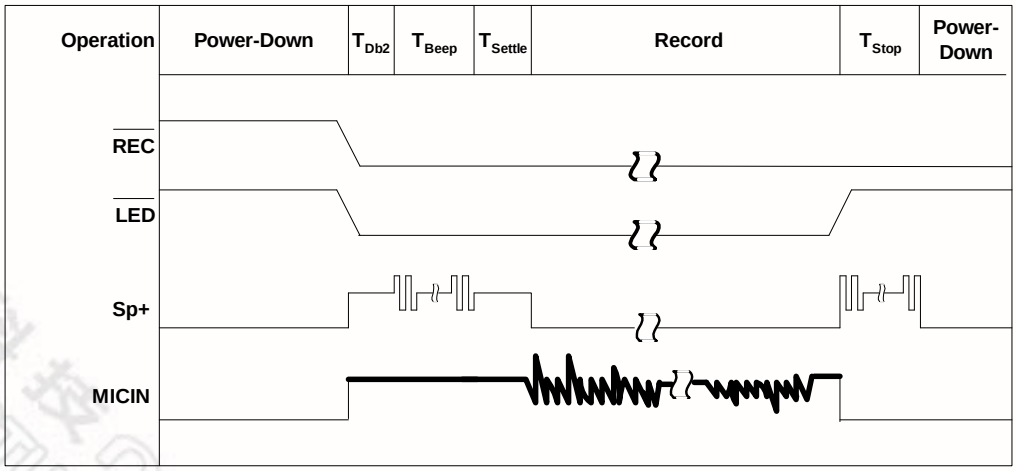


FIGURE 4: RECORD MESSAGE UNTIL ARRAY IS FULL WITH BEEP FEATURE

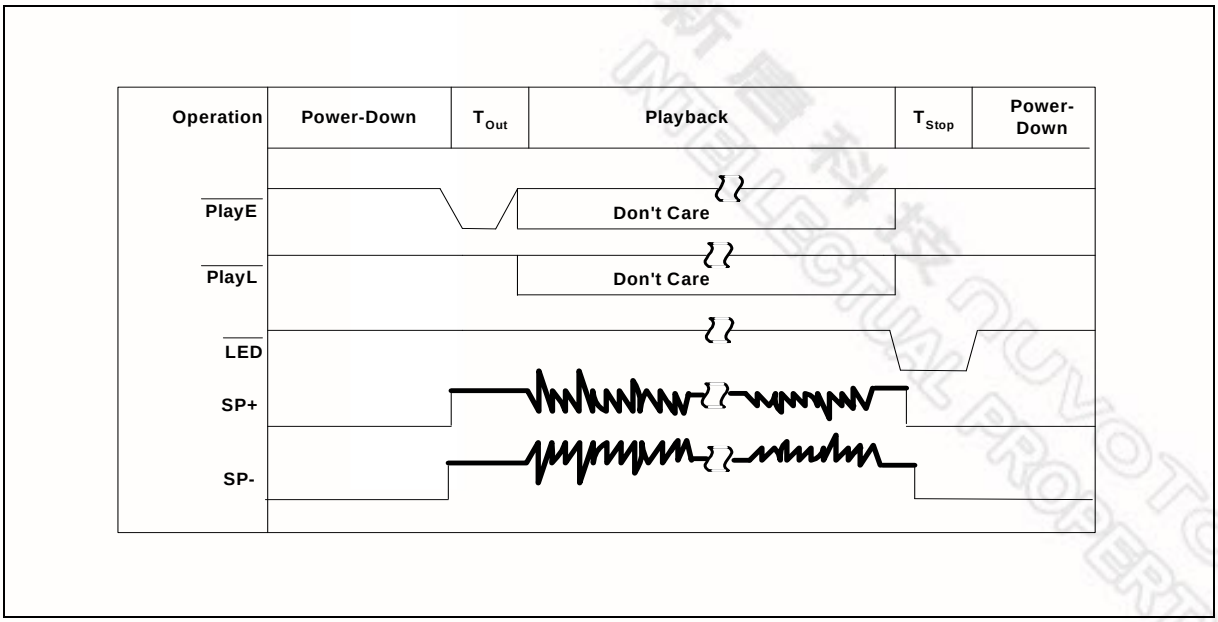


FIGURE 5: EDGE-TRIGGERED PLAYBACK ($\overline{\text{PLAYE}}$) UNTIL END OF MESSAGE

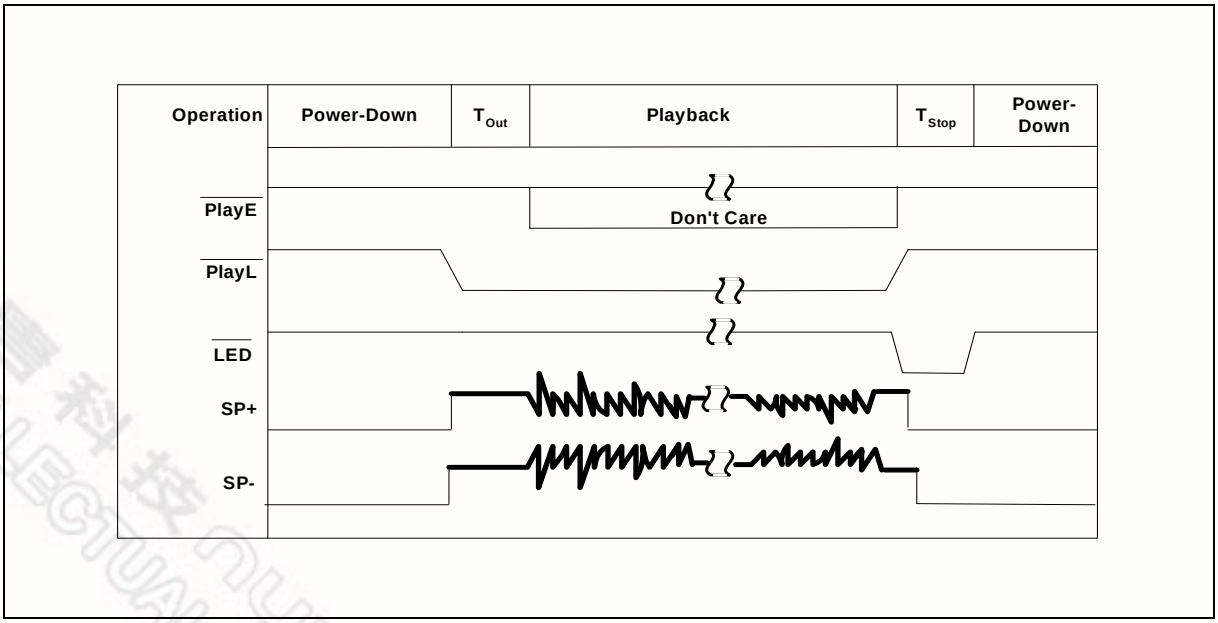


FIGURE 6: LEVEL-TRIGGERED PLAYBACK ($\overline{\text{PLAYL}}$) UNTIL $\overline{\text{PLAYL}}$ GOES HIGH

