ML22Q394

ADPCM Speech Synthesis LSI

GENERAL DESCRIPTION

ML22394 is voice synthesis LSI with built-in Flash memory that stores speech data.
This LSI includes edit ROM, ADPCM2 decoder, low pass filter and D-class speaker amplifier. Also, ML22394 support the I2C interface.
By integrating all the functions required for voice output into a single chip, this LSI can be more easily incorporated in compact portable devices.

- Built-in memory capacity and maximum playback time:

Product name	ROM capacity	Maximum playback time (sec) (at f_s=8.0kHz)	
		4bitADPCM2	16bitPCM
ML22Q394-XXX	692 Kbits	22.1	5.5

Notes: ROM capacity shows the numerical value of only a voice area.

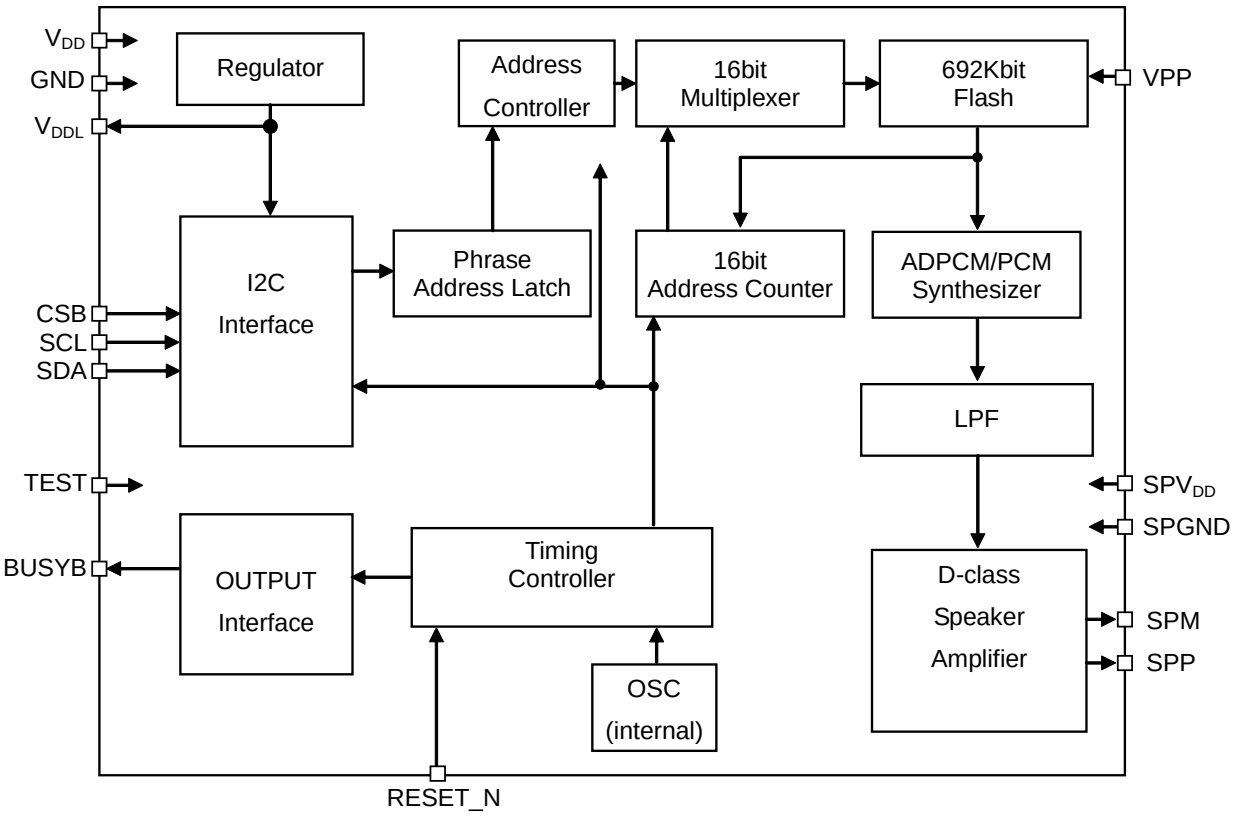
- Voice synthesis method: 4-bit ADPCM2
  8-bit Nonlinear PCM
  8-bit PCM , 16-bit PCM
  Can be specified for each phrase.
- Speech ROM capacity ML22Q394: 692-Kbit Flash
- Sampling frequency(Fs): 6.4 / 8.0 / 10.7 / 12.8 / 16.0 / 21.3 / 25.6 / 32.0 kHz
  f_s can be specified for each phrase.
- Analog output: Built-in D-class amplifier
- CPU command interface: I2C interface
- Maximum number of phrases: 30 phrases
- Disconnection detection function /Speaker pin short detection function
- Source oscillation frequency: 4.096 MHz(internal)
- Power supply voltage: 2.0 to 5.5V
- Flash memory rewritable time: 80 times
- Operating temperature range: –40 to +85°C
- Package: 16-pin plastic SSOP
- Product name: ML22Q394-NNNMB, ML22Q394-xxxMB(xxx: ROM code No.)

The following table shows the differences among the other speech synthesis LSIs.

Parameter	ML22330/ ML22Q330	ML22Q374	ML22Q384	ML22Q394
CPU interface	Serial	←	Event input	I2C
Memory capacity	640Kbit	692Kbit	←	←
Playback method	4-bit ADPCM2 8-bit nonlinear PCM 8-bit straight PCM 16-bit straight PCM	←	←	←
Maximum number of phrases	30	←	←	←
Sampling frequency (kHz)	6.4/8.0/10.6/ 12.0/12.8/16.0/ 21.3/25.6/32.0	←	←	←
Clock frequency	4.096MHz (with a built-in crystal oscillator circuit)	4.096MHz (internal oscillation)	←	←
Low-pass filter	FIR interpolation filter	←	←	←
Speaker driving amplifier	Built-in AB-Class 0.7W (8Ω, DV_{DD} = 5 V)	Built-in D-Class 1.0W (8Ω, DV_{DD} = 5 V)	←	←
Edit ROM function	Yes	←	←	←
Volume control	32 levels	←	←	←
Silence insertion	Yes 20 ms to 1024 ms (4 ms/step)	←	←	←
Repeat function	Yes	←	←	←
Power supply voltage	2.3 V to 5.5 V	2.0 V to 5.5 V	←	←
Operating temperature range	–40 to +85°C	←	←	←
Package	30-pin SSOP	16-pin SSOP	←	←

BLOCK DIAGRAMS

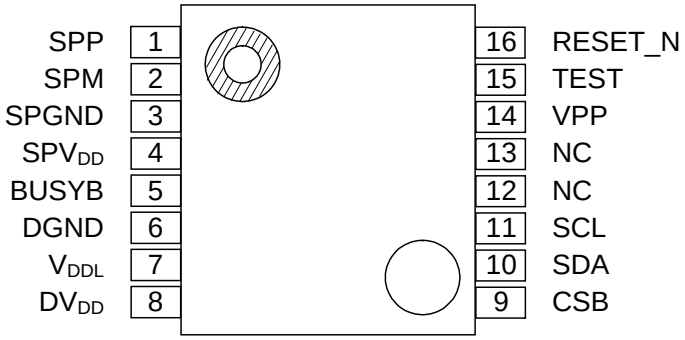
ML22Q394-NNNMB/ML22394-xxxMB



PIN CONFIGURATIONS (TOP VIEW)

ML22Q394-NNNMB/ML22394-xxxMB

16-Pin Plastic SSOP



NC : Unused pin

PIN DESCRIPTION

Pin	Symbol	I/O	Initial value (At the RESET_N Input)	Initial value (At standby)	Description
1	SPP	O	Hi-Z	Hi-Z	Positive(+) output pin of the speaker amplifier built-in
2	SPM	O	Hi-Z	Hi-Z	Negative(-) output pin of the speaker amplifier built-in.
3	SPGND	—	—	—	Ground pin for the speaker amplifier.
4	SPV_{DD}	—	—	—	Power supply pin for the speaker amplifier. Connect a bypass capacitor of 1μF or more between this pin and SPGND pin.
5	BUSYB	O	Hi-Z	1	BUSY output pin. When BUSYB use mode is set, the "L" level is outputted during playback. At the time of a disconnection detection function, when disconnection is detected, the "L" level is outputted. In addition, when BUSYB use mode is not set, the initial value is outputted.
6	DGND	—	—	—	Digital ground pin.
7	V_{DDL}	—	—	—	Regulator output pin for internal logic circuitry. Connect a capacitor of 10μF or more between this pin and DGND pin
8	DV_{DD}	—	—	—	Power supply pins for logic circuitry. Connect a capacitor of 1μF or more between this pin and DGND pin.
9	CSB	I	1	1	Chip select pin, when CSB use mode is set. At the “L” level, data input is available. When CSB use mode is not set, this pin should be fixed to “H” level od “L” level.
10	SDA	I	1	1	Input pin for I2C serial data. Use for setting the mode of write and writing address, writing data. This pin should be connected to pull-up resistor.
11	SCL	I	1	1	Clock input pin for I2C serial interface. This pin should be connected to pull-up resistor.
14	VPP	—	—	—	Power supply pin for rewriting Flash memory. Fix this pin to GND except when rewriting Flash memory.
15	TEST	I	0	0	Test pin. Fix this pin to a DGND level.
16	RESET_N	I	0	1	At the “L” level, the LSI enters initial state. After the power supply voltage is stable, drive this pin to “H” level.

