

MS212
Simple SPI Recorder IC
With Voice Changer &
Special Prompts

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Contents

CONTENTS	2
FIGURES	3
FEATURES	4
BLOCK DIAGRAM	5
APPLICATION	5
PACKAGE	5
GENERAL DESCRIPTION	5
PAD CONFIGURATION (DRAFT)	6
PINS CONFIGURATION	7
PIN DESCRIPTIONS	7
GENERAL FUNCTIONAL DESCRIPTION	11
RESET AND INITIALIZATION	12
Manual Reset.....	12
USED SPI COMMANDS	12
MESSAGES ON SPI FLASH	13
Recorded Message	13
Preload Message	14
Welcome Message.....	14
Prompt Message.....	14
POWER-ON MESSAGES	14
AUTO-ERASING	15
ONE-KEY OPERATION	15
KEY FUNCTION CHANGE	15
MIXED PLAYING MODE	16
SAMPLE RATE AND RESISTOR VALUE	18
RECORDING FUNCTION DESCRIPTION	19
Default Record Timing.....	19
Recording Signal Path.....	19
Microphone Amplifier Circuits	20
SPI Flash Power Noise Rejection.....	22
PLAYING FUNCTION DESCRIPTION	23
Playing Timing Diagram.....	23
Playing Timing of 2-SEGMENT Mode	24
Signal Flow When Playing.....	25
Playing-Stop Condition & Auto-Repeat.....	26
Connecting External Power Amplifier	27
GENERATING APPLICATION SPI ROM IMAGE	28
TYPICAL APPLICATION CIRCUITS	29
ABSOLUTE MAXIMUM RATINGS	30
AC & DC ELECTRICAL CHARACTERISTICS	30
DC Characteristics	30
AC Characteristics	31
PACKAGE OUTLINE	32

Figures

Figure 1. MS212 Block Diagram.....5
 Figure 2. MS212 PAD Configuration6
 Figure 3. MS212 SSOP28 Package configuration.....7
 Figure 4. Manual Reset.....12
 Figure 5. Mixed playing mode concept.....16
 Figure 6. Mixed playing mode playing sequence.....17
 Figure 7. Record Timing Diagram.....19
 Figure 8. MS212 Recording data path.....20
 Figure 9. MS212 Amplifier Components.....21
 Figure 10. Playing Timing Diagram.....23
 Figure 11. Playing 2-segment Mode. (Low address first).....24
 Figure 12. Playing 2-segment Mode. (High address first).....25
 Figure 13. Playing signal flow.....26
 Figure 14. Auto repeat configuration.....27
 Figure 15. MS212 Connecting external amplifier of BTL Mode.....27
 Figure 16. MS212 SPI Generation Tool.....28
 Figure 17. Typical Application Circuit for Recording Application.....29

Features

- Recording Microphone input to connected SPI flash memory, very low cost.
- All data kept when power is OFF.
- 1 MBIT SPI flash may record 30 seconds of speech with 8 KHz sample rate¹.
- Supports up to **128** MBIT, which is about 35 minutes with 8 KHz sample rate.
- Support μ -LAW² or ADPCM format recording.
- Can records/play sound by Piezo-electric buzzer with good quality.
- Play the recorded sound directly from the SPI flash memory to 8 ohm speaker.
- Sample-rate is adjusted by external resistor.³
- Built-in 1280 bytes of RAM for FIFO & Filter while erasing flash memory.
- Operating from 2.3 ~ 4.8V.
- Sleep power consumption < 5 μ A with FLASH memory.
- Key button inputs
 - ◆ PLAE, edge trigger to play the recorded sound.
 - ◆ PLAL, level-hold to play the recorded and preload sound.
 - ◆ RECE, edge trigger to start recording.
 - ◆ RECL, level hold to start recording. And RECL can interrupt PLAL operation, suitable for card applications.
- SPI Flash may have pre-load audio with special options. Preload data and option will not be erased when recording new sound.
- BEEP prompt for recording.
- Support one-key operation: Long press is recording, and double-click for playing at RECL key.
- Preload FLASH Options are as follows:
 - ◆ Preload music playing order, first or second.
 - ◆ ADPCM or μ -LAW format recording.
 - ◆ Preload music playing with double sample rate.
 - ◆ **Preload music playing mixed with recorded speech.**
 - ◆ Quieter volume for power saving.
 - ◆ Power-On welcome message that can be played when power-on only.
 - ◆ Recording Prompt message that is played before recording only.
 - ◆ LED output duty by output sound volume.
 - ◆ 4-segments of recording that each key changed to different segment recording/playing function.
 - ◆ Auto-Erase after a period of time.
 - ◆ Recording LOCK by external switch.
 - ◆ Power On-PLAY
 - ◆ Simple Amplifier Mode.
 - ◆ Key function change that can be set independently:
 1. PLAE changed to recorded voice play only.
 2. PLAL changed to recorded voice play only.
 3. RECE changed to act as AMP ON.
 4. RECE changed to act as ERASE key.
 5. RECL change to one-key operation.
- Auto-repeat function select by PIN connection.
- Playing/Recording LED Indicator.

¹ The length is in ADPCM Format.

² U-LAW recording needs faster SPI flash due to internal RAM size limit. Check MSHINE Technologies Corp for further information.

³ For recording applications with ADPCM format, sample rate is limited by $2400/[\text{Flash sector-erase-time}]$. Recording sample will missing if recording-sample rate is greater than $2400/[\text{Flash sector-erase-time}]$. Pre-record sound segment has no such limit. For μ -LAW recording, sample rate is limited by $1200/[\text{Flash sector-erase-time}]$.

Block Diagram

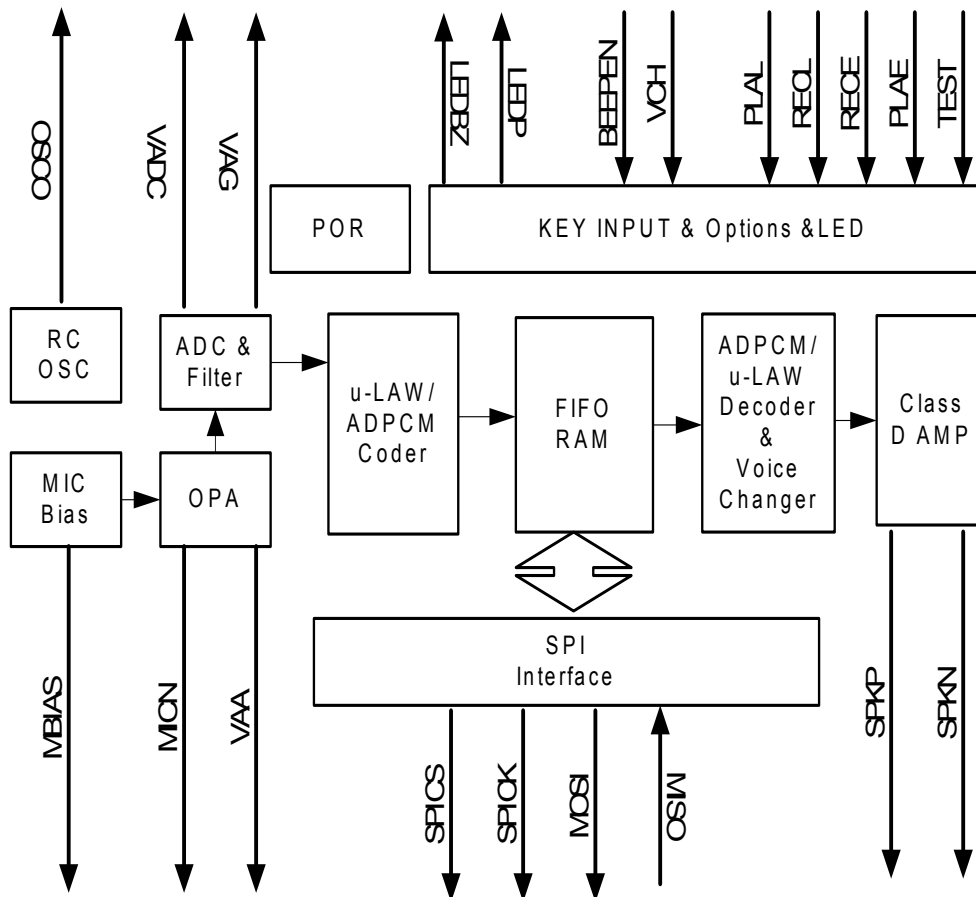


Figure 1. MS212 Block Diagram.