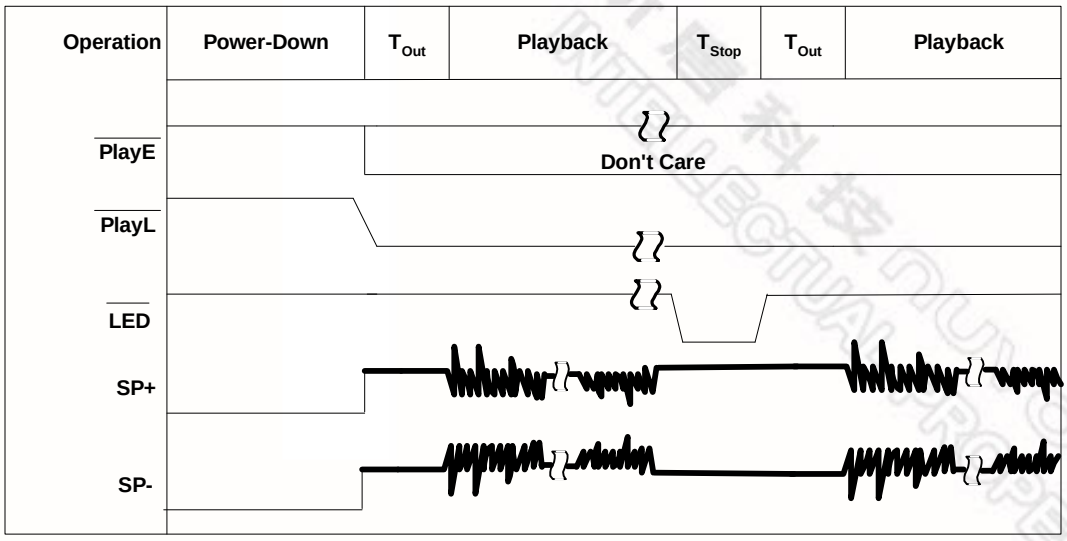


FIGURE 7: LOOPING PLAYBACK VIA $\overline{\text{PLAYL}}$

7. ABSOLUTE MAXIMUM RATINGS [1]

ABSOLUTE MAXIMUM RATINGS (DIE)

CONDITION	VALUE
Junction temperature	150°C
Storage temperature range	-65°C to +150°C
Voltage applied to any pins	(V_{SS} –0.3V) to (V_{CC} +0.3V)
V_{CC} – V_{SS}	-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.

7.1. OPERATING CONDITIONS

OPERATING CONDITIONS (DIE)

CONDITION	VALUE
Operating temperature range	0°C to +50°C
Operating voltage (V_{CC}) [1]	+2.4V to +5.5V
Ground voltage (V_{SS}) [2]	0V

[1] $V_{CC} = V_{CCA} = V_{CCD}$

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

8. ELECTRICAL CHARACTERISTICS

8.1. DC PARAMETERS

PARAMETER	SYMBOL	MIN[2]	TYP[1]	MAX[2]	UNITS	CONDITIONS
Input Low Voltage	V_{IL}			0.3xVcc	V	
Input High Voltage	V_{IH}	0.7xVcc			V	
Output Low Voltage	V_{OL}			0.3xVcc	V	I_{OL} = 4.0 mA[3]
Output High Voltage	V_{OH}	0.7xVcc			V	I_{OH} = -1.6 mA[3]
Standby Current	I_{STBY}		1	10	µA	[4] [5]
Record Current	I_{REC}			15	mA	V_{CC} = 5.5V
Playback Current	I_{PLAY}			15	mA	V_{CC} = 5.5V, no speaker load
Pull-up device for $\overline{REC}$, $\overline{PLAYE}$ & $\overline{PLAYL}$ pins	R_{PU1}		40		kΩ	
Pull-up device for $\overline{SE}$	R_{PU2}		80		kΩ	
MICIN Input Resistance	R_{MICIN}		10		KΩ	
Output Load Impedance	R_{EXT}	8			Ω	Speaker load
MIC Input Voltage	V_{IN}	8		800	mV	Peak-to-peak
MIC Amplifier Gain	A_{MicAmp}	1		100		Depend on R_O/R_I
Gain from MIC to SP+/SP-	A_{MSP}	+6		+46	dB	Depend on R_O/R_I

Notes:

[1] Typical values @ T_A = 25°, V_{CC} = 3.3V and sampling frequency (SF) at 8 kHz, unless stated.

[2] Not all specifications are 100 percent tested. All Min/Max limits are guaranteed by Nuvoton via design, electrical testing and/or characterization.

[3] LED output during recording.