ABSOLUTE MAXIMUM RATINGS

(DGND = SPGND = 0 V)

Parameter	Symbol	Condition	Rating	Unit
Power supply voltage	DV_{DD}	Ta=25°C	–0.3 to +7.0	V
Speaker power supply voltage	SPV_{DD}		–0.3 to +7.0	V
Internal logic power supply voltage	V_{DDL}		–0.3 to +3.6	V
Flash power supply voltage	VPP		–0.3 to +9.5	V
Input voltage	V_{IN}		–0.3 to	V
Power dissipation	P_D		1	W
Output short-circuit current	I_{SC1}	except SPP pin, SPM pin	-12 to +11	mA
	I_{SC2}	SPP pin, SPM pin	300	mA
Storage temperature	T_{STG}	—	–55 to +150	°C

RECOMMENDED OPERATING CONDITIONS

(DGND = SPGND = 0 V)

Parameter	Symbol	Condition	Range	Unit
Power supply voltage	DV_{DD}	—	2.0 to 5.5	V
		Flash memory write	2.7 to 5.5	
Speaker power supply voltage	SPV_{DD}	—	2.0 to 5.5	V
Flash power supply voltage	V_{PP}	Flash memory write	7.7 to 8.3	V
Flash memory rewrite cycles	N	—	80	—
Operating temperature	T_{OP1}	—	–40 to +85	°C
	T_{OP2}	Flash memory write	0 to +40	

ELECTRICAL CHARACTERISTICS

DC Characteristics

DV_{DD} = SPV_{DD} = 2.0 to 5.5 V, DGND = AGND = 0 V, Ta = –40 to +85°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
"H" input voltage	V_{IH}	—	0.7×DV_{DD}	—	DV_{DD}	V
"L" input voltage	V_{IL}	—	0	—	0.3×DV_{DD}	V
"H" output voltage 1	V_{OH1}	I_{OH} = –0.5 mA	DV_{DD}–0.5	—	—	V
"L" output voltage 1	V_{OL1}	I_{OL} = 0.5 mA	—	—	0.5	V
"H" input current 1	I_{IH1}	V_{IH} = DV_{DD}	—	—	1	µA
"H" input current 2	I_{IH2}	V_{IH} = DV_{DD} TEST pin	0.02	0.3	1.5	mA
"L" input current 1	I_{IL1}	V_{IL} = DGND	–1	—	—	µA
"L" input current 2	I_{IL2}	V_{IL} = DGND RESET_N pin	–1.5	–0.3	–0.02	mA
"L" input current 3	I_{IL3}	V_{IL} = DGND CSB Pull-up input	–1.5	–0.3	–0.02	mA
"H" output current 1	I_{ooH1}	V_{OH} = DV_{DD} = SPV_{DD} (High impedance) BUSYB pin, SPP pin, SPM pin	—	—	1	µA
"H" output current 2	I_{ooH2}	V_{OH} = DV_{DD} (Nch Open drain) BUSYB pin	—	—	1	µA
"L" output current 1	I_{ooL1}	V_{OL} = DGND = SPGND (High impedance) BUSYB pin, SPP pin, SPM pin	–1	—	—	µA
"L" output current 1	I_{ooL2}	V_{OL} = DGND (Pch Open drain) BUSYB pin	–1	—	—	µA
Supply current during playback	I_{DD1}	No output load, DV_{DD} = 3.0V	—	4.0	6.0	mA
	I_{DD2}	No output load, DV_{DD} = 5.0V	—	6.0	10	
Awaiting command supply current	I_{DDC1}	DV_{DD} = SPV_{DD} = 5.0V	—	3.0	5.0	mA
Standby supply current	I_{DDS1}	Ta = –40 to +40°C	—	0.5	3.0	µA
	I_{DDS2}	Ta = –40 to +85°C	—	0.5	8.0	
Source oscillation frequency	f_{OSC}	Ta = –10 to +50°C	4.034	4.096	4.158	MHz
		Ta = –40 to +85°C	3.973	4.096	4.219	

Characteristics of Analog Circuitry

DV_{DD} = SPV_{DD} = 2.0 to 5.5 V, DGND = SPGND = 0 V, Ta = –40 to +85°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SPM, SPP output load resistance	R_{LSP}	—	8	—	—	Ω
Speaker amplifier output power	P_{SPO}	SPV_{DD} = 5.0V, f = 1kHz R_{SPO} = 8Ω, THD≥10%	—	1.0	—	W

AC Characteristics

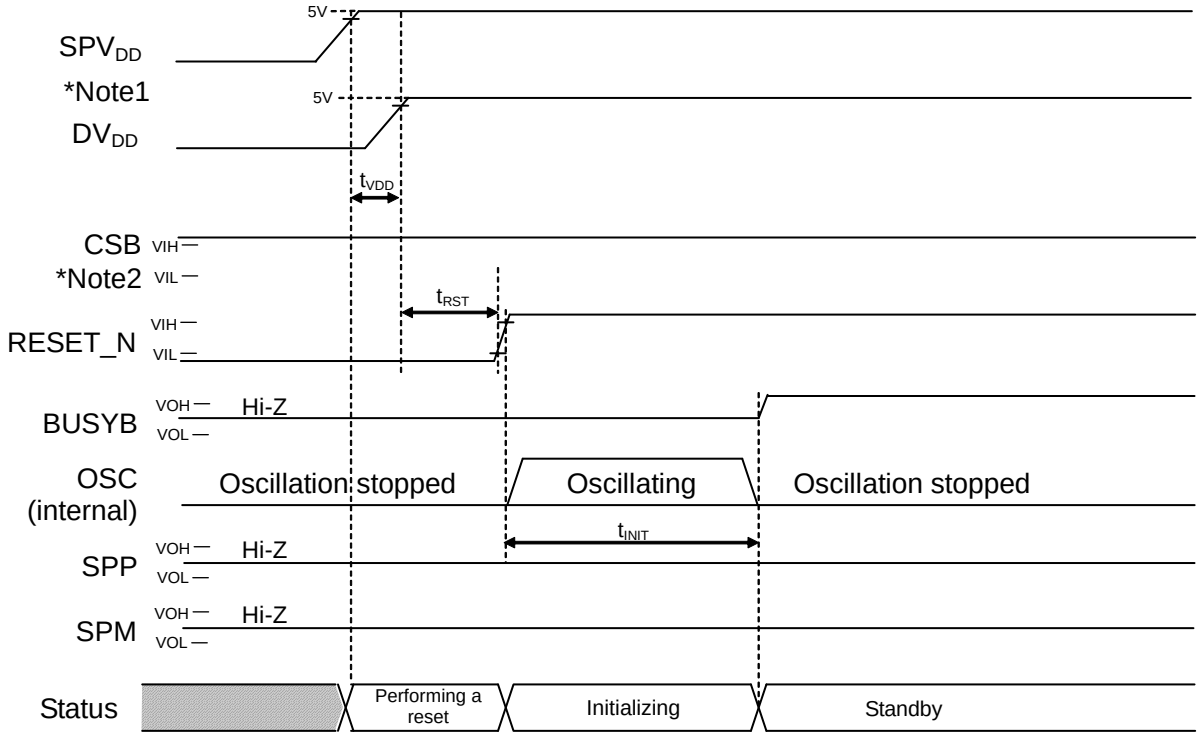
DV_{DD} = SPV_{DD} = 2.0 to 5.5 V, DGND = SPGND = 0 V, Ta = –40 to +85°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
RESET_N input pulse width	t_{RST}	—	100	—	—	µs
Start time SPV_{DD} after starting DV_{DD}	t_{VDD}	—	0	—	—	ns
Initialization time after reset release	t_{INIT}	—	—	—	20	ms
BUSYB change time from "L" to "H",after RESET_N fall edge	t_{BSYR}	—	—	—	500	ns
SCL clock frequence	t_{SCL}	I2C Fast mode	0	—	400	kHz
Hold time (repeated) START condition After this period, the first clock pulse is generated.	$t_{HD;STA}$	I2C Fast mode	0.6	—	—	µs
SCL “L” level pulse width	t_{LOW}	I2C Fast mode	1.3	—	—	µs
SCL “H” level pulse width	t_{HIGH}	I2C Fast mode	0.6	—	—	µs
Setup time for repeated START condition	$t_{SU;STA}$	I2C Fast mode	0.6	—	—	µs
Data hold time: For I2C bus devices	$t_{HD;DAT}$	I2C Fast mode	0	—	0.9	µs
Data setup time	$t_{SU;DAT}$	I2C Fast mode	100	—	—	ns
SDA and SCL signal rise time	t_r	I2C Fast mode	20	—	300	ns
SDA and SCL signal fall time	t_f	I2C Fast mode	20	—	300	ns
STOP condition setup time	$t_{SU;STO}$	I2C Fast mode	0.6	—	—	µs
Bus free time between STOP condition and START condition	t_{BUF}	I2C Fast mode	1.3	—	—	µs
Capacitive load for each bus line	C_b	I2C Fast mode	—	—	400	pF
Noise margin at a “L” level in each device connected (including hysteresis)	V_{nL}	I2C Fast mode	0.1× DV_{DD}	—	—	V
Noise margin at a “H” level in each device connected (including hysteresis)	V_{nH}	I2C Fast mode	0.1× DV_{DD}	—	—	V
Pulse width of spikes which must be suppressed by the input filter	t_{sp}	I2C Fast mode	0	—	50	ns
SDA reception possible time, after an oscillation start	t_{PUP1}	—	2	—	—	ms
Playback time	t_{VCYC}	—	20	—	—	ms
BUSYB change time from "H" to "L", after a command is inputted	t_{CB}	—	—	—	300	µs
CSB “H” level pulse width	t_{CSW}	CSB use mode	50	—	—	ns
Oscillation stop time, after playback	t_{OSST}	—	—	—	500	µs
Next command transmit time In the case of the playback	t_{NCM}	—	—	—	10	ms
Next command transmit time after shifting to a standby state	t_{CMS}	CSB use mode	50	—	—	ns
Disconnection judging time by the DISCONNECT command	t_{DCD}	—	100	—	—	ms
BUSYB change time from "L" to "H",after Over-current detection of a speaker amplifier	t_{SD}	—	—	—	80	µs
Processing time before playback start	t_{PLBF}	—	0.3	—	2.1	ms
Processing time after playback start	t_{PLAF}	—	0.15	—	1.2	ms
Fade-out time at Change Immediately mode or Change Immediately Once mode	t_{FDO}	—	—	22	—	ms

Note: Output pin load capacitance = 45 pF

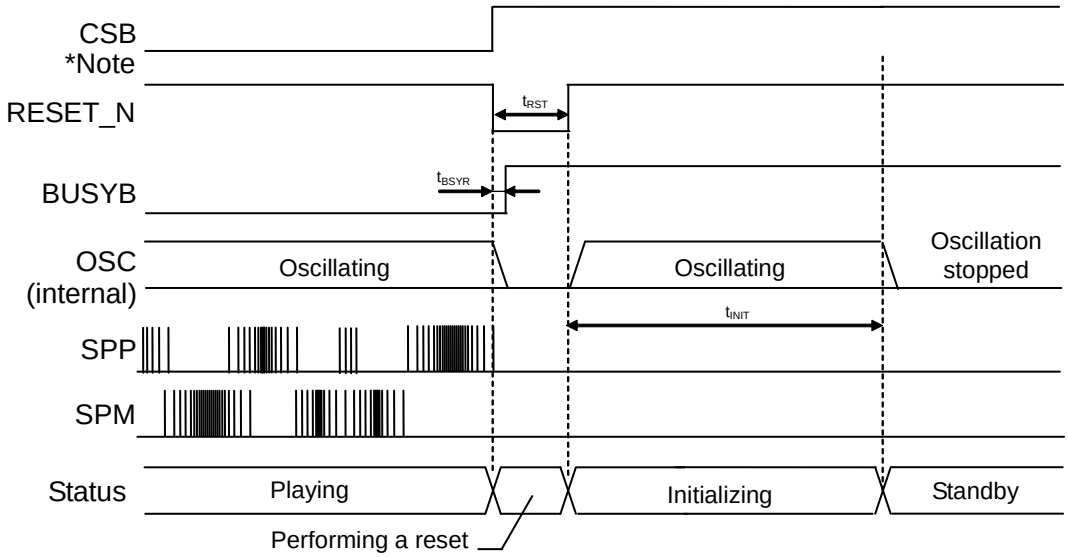
TIMING DIAGRAMS

Power-On Timing



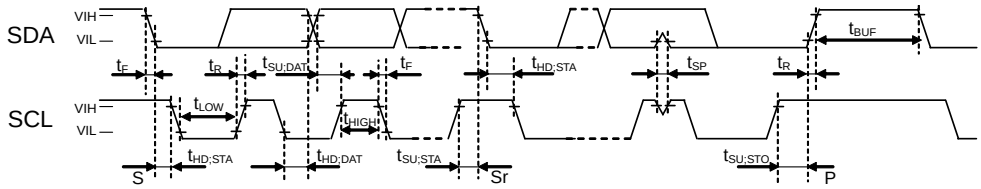
Note 1: Turn on DV_{DD} and SPV_{DD} simultaneously, or turn on SPV_{DD} after turning on DV_{DD}.
Note 2: When CSB use mode is not set, this pin should be fixed to “H” level or “L” level.