Application

- Sound recording toys, cards, and other applications.

Package

- TBD.

General Description

MS212 is a recording IC that can be used for all kinds of sound recording applications. It can also be configured as a simplified band-limited sound amplifier. With different SPI flash memory connected, it can record sound up to 40 minutes with very good sound quality.

PAD Configuration (Draft)

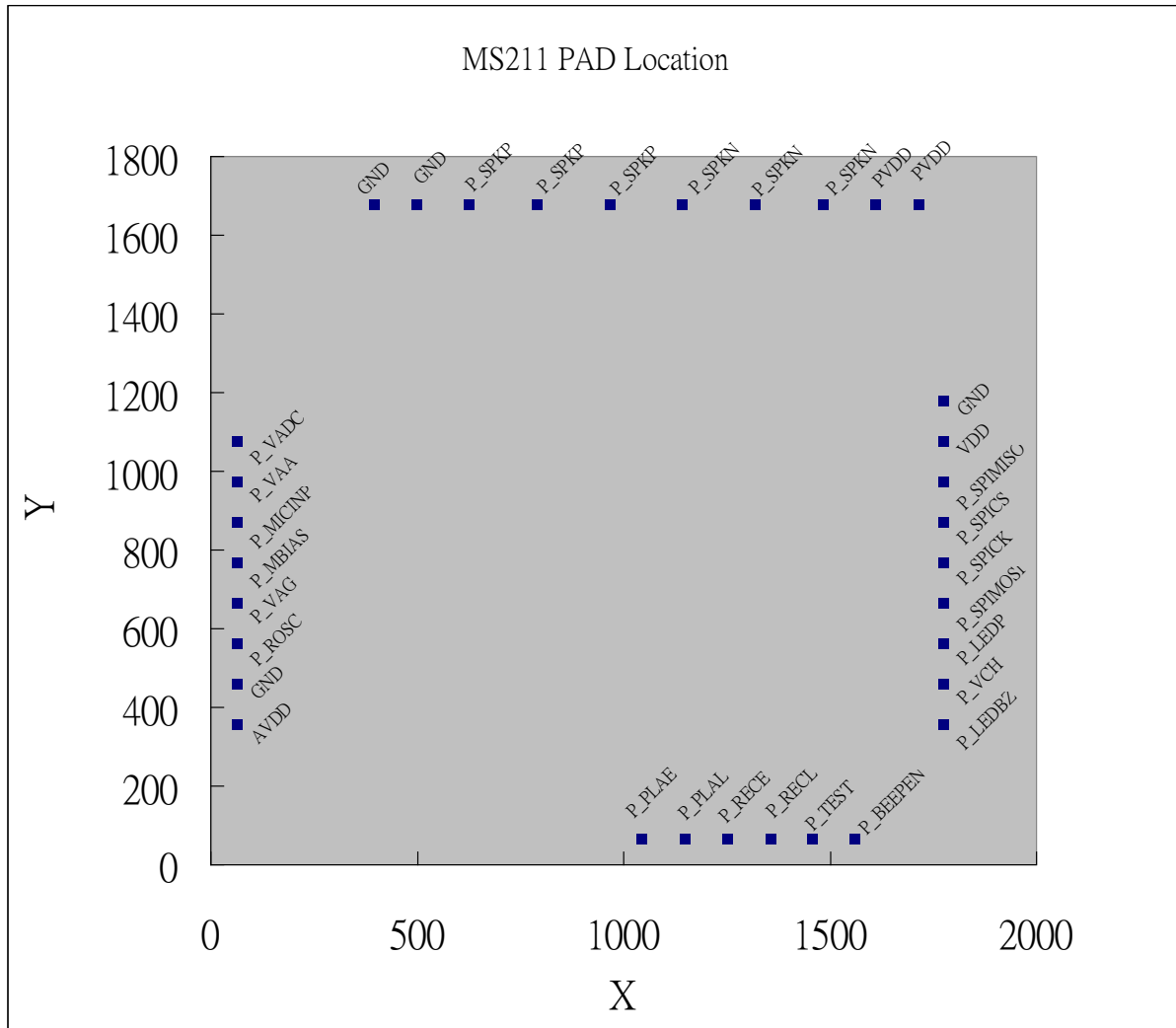


Figure 2. MS212 PAD Configuration

Pins Configuration

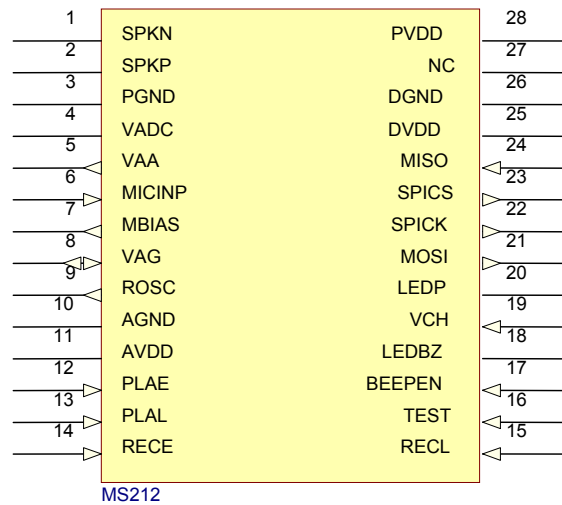


Figure 3. MS212 SSOP28 Package configuration.

Pin Descriptions

Pin No.	Notation	TYPE	Functional Description
Power Pins			
25	DVDD	Power	VDD power source of digital circuits.
26	DVSS	Power	GND power of digital circuits.
11	AVDD	Power	Analog/SPK Power VDD
10	AVSS	Power	Analog/SPK Power GND
28	PVDD	Power	Power Amplifier Supply
3	PVSS	Power	Power Amplifier GND.
Special Pins			
9	ROSC	O	External resistor to DVSS
16	TEST	IU	Input low for test mode.

Key buttons & Options																		
12	PLAE	IU ⁴	Play button input. Edge Trigger. If the data is not played over, playing will stop at the second trigger. In 1-segment mode, only 1 segment will played. In 2 segment mode, 2 segment of voices will be played.															
14	RECE	IU	Record start input. Edge Trigger. Second trigger will stop the record process.															
13	PLAL	I	Play, level hold input, low active. This pin has no internal PULL HIGH resistor, applications MUST connect to VDD with a resistor.															
15	RECL	IU	Record, level trigger, low active.															
19	VCH	IU	Voice Changer/Lock option, <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Connection</th> <th>Effect</th> </tr> </thead> <tbody> <tr> <td>Floating</td> <td>None</td> </tr> <tr> <td>Short to LEDP</td> <td>Lock⁵</td> </tr> <tr> <td>Short to LEDBZ</td> <td>Pitch-shift</td> </tr> </tbody> </table>	Connection	Effect	Floating	None	Short to LEDP	Lock ⁵	Short to LEDBZ	Pitch-shift							
Connection	Effect																	
Floating	None																	
Short to LEDP	Lock ⁵																	
Short to LEDBZ	Pitch-shift																	
17	BEEPEN	IU	Beep & Repeat Option. Normally Beep frequency is 1.0 KHz at 8.0 KHz sample rate. The operation is as following table. <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Connection</th> <th>Beep</th> <th>Repeat</th> </tr> </thead> <tbody> <tr> <td>Floating</td> <td>ON</td> <td>OFF</td> </tr> <tr> <td>Short to GND</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>Short to LEDP</td> <td>OFF</td> <td>ON</td> </tr> <tr> <td>Short to LEDBZ</td> <td>ON</td> <td>OFF</td> </tr> </tbody> </table>	Connection	Beep	Repeat	Floating	ON	OFF	Short to GND	OFF	OFF	Short to LEDP	OFF	ON	Short to LEDBZ	ON	OFF
Connection	Beep	Repeat																
Floating	ON	OFF																
Short to GND	OFF	OFF																
Short to LEDP	OFF	ON																
Short to LEDBZ	ON	OFF																
LED Pins																		

⁴ IU means input with pull up resistor inside.

⁵ Lock functions are defined in SPI options.