[4] V_{CCA} and V_{CCD} are connected together. Also, V_{SSA} and V_{SSD} are connected together

[5] $\overline{REC}$, $\overline{PLAYE}$, $\overline{PLAYL}$ and $\overline{SE}$ must be at V_{CCD}. External components are biased under a separated power supply.

8.2. AC PARAMETERS [1]

CHARACTERISTIC	SYMBOL	MIN[3]	TYP[2]	MAX[3]	UNITS	CONDITIONS
Sampling Frequency	F_S	4		8	kHz	[4]
Record Duration	T_{REC}		4		sec	[4]
Playback Duration	T_{PLAY}		4		sec	[4]
Record Debounce Time without Beep	T_{Db1}		64		msec	[4] [5]
Record Debounce Time with Beep	T_{Db2}		32		msec	[4] [5]
Beeping Settle Time	T_{Settle}		32		msec	[4] [5]
Beeping Duration	T_{Beep}		64		msec	[4] [5]
Beep Frequency	F_{Beep}		3		kHz	[4] [5]
Output Delay Time	T_{Out}		75		msec	[4] [5]
Stop Time	T_{Stop}		64		msec	[4] [5]
Speaker Output Voltage	V_{OUT}		1.5		Vp-p	R_{EXT} = 8Ω
Speaker Output Power	P_{OUT}		70		mW	R_{EXT} = 8Ω

Notes:

[1] Conditions are V_{CC} = 3.3V, T_A = 25° and sampling frequency (F_S) at 8 kHz, unless stated.

[2] Typical values @ V_{CC} = 3.3V , T_A = 25° and F_S at 8 kHz.

[3] Not all specifications are 100 percent tested. All Min/Max limits are guaranteed by Nuvoton via design, electrical testing and/or characterization.

Nuvoton[4] When different F_S is applied, the value will change accordingly. Also, stability of internal oscillator may vary as much as ±10% over the operating temperature and voltage ranges.

[5] The timing varies with respect to the sampling frequency applied. It can be calculated using the formula: Time = 512 / sampling frequency.

9. TYPICAL APPLICATION CIRCUIT

The following typical application examples on ISD18A04 series are for references only. They make no representation or warranty that such applications shall be suitable for the use specified. Each design has to be optimized in its own system for the best performance on voice quality, current consumption, functionalities and etc.