Power-Down Timing (At the RESET_N Input)



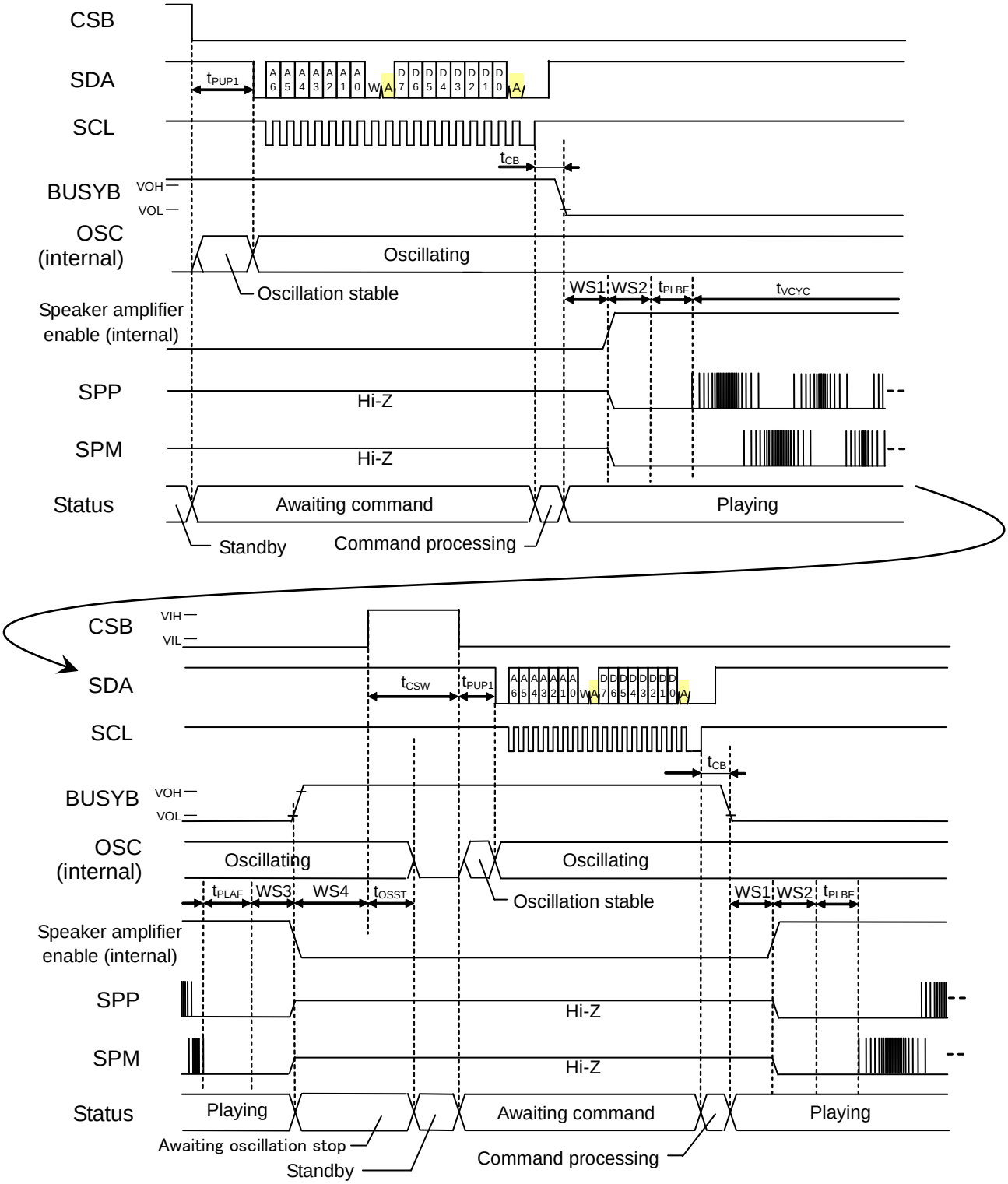
Note: When CSB use mode is not set, this pin should be fixed to “H” level or “L” level.

I2C Command Interface Timing



CSB use mode

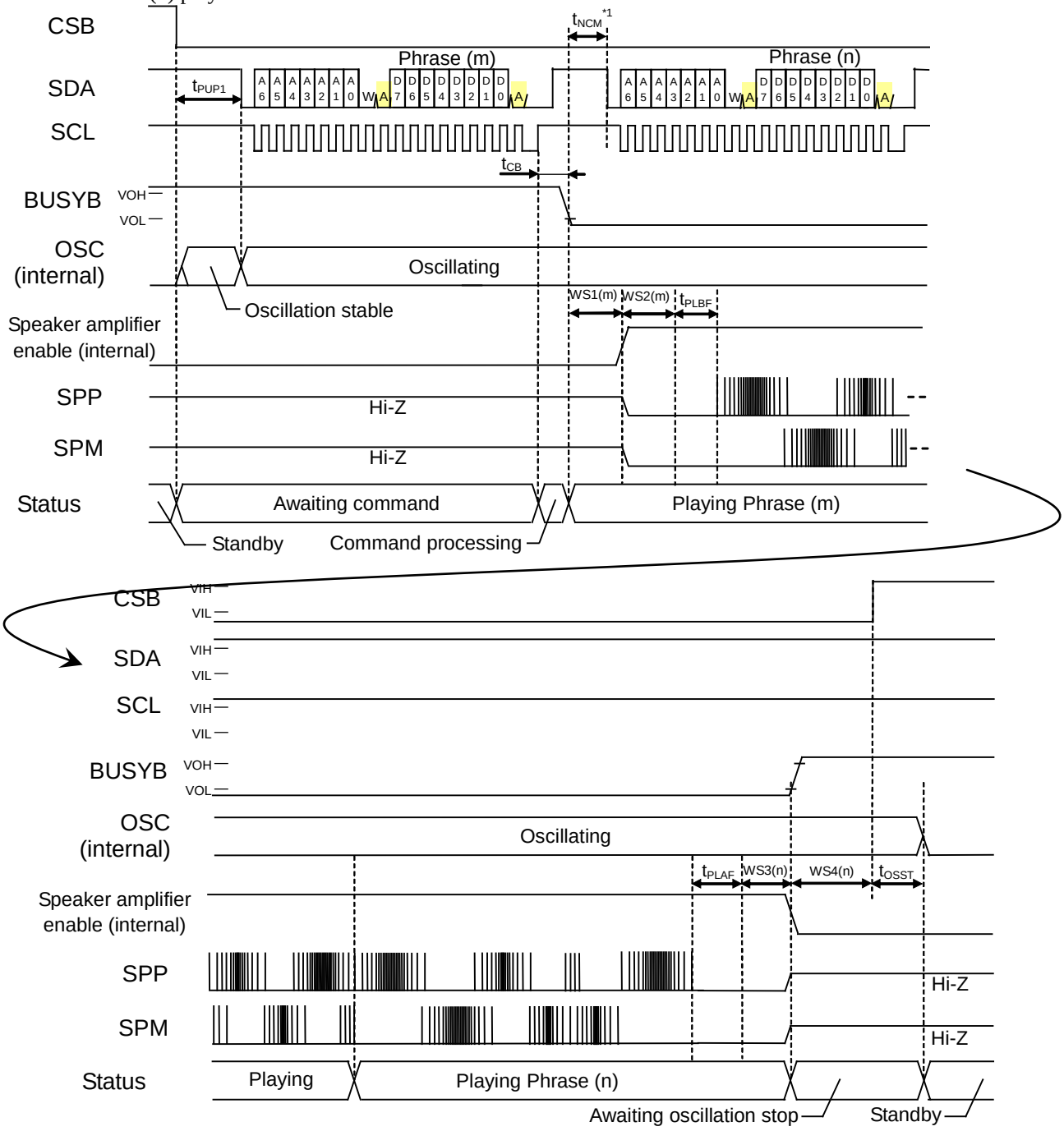
Play Once mode Timing



- The wait time of WS1, WS2, WS3, and WS4 can be set up for every phrase, when creating sound data using Speech Utility.
- About this function, refer to “3. PHRASEn command” in “Description of Command Functions”

Scheduled Play Once mode and Scheduled Play mode Timing (Continuous Play)

After inputting the next PHRASEn command(Phrase(n)), a phrase(Phrase(m)) is played back to the last and thePhrase(n) playback is started.