20	LEDP	O	Output low when playing. ⁶
18	LEDBZ	O	Output 3 Hz when playing and output low when recording. ⁷
SPI Pins			
23	SPICS	O	SPI Chip Select (Low active). It will change to PULL-HIGH with high impedance at sleep mode and RESET. Connected SPI FLASH Memory may be programmed by external source if BEEPEN and TEST pins are low.
22	SPICK	O	SPI clock signal. It will change to PULL-HIGH with high impedance at SLEEP mode and RESET. Connected SPI FLASH Memory may be programmed by external source if BEEPEN and TEST pins are low.
21	MOSI	O	Master data/command output. It will change to PULL-HIGH with high impedance at SLEEP mode and RESET. Connected SPI FLASH Memory may be programmed by external source if BEEPEN and TEST pins are low.
24	MISO	I	Master data input. Its internal pull-high resistor will be enabled in SLEEP mode. Note that its VIH/VIL level is around 1/2 without Schmitt Trigger.
Mic and Analog pins			
8	VAG	O	Analog virtual ground. Capacitor of 1 uF to AVSS is required. This pin is also the positive input of the OP-AMP. A resistor 100K to MBIAS shall be connected for 3-battery (>3.6V) applications.
5	VAA	O	Anti-Alias filter PAD. It is also the output of the OP-AMP.
7	MBIAS	O	Microphone bias voltage source. A capacitor 1 uF to

⁶ LEDP and LEDBZ has special timing in SOUND-DETECT Mode. Please check “sound detect mode” for details.

⁷ LEDP and LEDBZ has special timing in SOUND-DETECT Mode. Please check “sound detect mode” for details.

			AVSS is required. When recording, its output voltage is around 2.5V.
6	MICNP	I	Negative input of internal OP-AMP. A feed back resistor and capacitor is required to connect VAA, and a resistor is used to connect the microphone.
4	VADC	O	A PAD for ADC voltage reference. A capacitor 1 uF is required to connect this pin to AVSS. When recording, its voltage is around 2.1V.
Speaker Driving Pins			
2	SPKP	O	Speaker output. High-Z when not playing.
1	SPKN	O	Speaker output. High-Z when not playing.

Table 1. MS212 Pins Description.

General Functional Description

MS212 is a simple chip that can record the voice from microphone/Speaker to SPI memory, and play the voice from SPI memory directly. It built in high-quality ADPCM/ μ -LAW engine that can compress the voice data from ADC to 4-bit/8-bit per sample.

In addition to start recording and playing by input pins, MS212 may start recording and playing with sound activity level. The special method is called **Sound-Detect Mode**.

When recording, sound are compressed to 4-bit/8-bit per sample, and then stored to flash memory. While erasing sectors on SPI flash memory, MS212 will store the compressed speech data in its own RAM. After the sector is erased, the compressed data will be written to the SPI memory as soon as possible. Also, it will overwrite the old record data and replaced by the new one whenever a voice is recorded.

Before start recording a short Beep prompt will be on the speaker. And 2 short “beep” will out after recording stopped. Beep function can be disabled with BEEPEN short to GND.

In 1-segment mode, MS212 will record the speech from the beginning of the SPI flash. In 2-segment mode, MS212 will record (overwrite) the speech of high-address voice segment.

For DEMO purpose, MS212 can play the greeting (Welcome) message when power-on and special “Prompt” message before recording.

When playing, MS212 will read the content from the SPI memory and decode with ADPCM/ μ -LAW decoder, and perform the voice-changer function as required. In 1-segment mode, MS212 will play just one voice segment. In 2-segment mode, MS212 will play 2 segments of voices one by one or mixed together. Which one should be played first is defined by preload FLASH option. After the sound segments are played, it will toggle LED pins to check if repeat is required. If BEEPEN is short to LEDBZ or LEDP, MS212 will repeat playing again. For mix-mode and Sound-Detect Mode, repeating has special options, and will be described in later sections.

MS212 playing is through Class D Amplifier that has very good power efficiency and sound quality.

If TEST is low and SPIMISO is low, with PLAE connect to LEDBZ, MS212 will be act as band-limited amplifier.

Reset and Initialization

MS212 has default Power-On-Reset (POR) that release at about 2.4 V. After around 300 ms after power-on, MS212 will start to check the SPI flash memory connected.

Manual Reset

If MS212 is used in bad power conditions, or changing flash memory is required, manual reset is another option. MS212 will enter “RESET” state if “TEST” and “BEEPEN” short to GND at the same time. The configurations are as below:

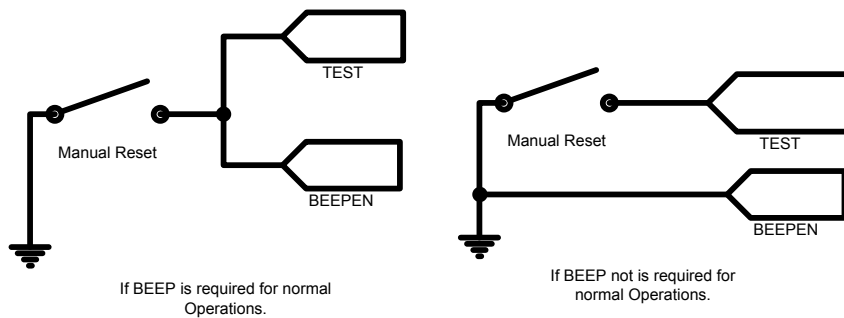


Figure 4. Manual Reset.

If normal operations do not “BEEP”, BEEPEN may short to GND constantly, and use TEST pin as the reset pin.

When MS212 is in RESET state, the connected SPI Flash can be burned/checked by external devices.

Used SPI Commands

The SPI flash connected must support the following commands:

COMMAND NAME	COMMAND CODE	DESCRIPTION				
JEDEC ID	9FH	Read the standard size information. MS212 Checks the 3 rd byte reply of command 9F as its size code. The mapping is as below: <table border="1" style="margin-top: 10px; width: 100%;"> <thead> <tr> <th style="background-color: #000080; color: white;">Command 0x9F reply 3rd byte</th> <th style="background-color: #000080; color: white;">Size</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">0x2F</td> <td style="text-align: center;">256K Bits</td> </tr> </tbody> </table>	Command 0x9F reply 3 rd byte	Size	0x2F	256K Bits
Command 0x9F reply 3 rd byte	Size					
0x2F	256K Bits					

		0x10/0x20/0x40	512K Bits
		0x11/0x21/0x41	1M Bits
		0x12/0x22/0x42	2M Bits
		0x13/0x23/0x43	4M Bits
		0x14/0x24/0x44	8M Bits
		0x15/0x25/0x45	16M Bits
		0x16/0x26/0x46	32M Bits
		0x17/0x27/0x47	64M Bits
		0x18/0x28/0x48	128M Bits
DS release	ABH	Read the signature or release from the deep sleep mode.	
Read Status Register	05H	Read the 8-bit register to know if busy.	
Write Status Register	01H	Write the 8-bit register.	
Write Enable	06H	Write enable	
Sector Erase	20H	Erase 4 Kbyte sector.	
Page Program	02H	Program 256 bytes.	
Deep Power Down	B9H	Deep power down of the SPI Flash memory.	
Data Read	03H	Read the SPI flash memory.	

Table 2. Used SPI commands.

New SPI Memory parts must have above commands if connecting to MS212.

Messages on SPI Flash

Many kinds of sounds/messages can be stored at SPI flash. Except the recorded message, other messages may be pre-write to the SPI flash for normal application. All the messages are described below:

Recorded Message

Recorded message is the normal recording/playing message that recorded by microphone connected and can play when PLAE/PLAL key pressed. It will be replaced every time user records it, and will be erased every time user ERASE it. Default there is only ONE recorded on the FLASH. However, MS212 may have MULTI-SECTION Mode that may have 4 recorded message on the FLASH. In that mode, all key-buttons has their own mapping message and operates with them only. That is long press PLAE will record the first message, and double-click PLAE will play that message. Also long press RECL will record another message and double click RECL can play that message.

Preload Message

Preload message is the message that will be played before, after, or mixed with the recorded message. The message will not be erased by ERASE key or recording process. It is fixed in the SPI flash. There will be only ONE or NONE preload-message on the SPI flash connected. If there is no PRELOAD message, the recorded message will be played alone.

Welcome Message

Welcome message is a special message played at power-on. That is, when power-on, MS212 can play the Welcome message, or the preload-message, or both of them, repeat or not. Welcome message may be 16 seconds long in 8K sample rate.

MS212 has a special mode that the Welcome message will be played as the third message. That is, Preload-Recorded-Welcome.

Prompt Message

Before each recording, MS212 may have a "Prompt message" played to notify users that their speech will be recorded. It can have beep sound following the message. If there is no prompt message, MS212 may use BEEP sound as the prompt. A connected SPI flash may have ONE or NONE of the Prompt message. Prompt message may be up to 16 seconds long.