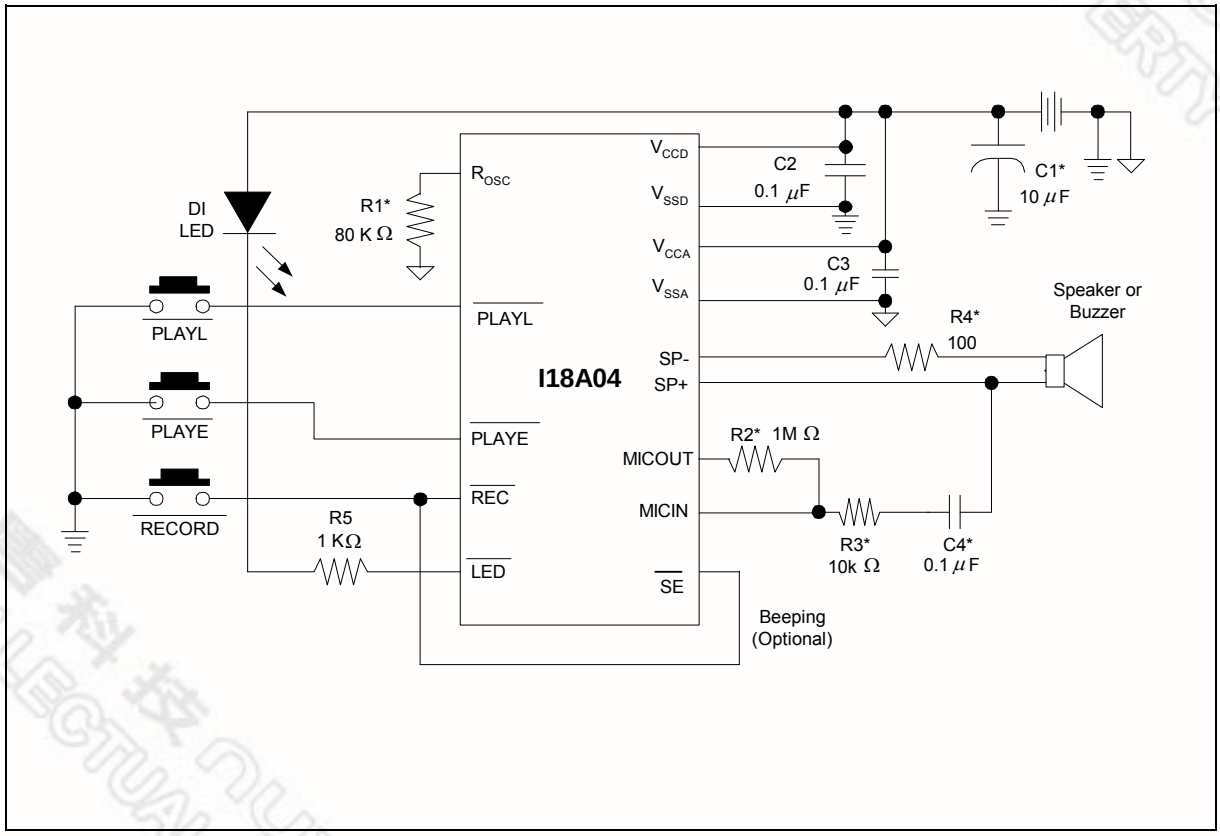
In addition, the below notes apply to the following application examples:

* The suggested values are for references only. Depending on system requirements, they must be fine tuned for best performance.

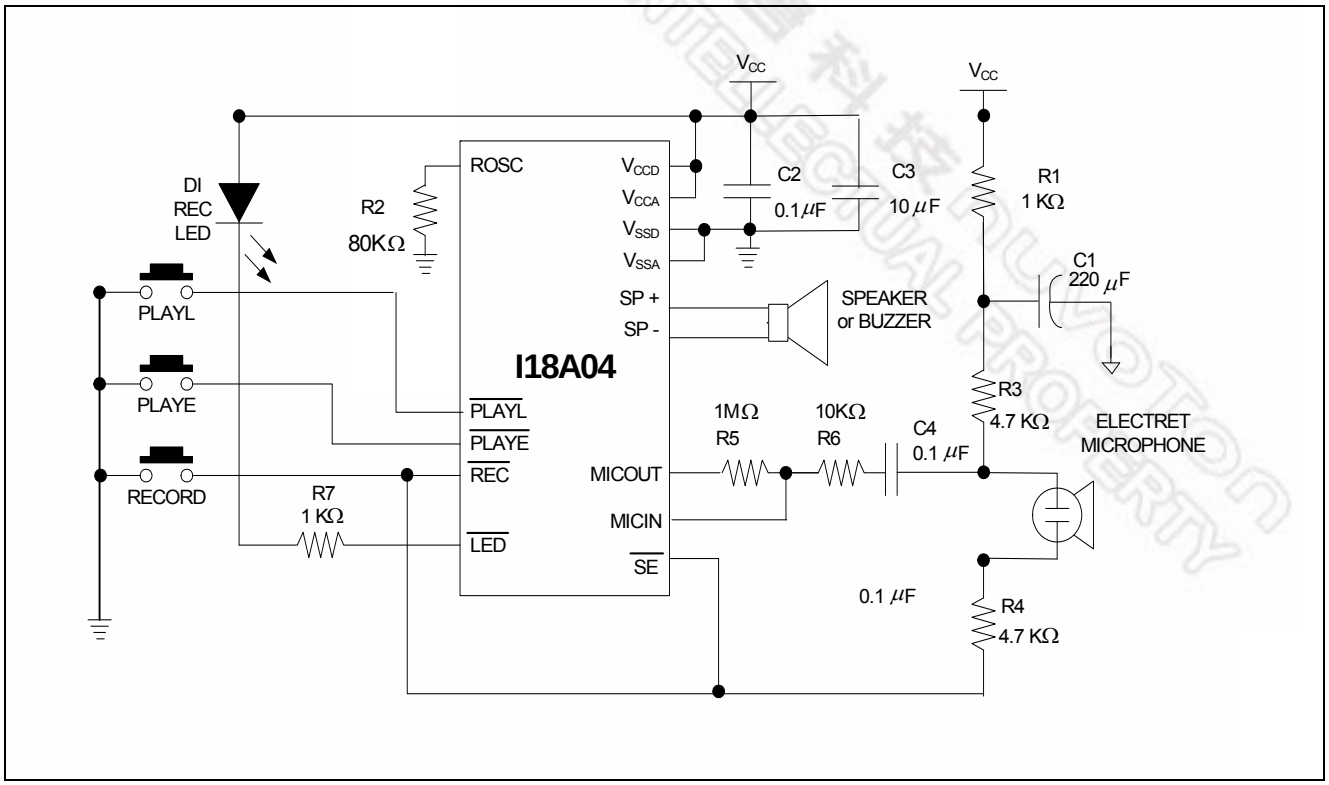
It is important to have a separate path for each ground and power back to the related terminals to minimize the noises. Besides, the power supplies should be decoupled as close to the device as possible.