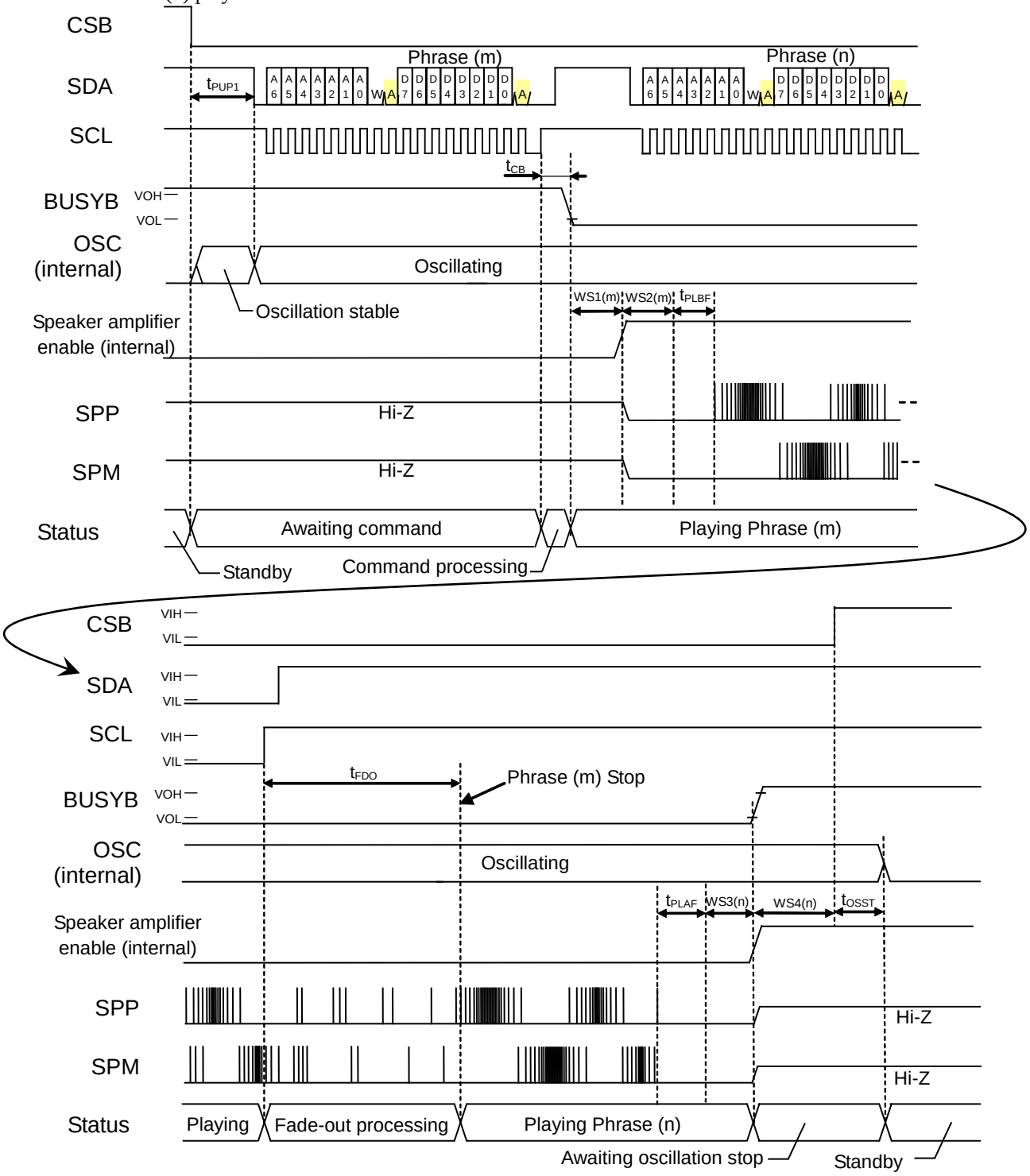


- The wait time of WS1, WS2, WS3, and WS4 can be set up for every phrase, when creating sound data using Speech Utility.
- The playback of Scheduled play mode is suspended with the STOP command. Confirm the completion (BUSYB= "H") of the playback after input of a STOP command. Next, input the next command (PHRASEn command).
- About this function, refer to “3. PHRASEn command” in “Description of Command Functions”

*1: It is applied to the Scheduled Play Once mode. Start the next PHRASEn command within the tNCM. When it can't start, confirm the completion (BUSYB= "H") of the playback. Next, input the next command (PHRASEn command).

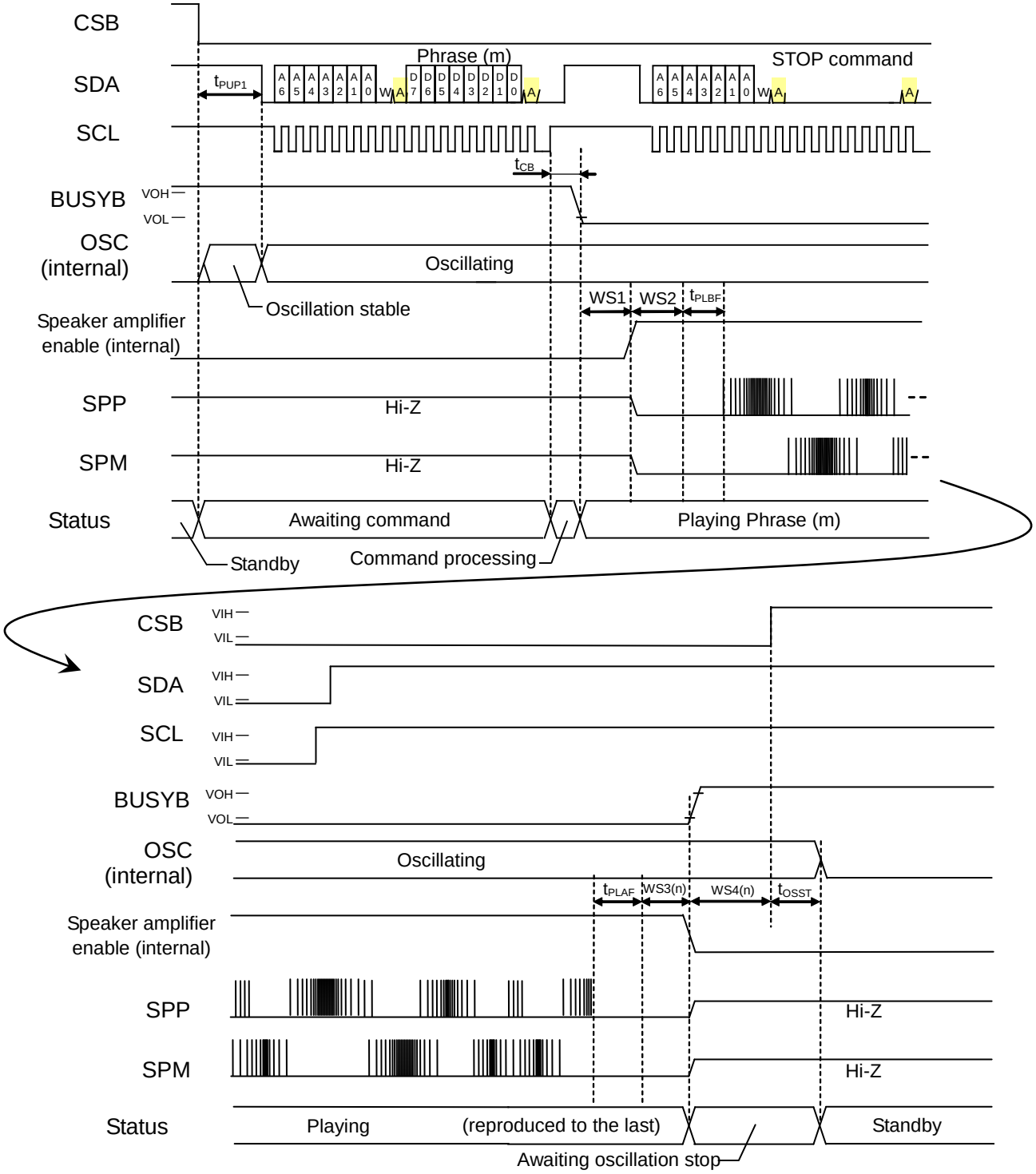
Change Immediately Once mode and Change Immediately mode Timing (Continuous Play)

After inputting the next PHRASEn command(Phrase(n)), fade-out of the playback(Phrase(m)) is carried out and thePhrase(n) playback is started.



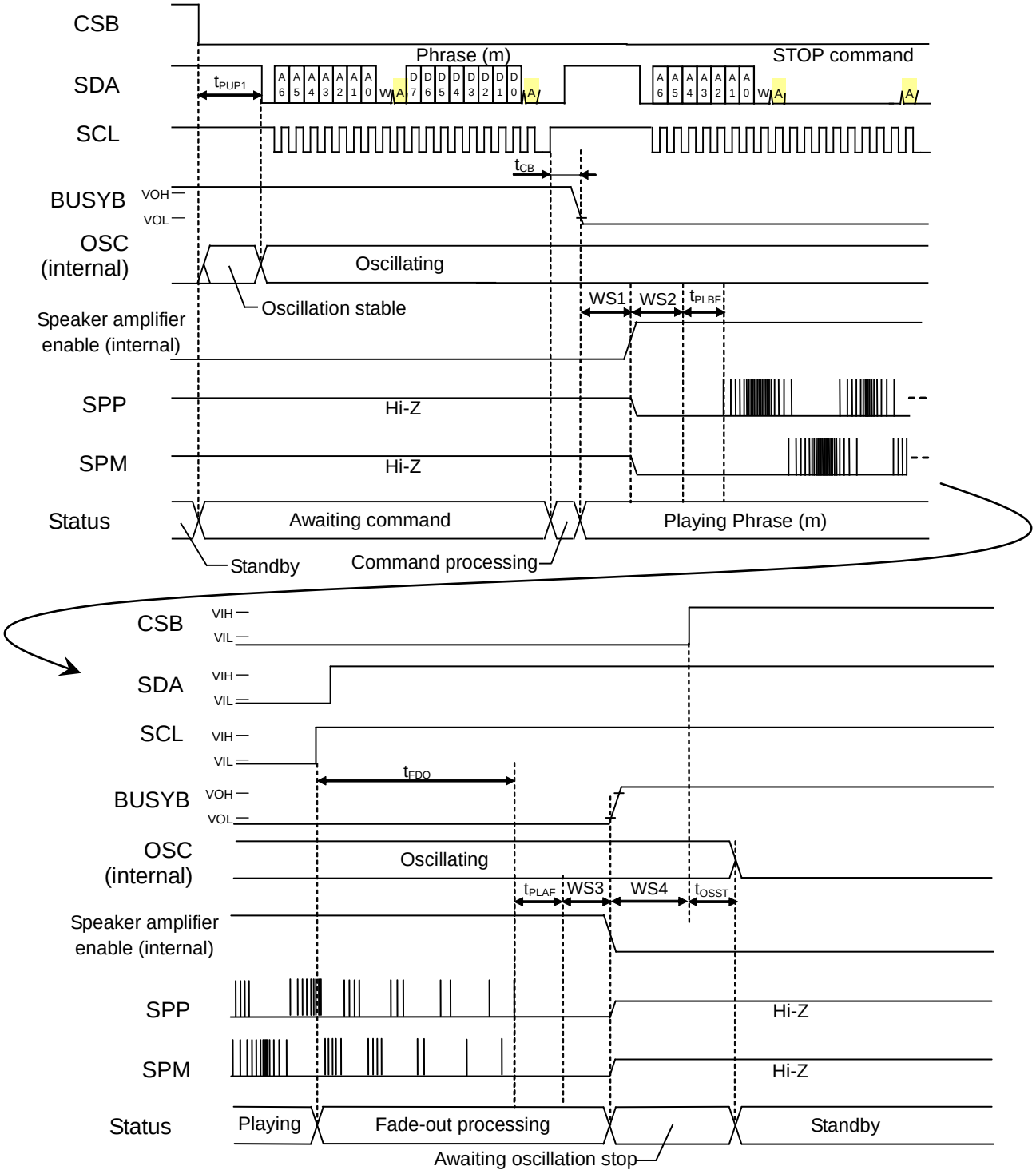
- The wait time of WS1, WS2, WS3, and WS4 can be set up for every phrase, when creating sound data using Speech Utility.
- The playback of Change Immediately mode is suspended with the STOP command.
- About this function, refer to “3. PHRASEn command” in “Description of Command Functions”

Timing which stops the playback in Scheduled Play Once mode and Scheduled Play mode
After inputting the STOP command, a phrase is played back to the last and the playback is stopped.