Power-On Messages

When power on, MS212 may play some messages automatically, repeat or not.

Power-On MSG combinations	Description
Welcome Message only	Just play Welcome message
Preload Message Only	Just play the preload message
Welcome-Preload	Play the Preload message after welcome message.
Preload-Welcome	Play the Welcome message after the preload-message

The repeat settings can be

1. No repeat. (Just once)
2. Repeat after 2 seconds of no operation.
3. Repeat after 4 seconds of no operation.
4. Repeat after 32 seconds of no operation.

Auto-Erasing

MS212 can auto-erase the recorded message after a period of no operation, which is mainly for the DEMO purpose. The condition are listed below:

1. Every time Power ON or 128 Seconds of NO-Operation.
2. Every time Power ON or 32 seconds of NO Operation
3. Every time Power ON and VCH short to LEDP pin.
4. Never auto-erase.

One-Key Operation

MS212 support ONE-KEY operation that the application uses ONE button to do the record and playing. Operations may vary as follows:

Method #	Recording	Playing
1	Long press (Level-hold) > 2 seconds	Short press (playing after key released) < 2 seconds
2	Long press (Level-hold) > 4 seconds	Short press (playing after key released) < 4 seconds
3.	Long Press > 2 seconds	Double-click

Usually single-button uses RECL pin. However, MS212 supports multi-segment mode that 4 pins are used for 4 segments of recording and playing.

Key Function Change

Though MS212 has only 4 pins for key-press input, their function all can be changed. The changing functions are list as below:

Former Function	New Function	Description
PLAL	PLAYREC	Just play the recorded message, not the preload

		message.
PLAE	PLAYREC	Just play the recorded message, not the preload message.
RECL	ONEKEY	One-Key Play-Recording operation.
RECE	AMP-ON	Turn-ON/OFF the amplifier
RECE	ERASE	Erase the recorded message

All the special functions can be set as LEVEL-HOLD or edge trigger.

Mixed Playing Mode

MS212 support mixed playing mode that can mix the pre-load music and the recorded sound playing together. It does not support ROBOT effect and has special configuration for auto-repeat function and gain settings. The data flow is as follows.

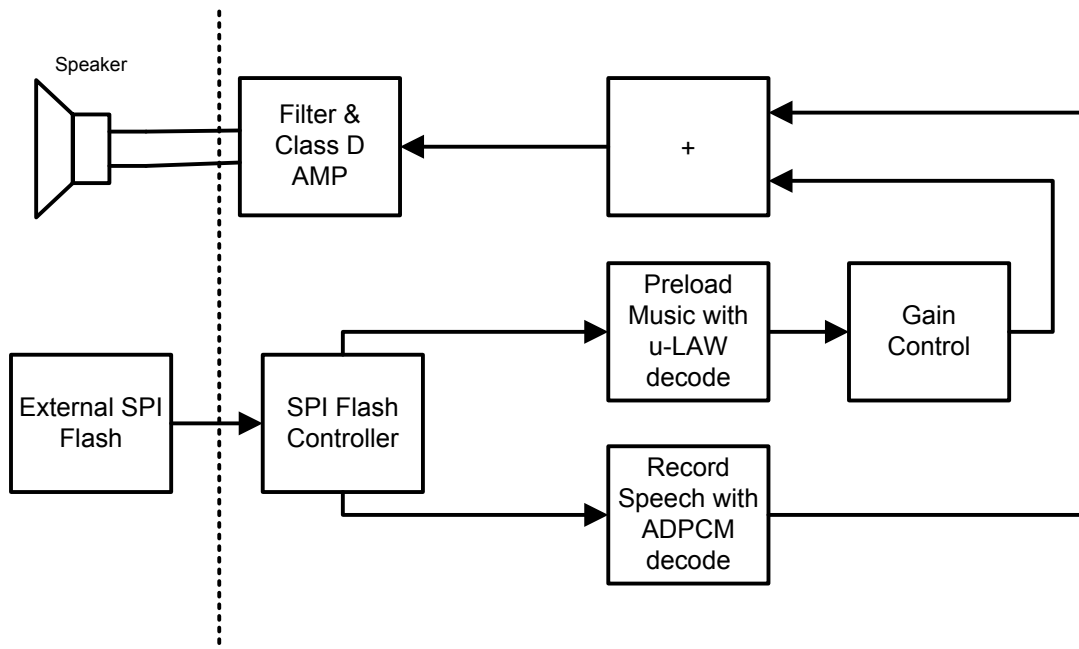


Figure 5. Mixed playing mode concept.

Because preload music may different length from the recorded speech, and auto-repeat may be used, the playing sequence is like the following figure.

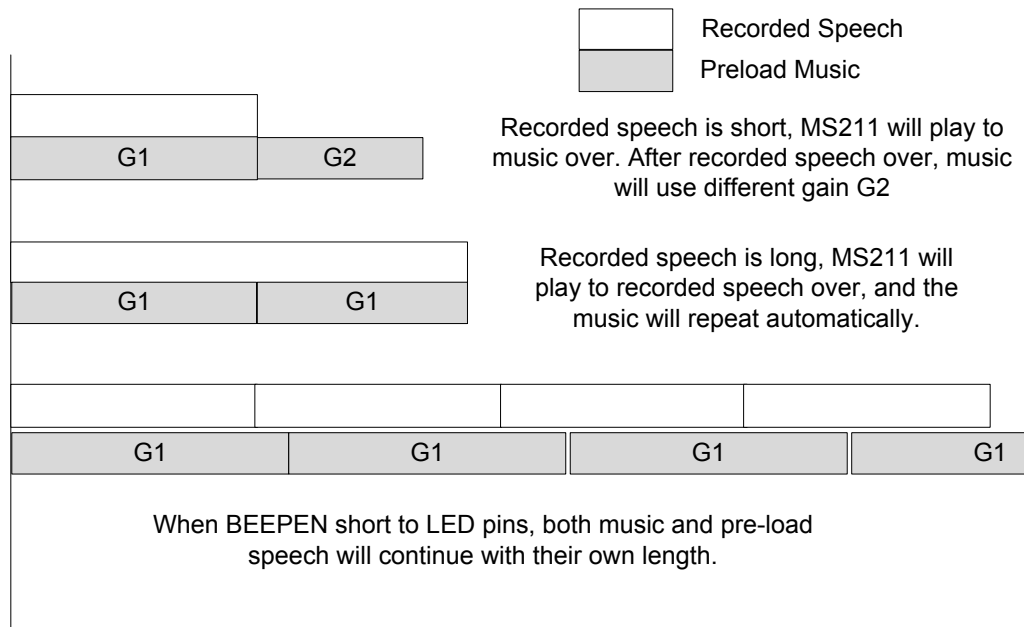


Figure 6. Mixed playing mode playing sequence.

And FLASH options may have different settings of G1 and G2. The configuration of G1 and G2 is as the following table.

Settings	G1	G2
Normal	-12 dB	0 dB
Quiet	-12 db	-12db
Loud	0 db	0 db

Table 3. Mixed Mode gain settings.

Sample Rate and Resistor Value

For different sample rate, resistor of correct value should connect to OSCO pin. The recommend value is as below (At 3.6V):

SAMPLE RATE (KHZ)	8.0	6.0	10.0	11.0	12.0	16.0
Typical Resistor (K Ohms)	91	120	73	68	62	47

Recording Function Description

MS212 can record the signal of microphone to the SPI Flash Memory. The following sub-sections will describe the detailed information.

Default Record Timing

When recording in normal operation, MS212 has input signals and LED output like the figure below. Note that LEDP3 and LEDBZ can be used for recording indicator.