Also, it is crucial to follow good audio design practices in layout and power supply decoupling. See recommendations in Application Notes from our websites.

Example #1: Using speaker as microphone for recording with LED output



Example #2: Using speaker and microphone separately; recording with LED output



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.

Good Audio Design Practices

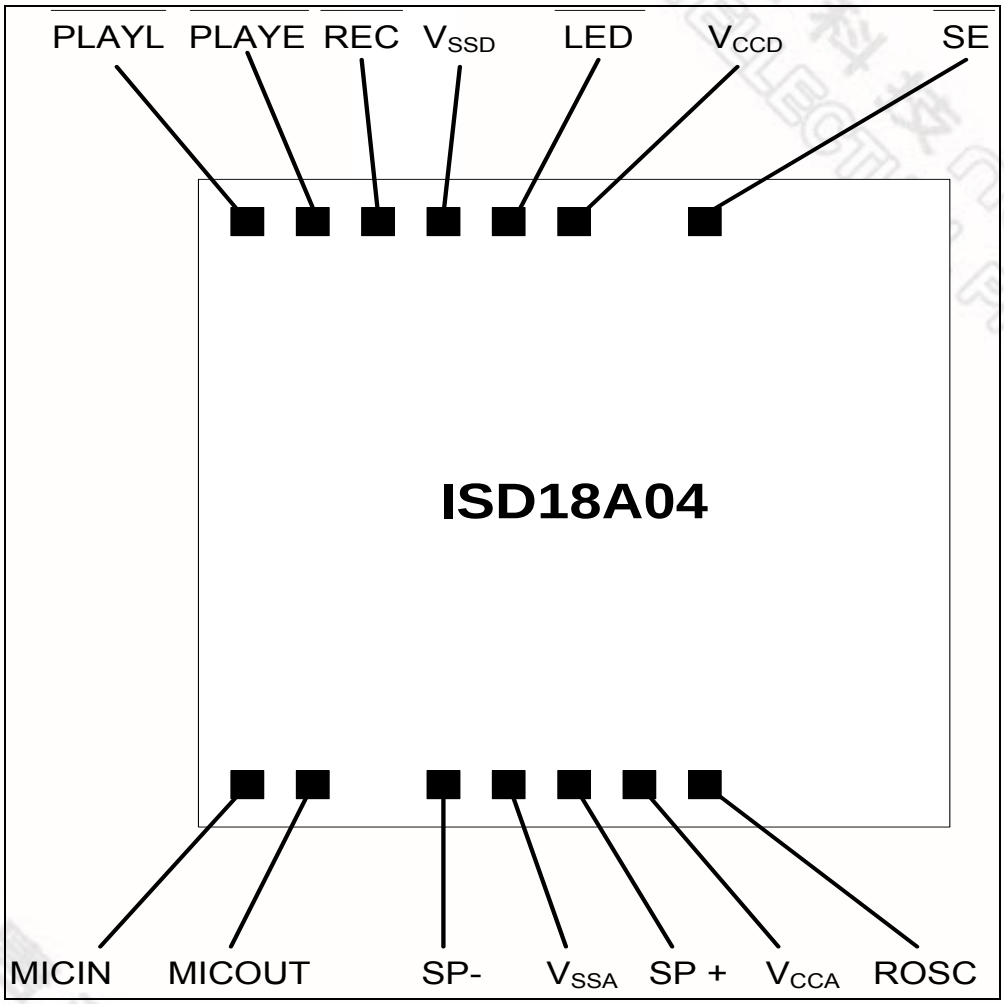
http://www.nuvoton-usa.com/products/isd_products/chipcorder/applicationinfo/apin11.pdf