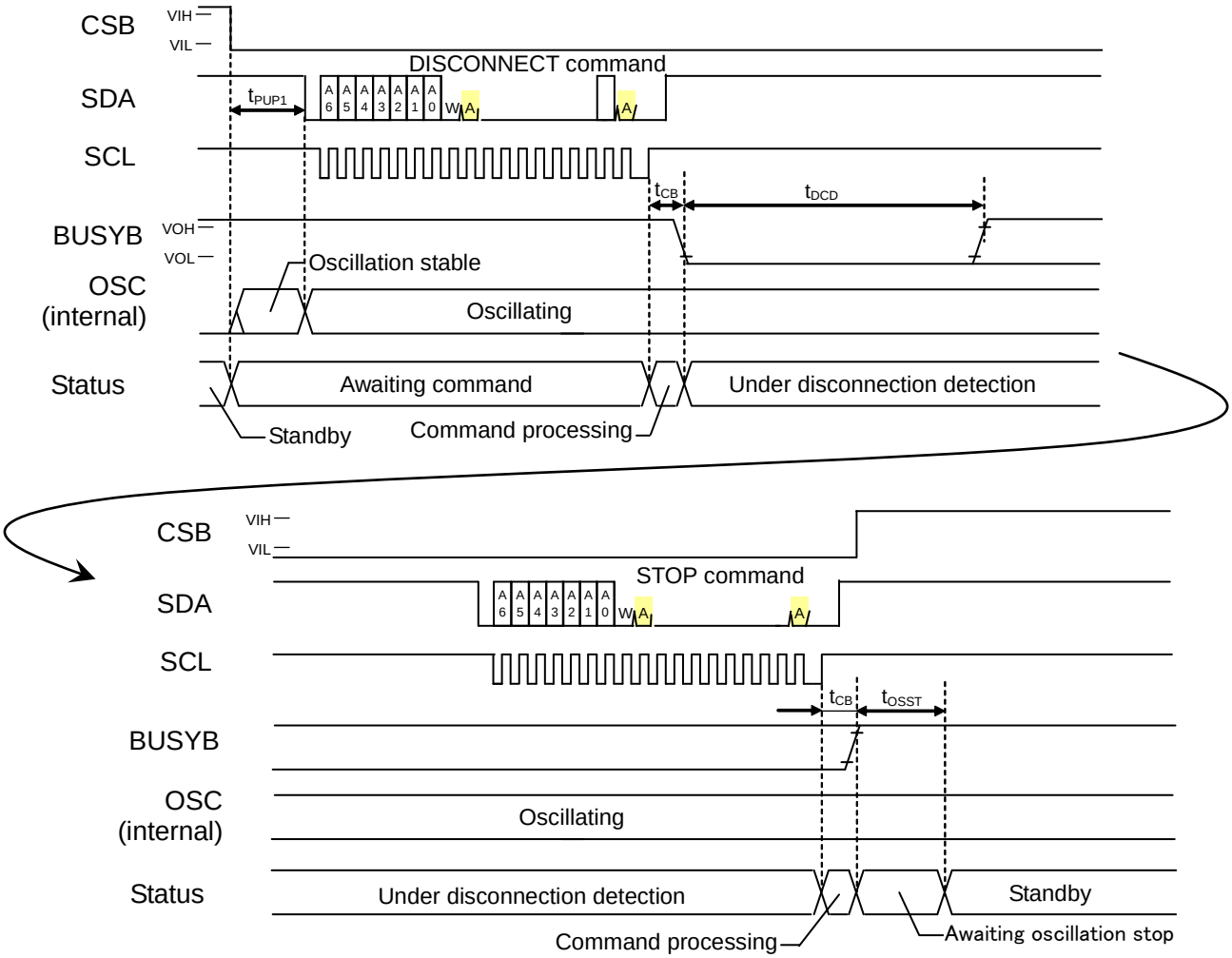
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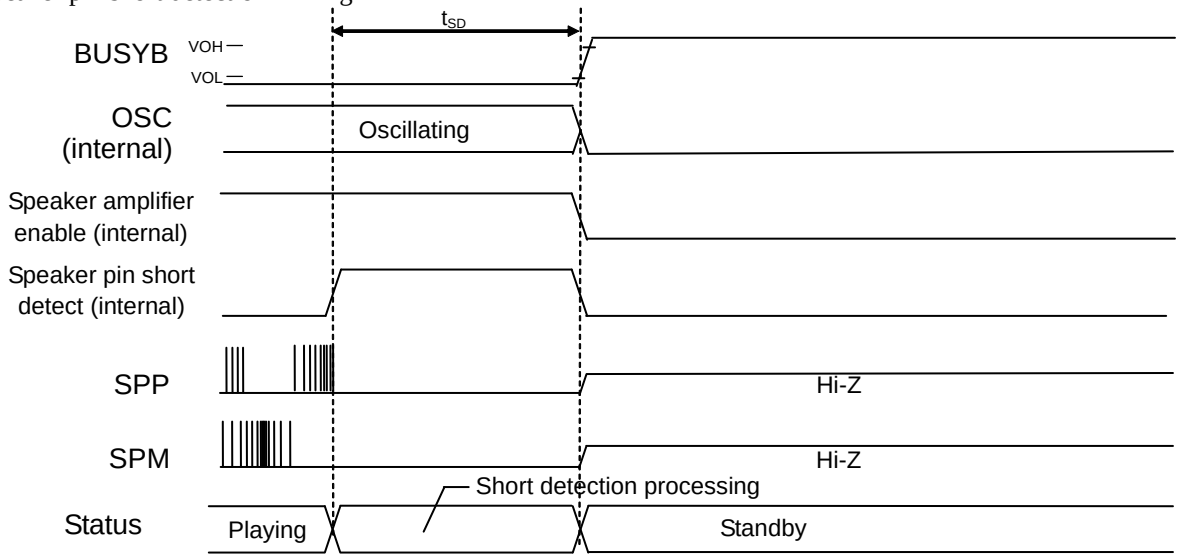


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Disconnection detection Timing