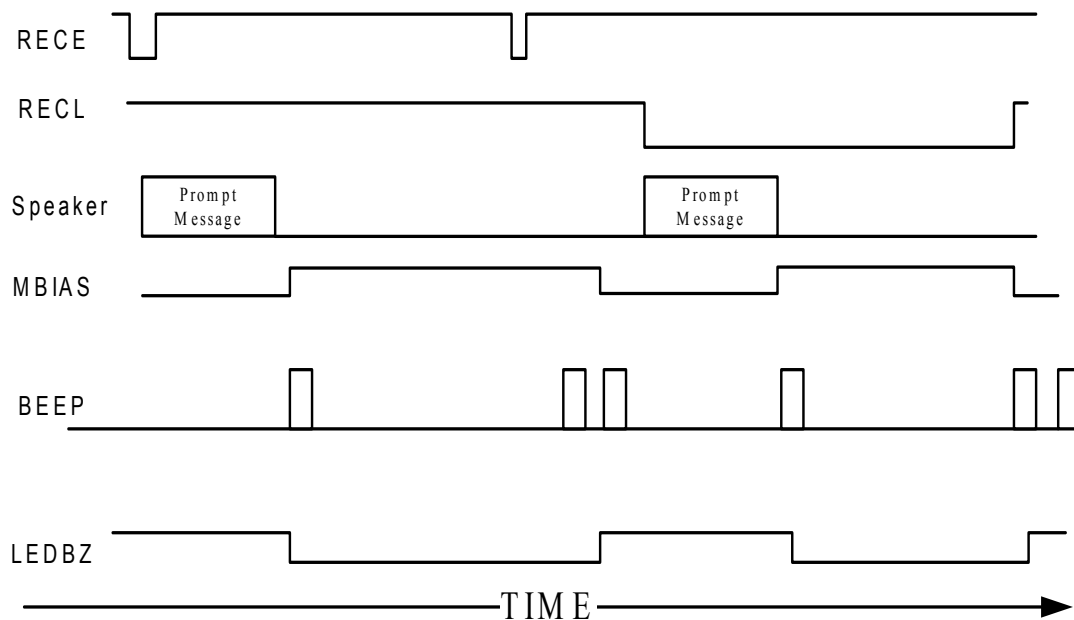


Figure 7. Record Timing Diagram.

MS212 Plays “Prompt” message before it records. If there is NO PROMPT message in SPI flash, it will just skip it.

Recording Signal Path

When recording, MS212 has the recording signal path as below.

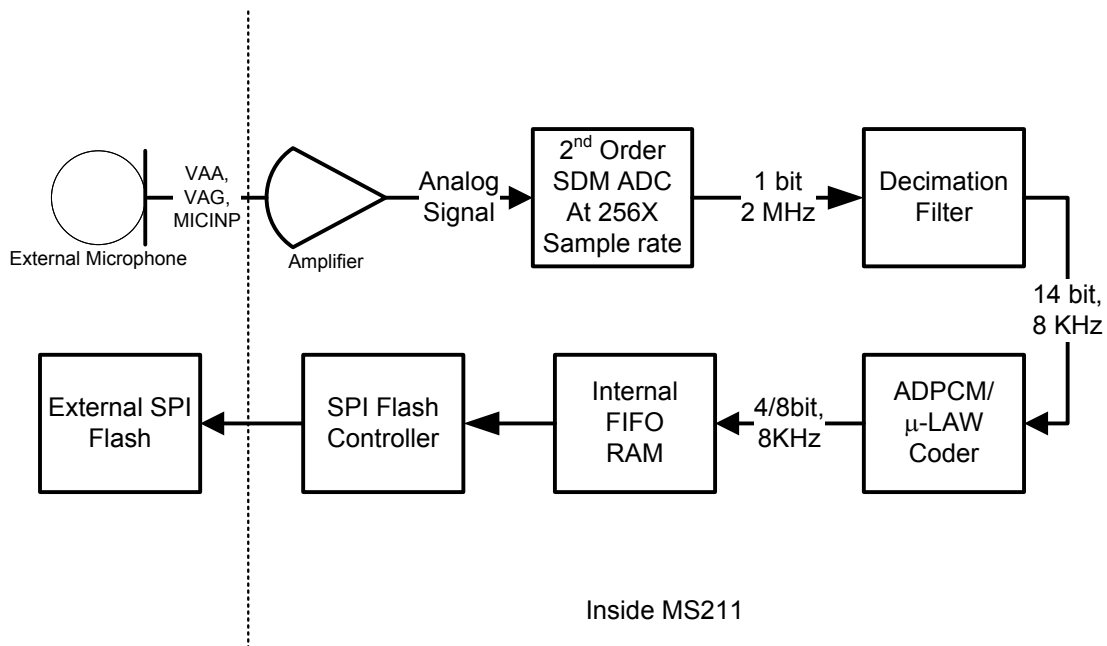


Figure 8. MS212 Recording data path.

When recording a segment, the sound signal will be sensed with external microphone and amplified by the built-in OP-AMP of MS212. The signal will be converted to digital signal first by the 1-bit, 2nd order sigma-delta ADC, which is normally working at 2.0 MHz, or at 256 times over-sample-rate. The decimator filter have around 1 db ripple in in-band, -3 db at 3400 Hz and can reject 40 DB aliasing noise above 4 KHz if sample rate is 8 KHz.

Microphone Amplifier Circuits

MS212 has an OP-AMP that can amplify the audio signal as required. Usually the external components are as follows.

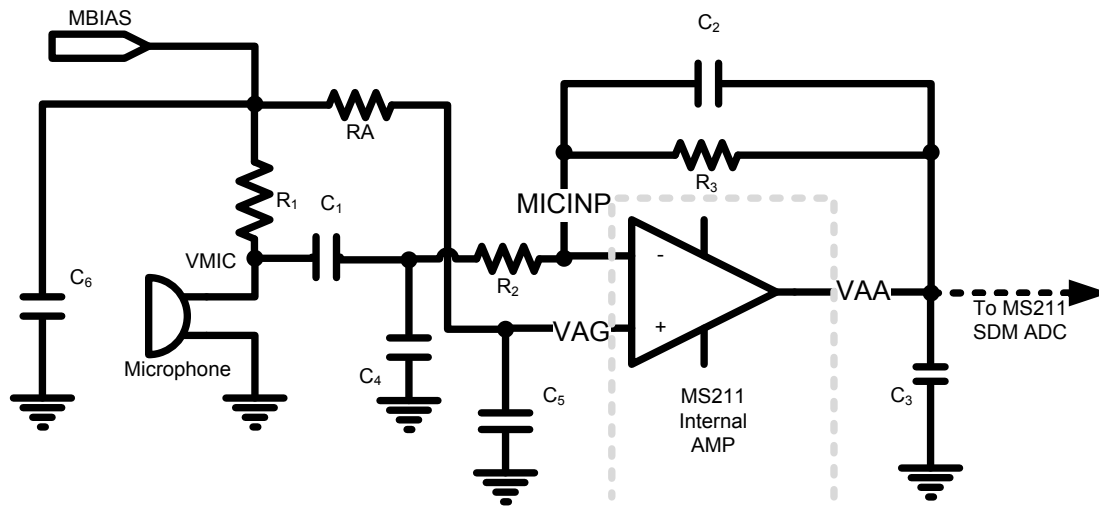


Figure 9. MS212 Amplifier Components.

From Above figure, the OP-AMP with its external components forms a band-pass filter, which has gain and related frequencies described below:

1. MBIAS will output a constant current source if external load need current more than 3 mA. Otherwise, it will be as high as 2.2V. For $V_{DD} \geq 3.6V$, R_A is required that will increase MBIAS to 2.6V.
2. R_1 provides the loading of the microphone. Usually it is 1K ohm to 3K ohms.
3. If C_4 is small, R_2 is the input impedance of the amplifier. If $R_2 \gg R_1$, we have the high-pass 3db frequency at $1/(2\pi R_2 C_1)$. If R_2 is 10K Ohms, C_1 is 0.1 uF, the 3DB frequency is around 160 Hz. For speech signal, usually we need 300 Hz ~ 3000 Hz be clearly amplified, and 160 Hz will be a good value.
4. R_3/R_2 decides the gain of the amplifier. Note that the OP-AMP has unit-gain-bandwidth at around 1.0 MHz. That is, if gain is 200 (26db), it will have the 3-db frequency at 5 KHz event C_2 is not connected. BTW, R_2 must be much greater than R_1 to get the microphone load line correct. That is, the following equation is usually applied:
 - a) $R_2 \geq 10$ K Ohms.
 - b) Gain = R_3/R_2
5. C_2, C_3, C_4 forms the low pass filter of the amplifier. C_4 is used to prevent noise generated by special housing of microphone, and C_3 can usually be omitted because SDM samples the data at 2.0 MHz, which usually do not need an anti-alias filter for 1.0 MHz signal and up. The low pass frequency is mainly dominated by C_2 and the unit-gain-BW of the OP-AMP. If gain is less than 30 dB, the low-pass will be dominated by C_2 and R_3 at $1/(2\pi R_3 C_2)$. If R_3 is 2 M Ohms, C_2 is 22 pF, the 3db frequency will be 3.6 KHz.