Single-Chip Board Layout Diagrams

http://www.nuvoton-usa.com/products/isd_products/chipcorder/applicationinfo/apin12.pdf

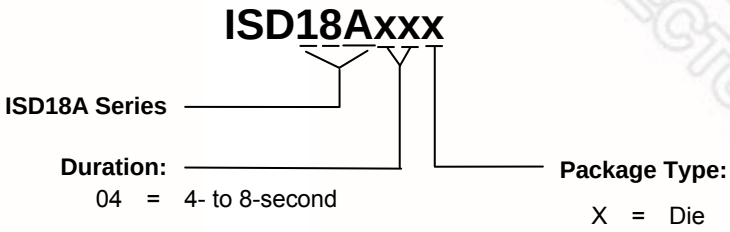
10. DIE INFORMATION

Contact Nuvoton Sales Representatives for detailed information.



11. ORDERING INFORMATION

Product Number Descriptor Key



When ordering, please refer to the following part numbers that are supported in volume for this product series. Consult the local Nuvoton Sales Representative or Distributor for availability information.

Package	Part Number	Ordering Number	Comments
Die	ISD18A04X	I18A04X	

For the latest product information, access Nuvoton's worldwide website at http://www.nuvoton-usa.com

12. VERSION HISTORY

VERSION	DATE	DESCRIPTION
A0	Jan 21, 2006	Initial revision
A2	May 24, 2006	Second revision
A3	Feb 12, 2009	Change to Nuvoton logo

Nuvoton products are not designed, intended, authorized or warranted for use as components in systems or equipment intended for surgical implantation, atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, or for other applications intended to support or sustain life. Furthermore, Nuvoton products are not intended for applications wherein failure of Nuvoton products could result or lead to a situation wherein personal injury, death or severe property or environmental damage could occur.

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Application examples and alternative uses of any integrated circuit contained in this publication are for illustration only and Nuvoton makes no representation or warranty that such applications shall be suitable for the use specified.

The 100-year retention and 100K record cycle projections are based upon accelerated reliability tests, as published in the Nuvoton Reliability Report, and are neither warranted nor guaranteed by Nuvoton. This product incorporates SuperFlash®.

Information contained in this ISD® ChipCorder® datasheet supersedes all data for the ISD ChipCorder products published by ISD® prior to August, 1998.

This datasheet and any future addendum to this datasheet is(are) the complete and controlling ISD® ChipCorder® product specifications. In the event any inconsistencies exist between the information in this and other product documentation, or in the event that other product documentation contains information in addition to the information in this, the information contained herein supersedes and governs such other information in its entirety. This datasheet is subject to change without notice.

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