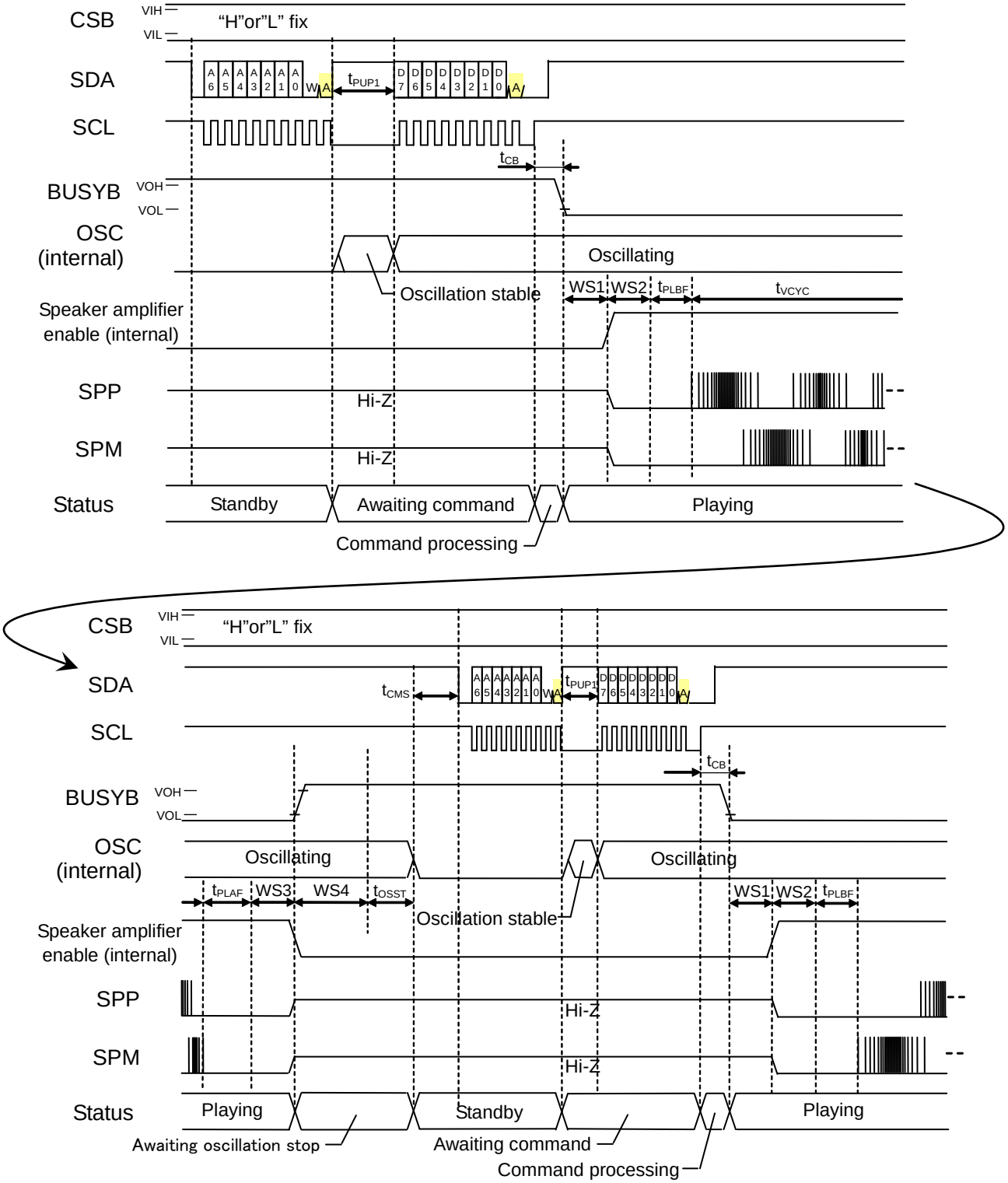


Speaker pin short detection Timing



CSB unuse mode

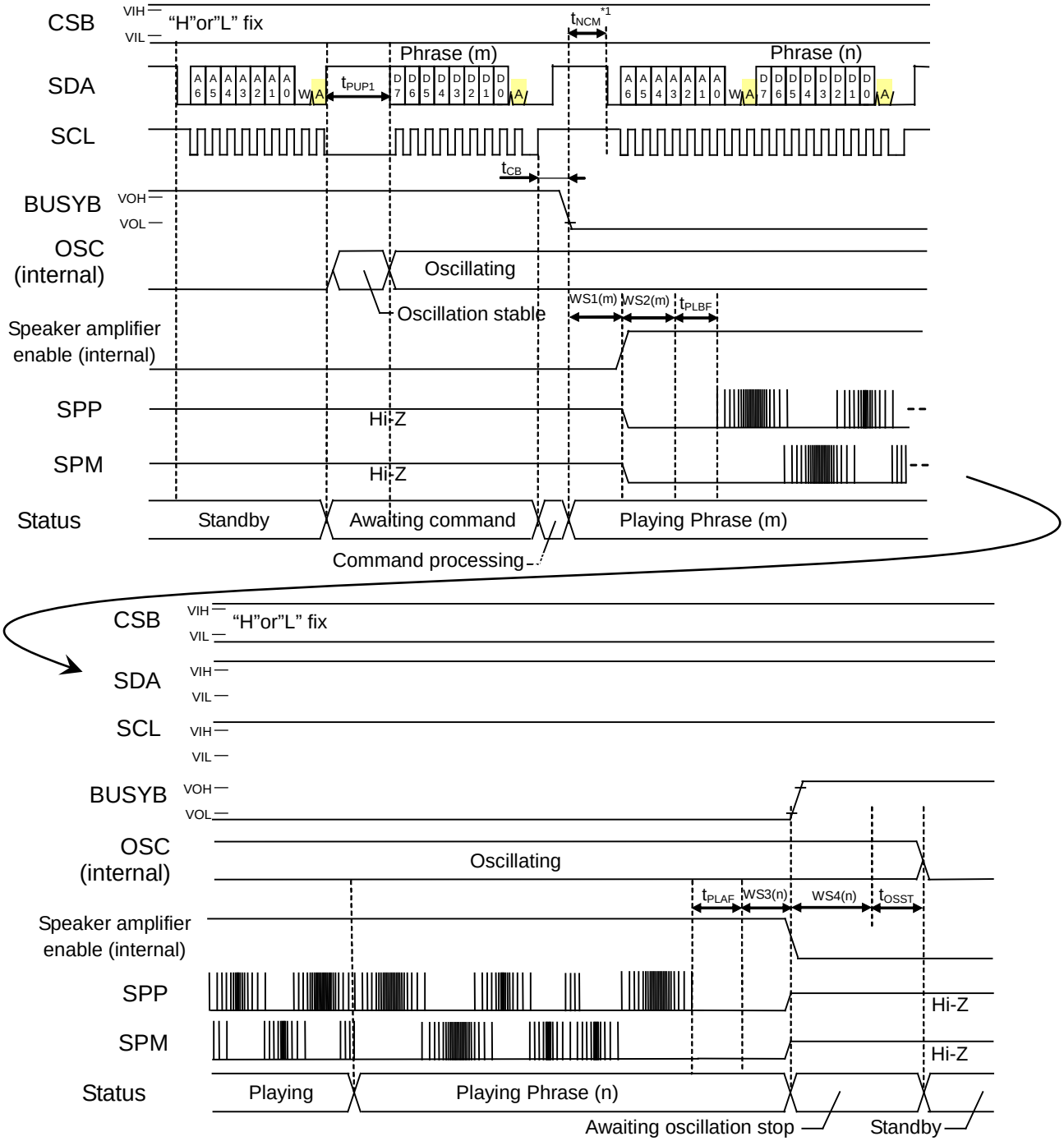
Play Once mode Timing



- The wait time of WS1, WS2, WS3, and WS4 can be set up for every phrase, when creating sound data using Speech Utility.
- About this function, refer to "3. PHRASEn command" in "Description of Command Functions"

Scheduled play once mode and Scheduled play Timing (Continuous Play)

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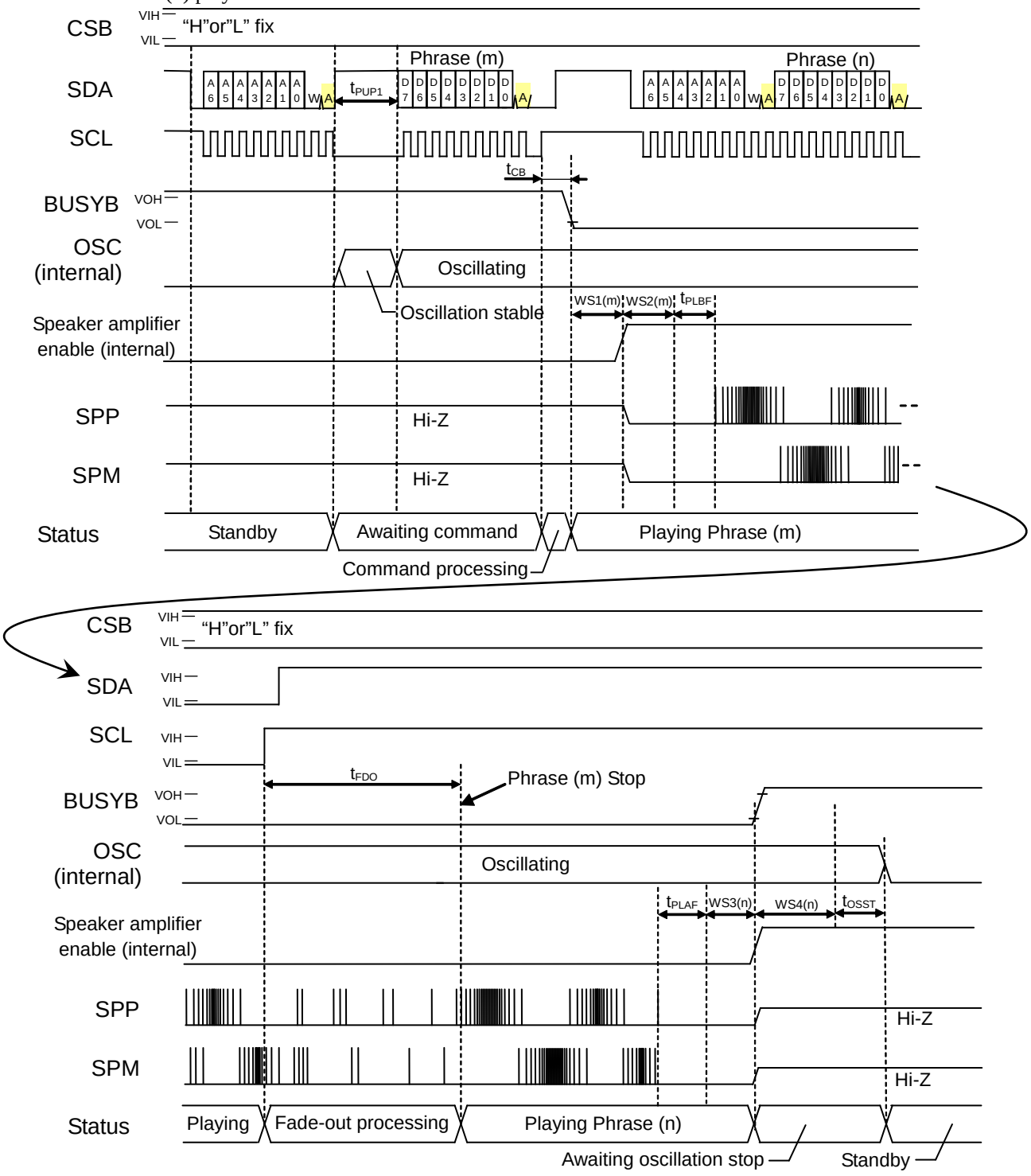


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- The playback of Scheduled play mode is suspended with the STOP command. Confirm the completion (BUSYB= "H") of the playback after input of a STOP command. Next, input the next command (PHRASEn command).
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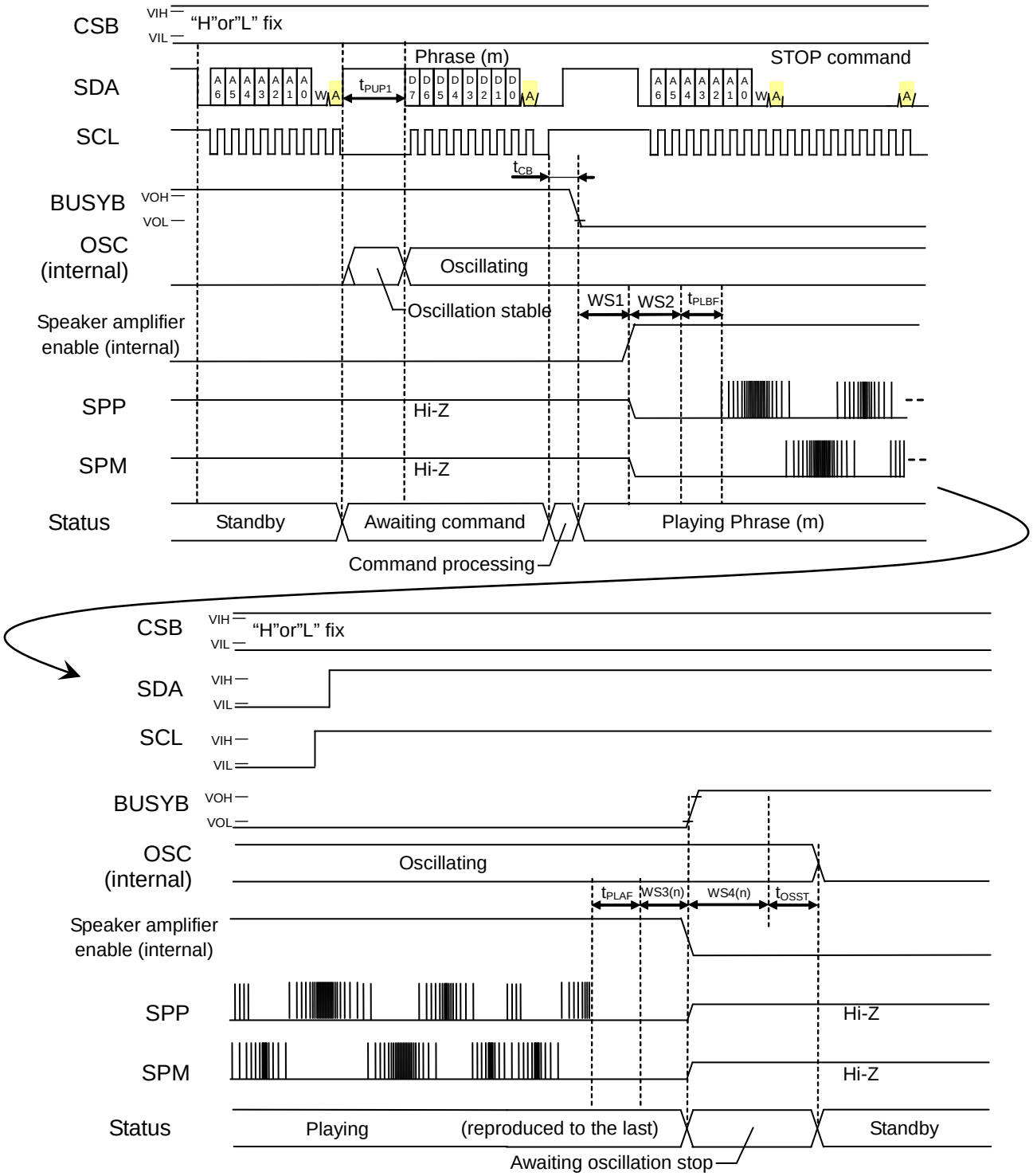
Change Immediately Once mode and Change Immediately Timing (Continuous Play)