SPI Flash Power Noise Rejection

MS212 uses regulated power sources for ADC and microphone amplifier. MS212 should have 1 μ F capacitor connect at VADC, MBIAS, and VAG. And 10 μ F capacitors connect at DVDD, DVSS, AVDD and AVSS. Then the power noise from SPI flash will be filtered. Please check the example circuit for details.

The other important method is not to mix the PCB of AVSS/DVSS AVDD/DVDD. Analog power MUST be connect to digital/global power with (almost) 0 ohm wires. For example, if MBIAS using a capacitor connecting to global ground or digital ground, the recording noise will come out. Check the example circuit for details.

Playing Function Description

MS212 can play the recorded sound from the SPI Flash memory. The following subsections will describe the playing function in detail.

Playing Timing Diagram

When PLAE or PLAL pressed, MS212 will start to play. The LED and sound segment timing is as the following figure, if there is no preload music.

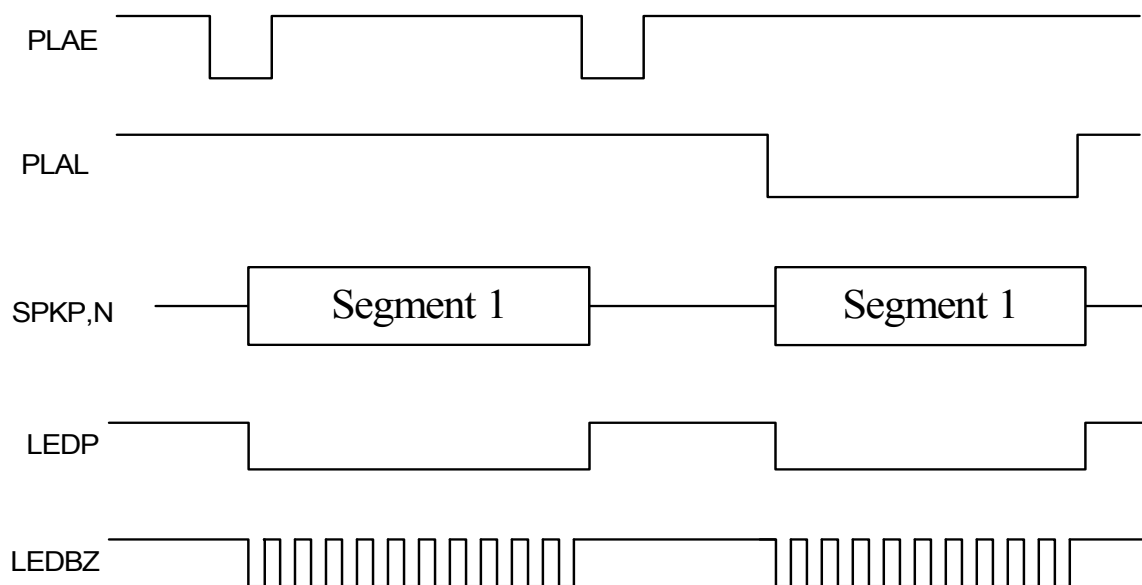


Figure 10. Playing Timing Diagram.

Playing Timing of 2-SEGMENT Mode

Also, MS212 can play 2 segments with a segment fixed. The timing is as Figure 11 and Figure 12.

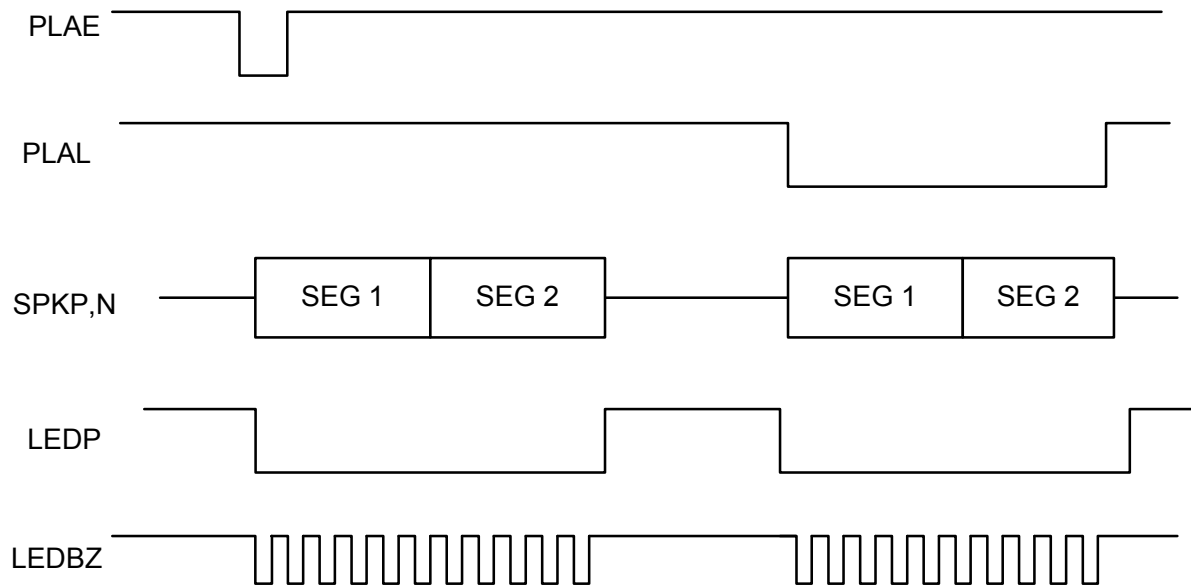


Figure 11. Playing 2-segment Mode. (Low address first)

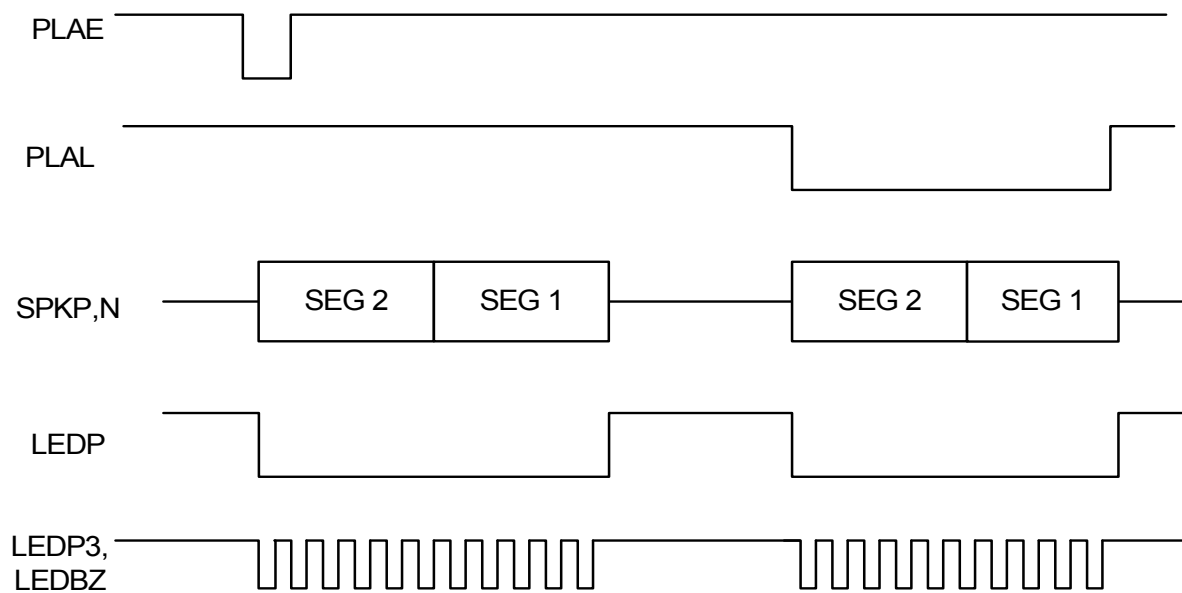


Figure 12. Playing 2-segment Mode. (High address first)

Note that MS212 can have WELCOME message as the 3rd playing message.

Signal Flow When Playing

When MS212 playing, the signal will be strait-forward as Figure 13. The data will be read from the SPI flash and interpolated to the amplifier.

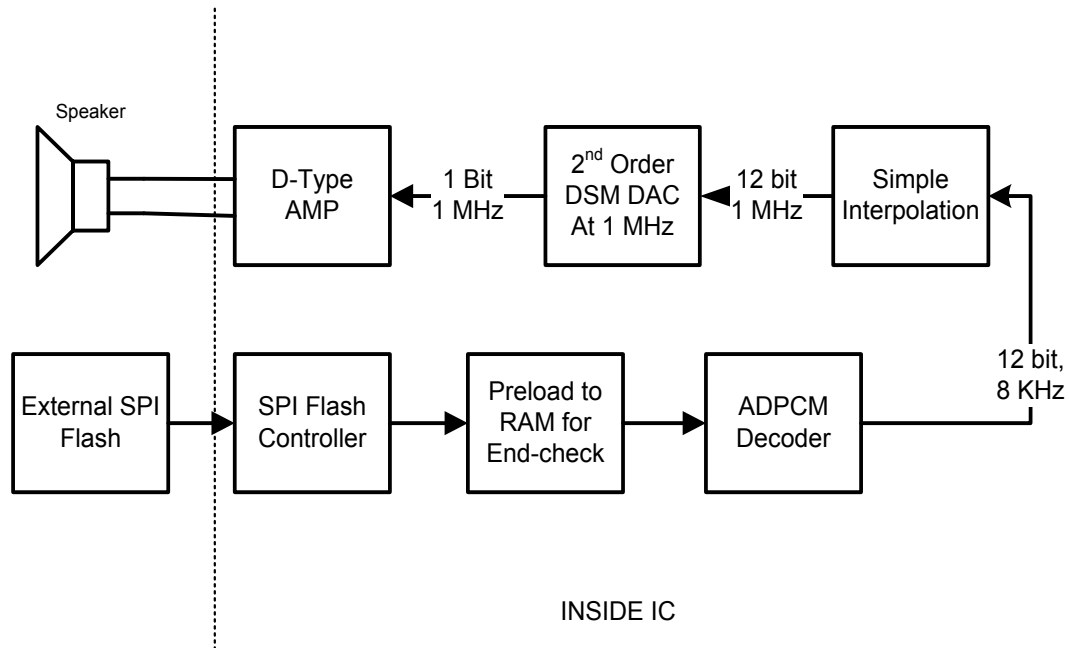


Figure 13. Playing signal flow.

Playing-Stop Condition & Auto-Repeat

When playing, MS212 will check the following condition to stop playing:

1. If PLAE pressed, it will stop when any other button pressed.
2. If PLAL pressed, it will stop when PLAL released.
3. If MS212 found 0xFF for 8 times, it think it is the end-code, and will stop playing.
4. If entire flash played, it will also stop.

MS212 will also check if BEEPEN pin is connected to PLED or LEDBZ. Either of them will make MS212 to restart playing again. The configuration is like Figure 14.

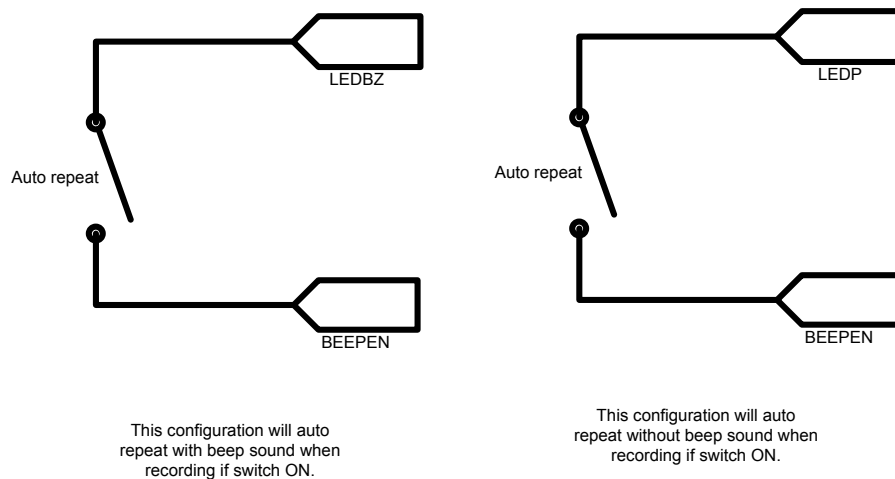


Figure 14. Auto repeat configuration.

Connecting External Power Amplifier

MS212 can connect external power amplifier with differential or single-ended method. The following chart shows MS310 connecting to power-amplifier with differential method (BTL Mode). Note that SPKP and SPKN is high impedance when not playing.

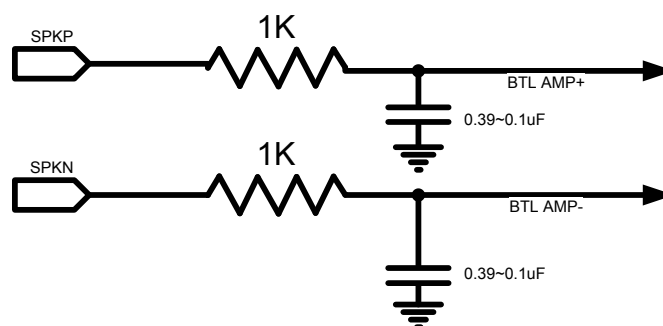


Figure 15. MS212 Connecting external amplifier of BTL Mode.

Generating Application SPI ROM Image

MSHINE provides the ROM generating tool like below:

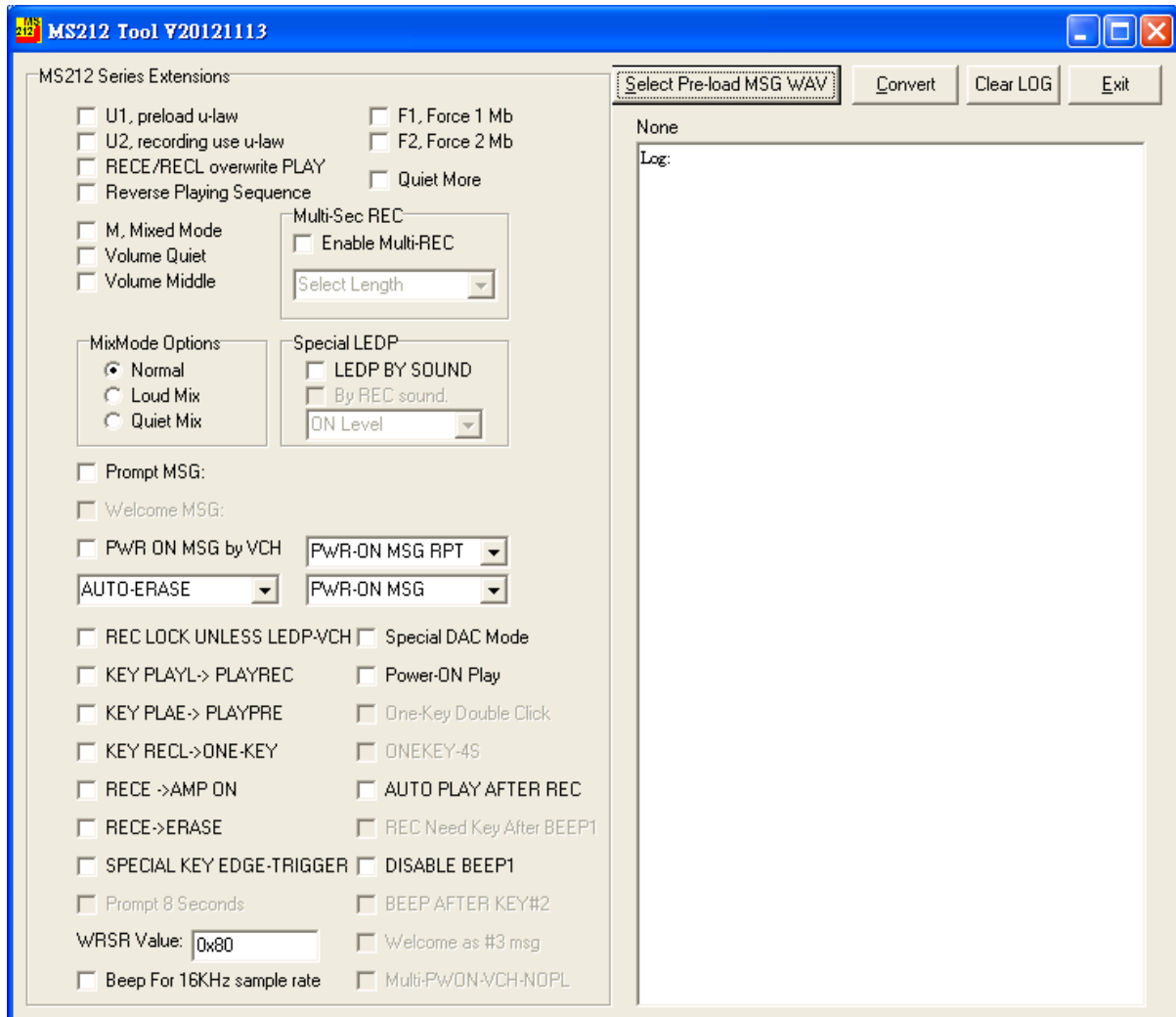


Figure 16. MS212 SPI Generation Tool.