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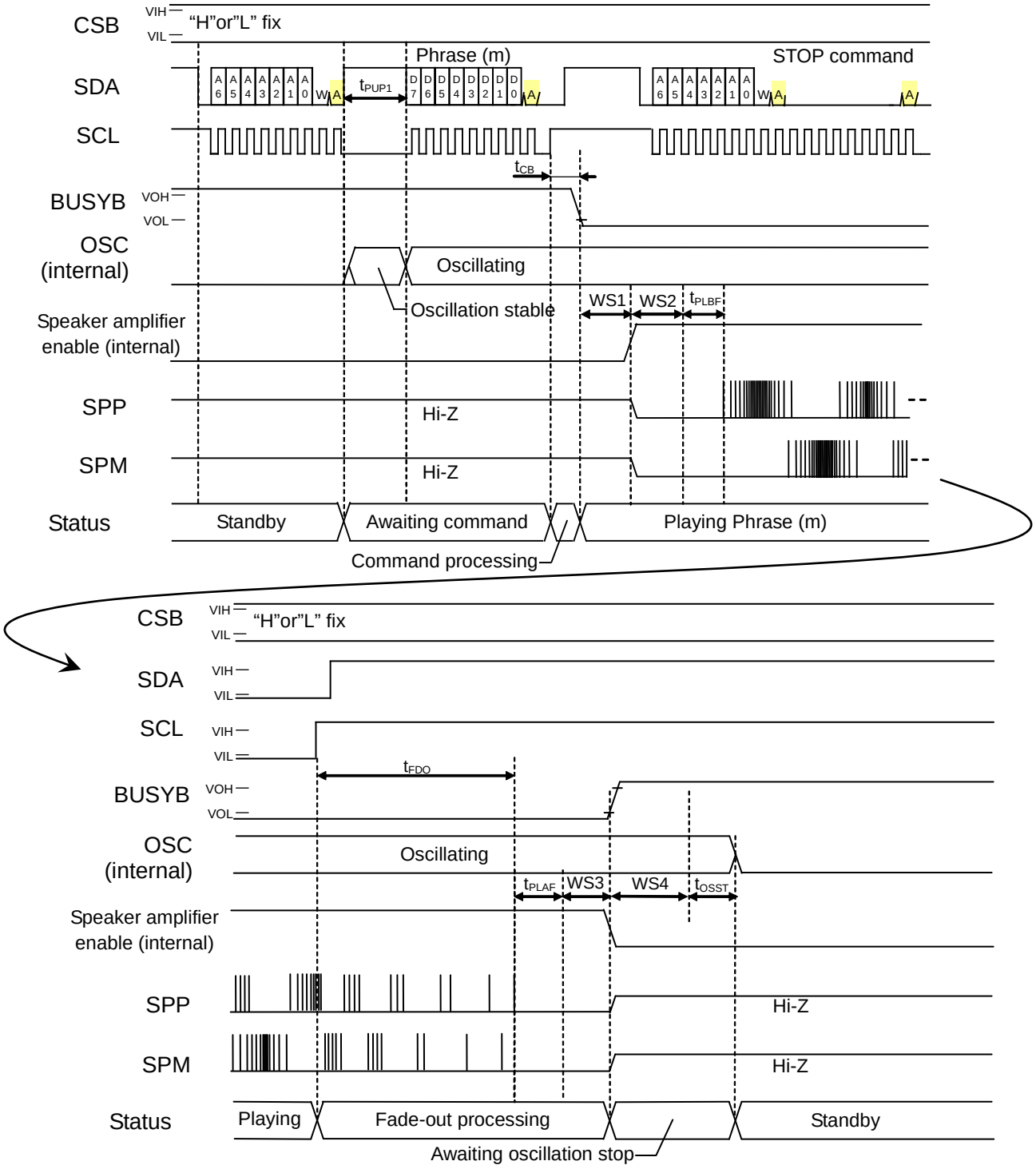
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- The playback of Change Immediately mode is suspended with the STOP command.
- About this function, refer to "3. PHRASEn command" in "Description of Command Functions"

Timing which stops the playback in Scheduled Play Once mode and Scheduled Play mode
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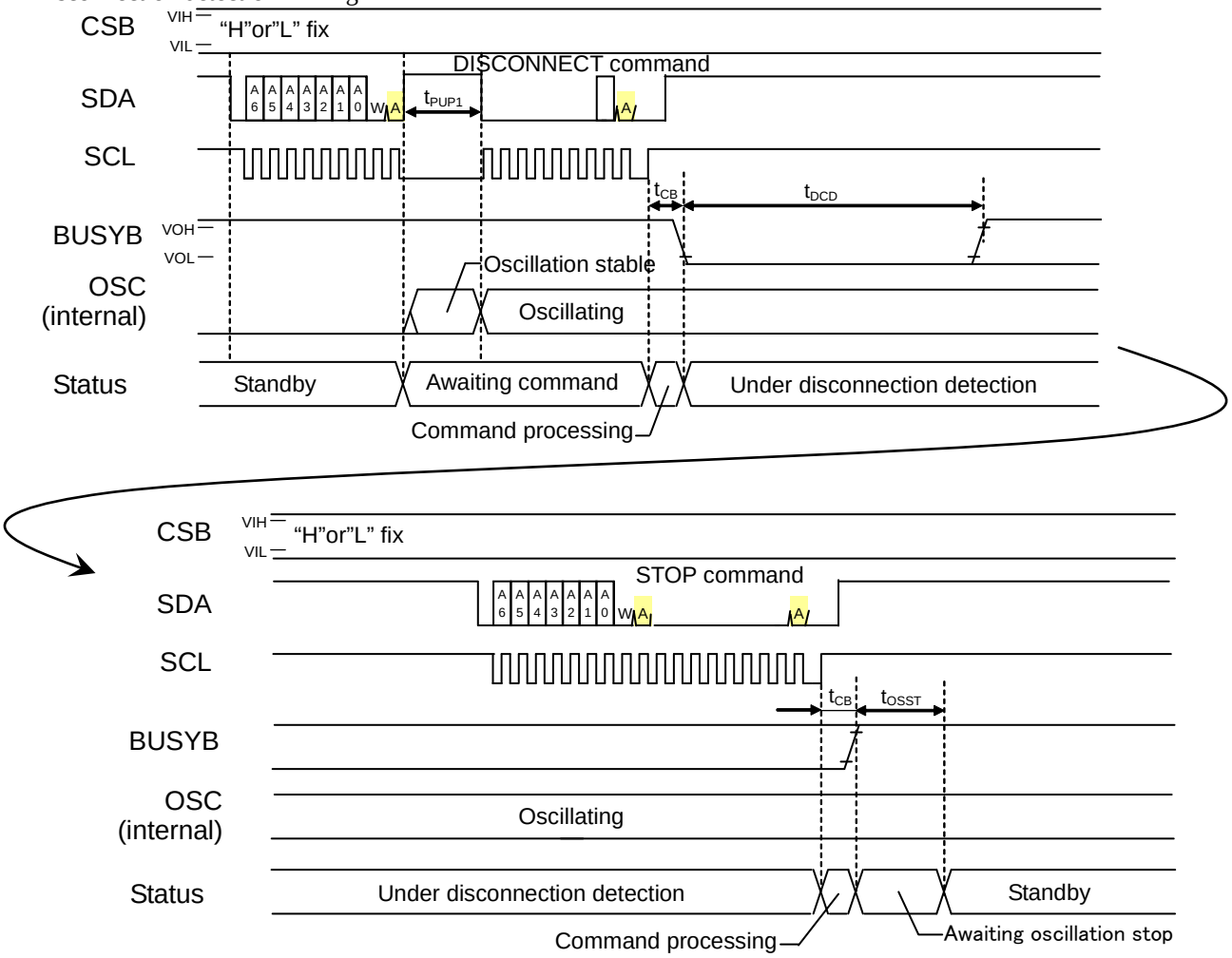
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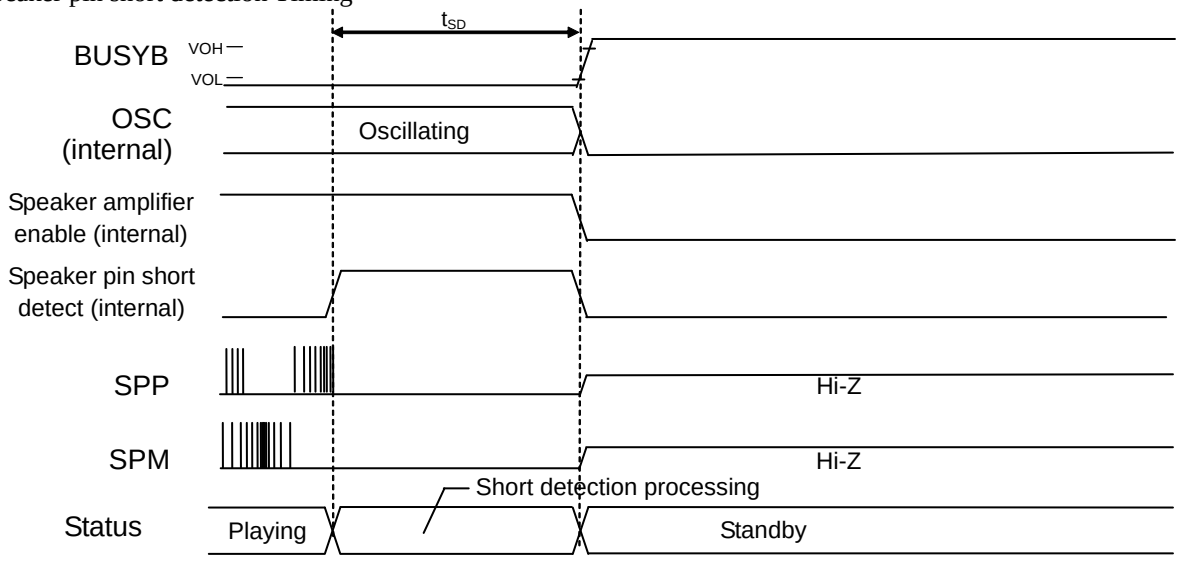


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Disconnection detection Timing



Speaker pin short detection Timing



FUNCTIONAL DESCRIPTION

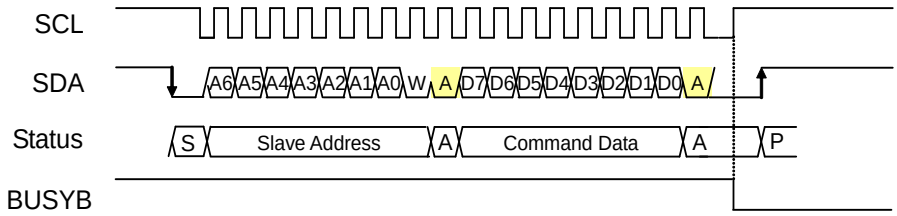
I2C Command Interface

The I2C Interface built-in is a serial interface (: slave side) that is compliant with I2C bus specification. It supports Fast mode and enables data reception at 400 kbps. The SCL and SDA pins are used to input the command data.
Pull-up resister should be connected to SCL pin and SDA pin.
For the master on the I2C bus to communicate with this device (: slave), input the slave address with the first seven bits after setting the start condition. The slave address can be set using the Speech Utility. The eighth bit of slave address is used to set the direction (: write or read) of communication. If the eighth bit is "0" level, it is write mode from master to slave. And, if the eighth bit is "1" level, it is read mode from master.
The communication is made in the unit of byte. And acknowledge is needed for each byte.