All the options can be configured by the tool above.

Typical Application Circuits

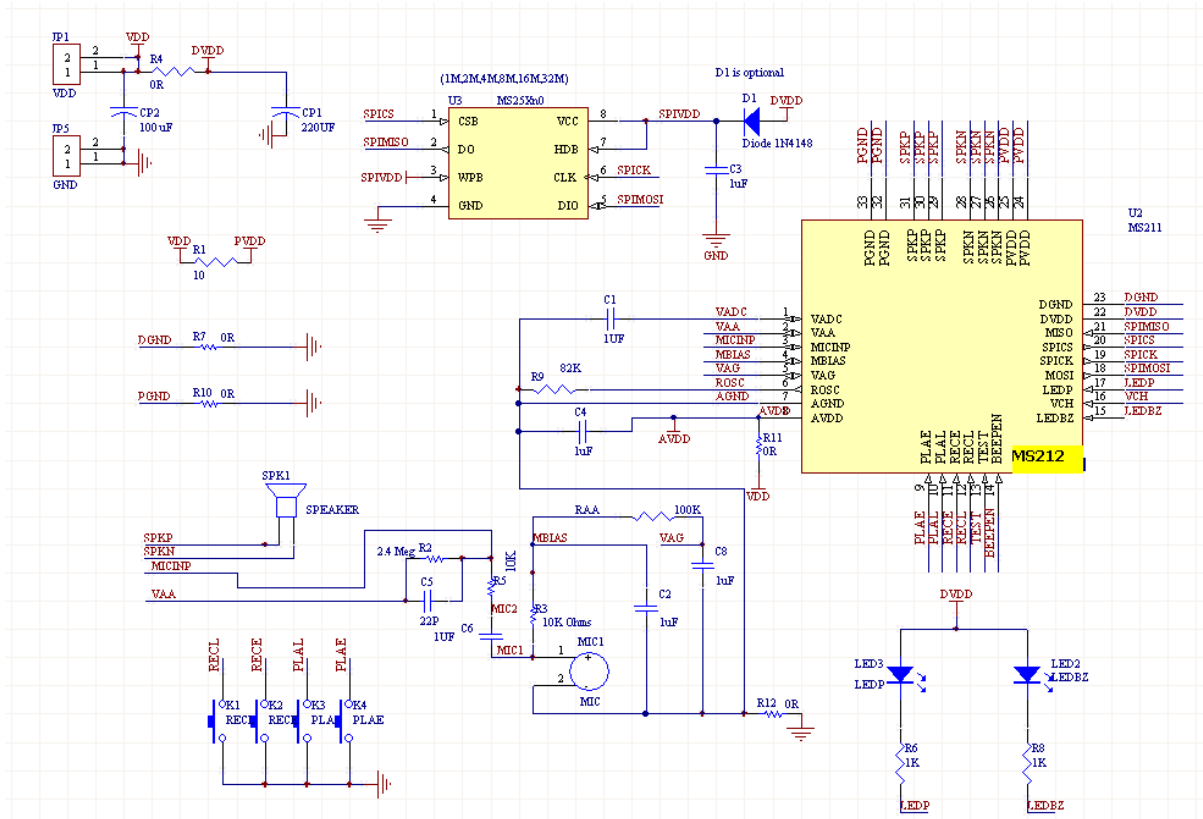


Figure 17. Typical Application Circuit for Recording Application.

Absolute Maximum Ratings

Comments

DC Supply Voltage.....-0.5V to + 4.8V
 Input Voltage.....-0.5V to VDD + 0.5V
 Output Voltage.....-0.5V to VDD + 0.5V
 Operating Temperature.....-40° to 85° C
 Storage Temperature.....-70° to 150° C

Never allow a stress to exceed the values listed under “Absolute Maximum Ratings”, otherwise the device would suffer from a permanent damage. Nor is a stress at the listed value be allowed to persist over a period, since an extended exposure to the absolute maximum rating condition may also affect the reliability of the device, if not causing a damage thereof.

AC & DC Electrical Characteristics

DC Characteristics

Parameters	Conditions	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	With SPI flash working at 4.5V	V _{DD}	2.3 ⁸	3.3	4.8 ⁹	V
Supply Current	8KHz, recording, VDD=3.0V	I _{REC}		13		mA
	8KHz, playing, VDD=3.0V, 8-Ohm speaker	I _{PLA}		30		mA
	Power-Down Mode, 3.0V ¹⁰	I _{DD1}		4	8	uA
	Power-Down Mode, 3.6V	I _{DD2}		5		uA
	Power-Down Mode, 4.5V	I _{DD3}		7	10	uA
Output voltage	I _{OH} =1, Push-pull pins.	V _{OH1}	V _{DD} -0.2	-	-	V
	I _{OL} =2 mA, push-pull pins	V _{OL1}	0.2	-	-	V
Input voltage ¹¹	All Input Pins	V _{IH1}	0.8 V _{DD}	-	V _{DD} +0.3	V
	All Input Pins	V _{IL1}	-0.3	-	0.2 V _{DD}	V
Output current	LED pins, VOL=0.5V, VOH=VDD-0.5V	I _{OL1} I _{OH1}	8		-8	mA
	AMP pins, 8-ohm speaker connected	I _{OL2} I _{OH2}		-100 +100		mA
	KEY pulled high input at 4.5V	I _{PH}		-0.04		mA
	KEY pulled high input at 3.6V	I _{PH}		-0.03		mA
MBIAS Output Current	VDD=3.3V	Imbo		3		mA
MBIAS Output CVoltage	VDD=3.3V			2.2		V
VAG output Voltage	VDD=3.3V	Vag		1.1		V

⁸ The supply voltage MUST be greater than the working voltage of the SPI Flash Memory.

⁹ When VDD>=3.3V, some 8-ohm speaker need to be connected with a resistor and an inductor.

¹⁰ SPI Flash's power is not included.

¹¹ Schmitt Trigger level around 2VDD/5, 3VDD/5 is implemented for all input pins **except MISO**.

POR Release voltage	Temp=23° C	Vpor		2.3		V
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Table 4. DC Characteristics of MS212.

AC Characteristics

Parameters	Conditions	Symbol	Min.	Typ.	Max.	Unit
Key button De-bounce time	Sample Rate = 8.0 KHz	Tkd		30		ms
ADC Input Range ¹²	VDD=2.3~4.5V	Vadi	0.25		2.1	VDC
External RC Frequency	VDD=4.5V, ROSC=91K OHMS	Frc	3.8	4.2	4.6	MHz
Sample Rate variation #1	VDD 4.6V → 3.6V, ROSC=91K ohms	FR1		+4%		
Sample Rate variation #2	VDD 4.6V → 3.6V, ROSC=91K ohms	FR2		-4%		
ADC Sample rate ¹³	VDD=3.0V	FS	6	8	16	KHz
Speech Signal SNR	VDD=3.0V	ADC _{SNR}		60 ¹⁴		DB
Speech Dynamic Range	VDD=3.0V	ADC _{SNDR}		70		DB
MBIAS Driving Current	VDD=3.0V	IMBIAS		2		MA
ADC POWER NOISE REJECT	VDD=3.0V	PSRR		50		DB
ADC COMMON MODE REJECT	VDD=3.0V	CMRR		40		DB
Input OPA Open loop gain	VDD=3.0v	G _{OL}	70			DB
OPA Input offset	VDD=3.0V	Oop			10	mV
OPA Unit gain bandwidth	VDD=3.0V	BWuni		1		MHz

¹² ADC input will be DC offset to VAG by OPA inside, which is usually 0.1V.

¹³ ADC Sample rate is limited by the sector-erase time with the memory since higher frequency needs more data stored at RAM when SPI is under sector-erase. The sample rate limit is [2400/sector-erase-time]. That is, sound sample will be dropped while recording if sample rate is greater than [2400/sector-erase-time].

¹⁴ Input signal is around 100 Hz sine wave.

MBIAS Power Noise Reject Ratio	VDD=3.3V,load=2.0 mA	PSRRmb		40		db
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Table 5. AC Characteristics.

Package Outline