The protocol of I2C communication is shown below.

– Command flow at data write
  START condition
  Slave address +W (0)
  Write address
  STOP condition

- Data write timing



The slave address can perform a 7-bit setup on the option screen of Speech Utility shown in figure.1.

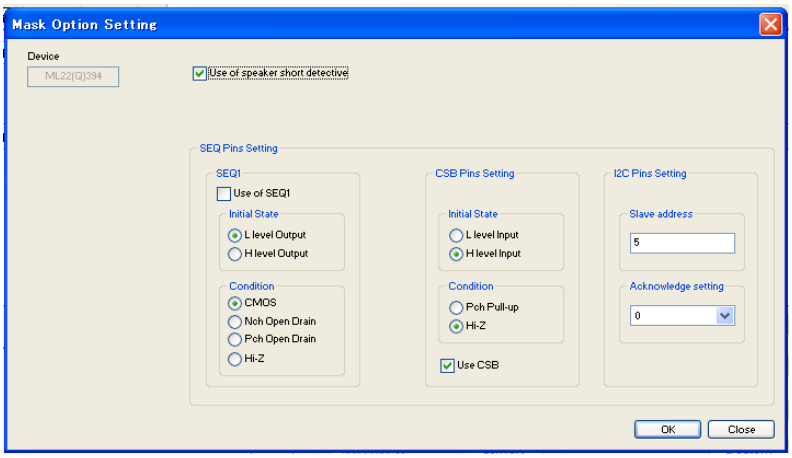


Figure .1 The option screen of Speech Utility

Setup by Speech Utility						
A6	A5	A4	A3	A2	A1	A0
0	0	0	0	0	0	0
0	0	0	0	0	0	1
0	0	0	0	0	1	0
0	0	0	0	0	1	1
0	0	0	0	1	0	0
			・			
			・			
			・			
1	1	1	1	1	1	0
1	1	1	1	1	1	1

For example, when it sets to "5" on the option screen of Fig. 1, a slave address is set to "0000101".

Command List

Each command is configured by the unit of byte (8-bit).

Command	D7	D6	D5	D4	D3	D2	D1	D0	Description
STOP	0	0	0	0	0	0	0	0	Stop command. The STOP command becomes effective except the phrase in Play Once mode and Scheduled Play Once mode.
DISCONNECT	0	0	0	0	0	0	0	1	Disconnection detection command. Please input the STOP command, after you use the DISCONNECT command.
PHRASE2	V2	V1	V0	0	0	0	1	0	Phrase command
PHRASE3	V2	V1	V0	0	0	0	1	1	
PHRASE31	V2	V1	V0	1	1	1	1	1	

Voice Synthesis Algorithm

Four types of voice synthesis algorithm are supported. They are 4-bit ADPCM2, 8-bit non-linear PCM, 8-bit straight PCM and 16-bit straight PCM. Select the best one according to the characteristics of voice.

The following table shows key features of each algorithm.

Voice synthesis algorithm	Applied waveform	Feature
4-bit ADPCM2	Normal voice waveform	Up version of LAPIS Semiconductor's specific voice synthesis algorithm (: 4-bit ADPCM). Voice quality is improved.
8-bit Nonlinear PCM	Waveform including high frequency signals (sound effect, etc.)	Algorithm, which plays back mid-range of waveform as 10-bit equivalent voice quality.
8-bit straight PCM		Normal 8-bit PCM algorithm
16-bit straight PCM		Normal 16-bit PCM algorithm

Memory Allocation and Creating Voice Data

The ROM is partitioned into four data areas: voice (i.e., phrase) control area, test area, voice area, and edit ROM area.
The voice control area manages the voice data in the ROM. It contains data for controlling the start/stop addresses of voice data for 1,024 phrases, use/non-use of the edit ROM function and so on.
The test area contains data for testing.
The voice area contains actual waveform data.
The edit ROM area contains data for effective use of voice data. For the details, refer to the section of "Edit ROM Function."
The edit ROM area is not available if the edit ROM is not used.

The ROM data is created using a dedicated tool.

Configuration of ROM data

0x00000 0x01FFF	Prohibition of use area (Fixed 64 Kbits)
0x02000 max.0x0FBFF	Voice area 2
0x0FFFF max.0x0FBFF	Edit ROM area Depends on creation of ROM data.
0x0FC00 0x0FFFF	Test area
0x10000 0x101FF	Voice control area (Fixed 4 Kbits)
0x10200 0x17FFF	Voice area 1

Playback Time and Memory Capacity

The playback time depends on the memory capacity, sampling frequency, and the playback method.
The equation to know the playback time is shown below. But this is not applied if the edit ROM function is used.

$$\text{Playback time [sec]} = \frac{1.024 \times (\text{Voice area 1} + \text{Voice area 2}) \text{ [Kbits]}}{\text{Sampling frequency [kHz]} \times \text{Bit length}}$$

(Bit length is 4 at the 4-bit ADPCM2 and 8/16 at the PCM.)

Example) In the case that the sampling frequency is 8 kHz, algorithm is 4-bit ADPCM2, the playback time is approx. 22.1 seconds, as shown below.

$$\text{Playback time} = \frac{1.024 \times 692 \text{ [Kbits]}}{8 \text{ [kHz]} \times 4 \text{ [bits]}} \cong 22.1 \text{ [sec]}$$

Make the playback time of one phrase more than 20msec.

Edit ROM Function

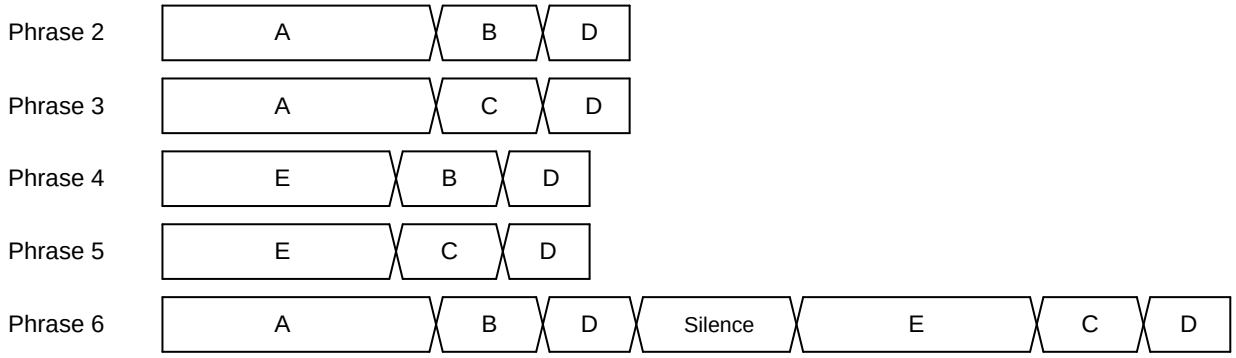
The edit ROM function makes it possible to play back multiple phrases in succession. The following functions are set using the edit ROM function:

- Continuous playback: There is no limit to set the number of times of the continuous playback. It depends on the memory capacity only.
- Silence insertion function: 20ms to 1,024 ms

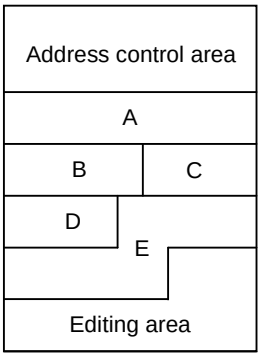
  Note: Silent insertion time varies for ±1ms by the sampling frequency

It is possible to use voice ROM effectively to use the edit ROM function.
Below is an example of the ROM structure, case of using the edit ROM function.

Example 1) Phrases using the Edit ROM Function



Example 2) Structure of the ROM that contents of Example 1 are stored

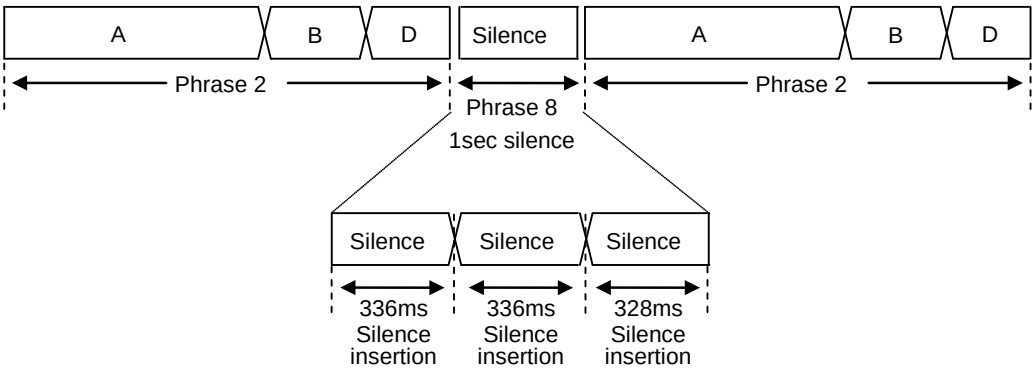


Notice of silence insertion function

If it is only silence phrase registered, please put in order three or more silence phrase.
The phrase which is constituted from one or two of silence phrase does not playback.

Example 3) Phrase composition in the case of using silence insertion function

The phrase to playback (The phrase 2 is playbacked twice on both sides of 1 sec silence.)



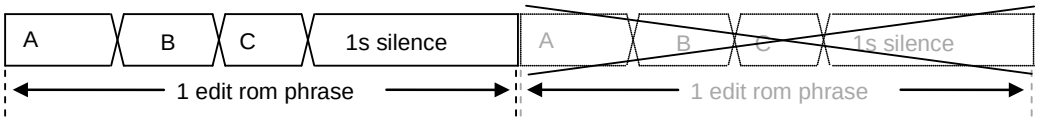
1 sec which is constituted by the three silences is registered as the phrase 8.

Notice of the silence insertion function, which a "Mute Time" was used for.

When "Mute Time" is used at the end of phrase , the continuous playback of that phrase isn't done.
Modify it to the sound which "Mute Time" was used for and the silence voice data in the case of the continuous playback mode.

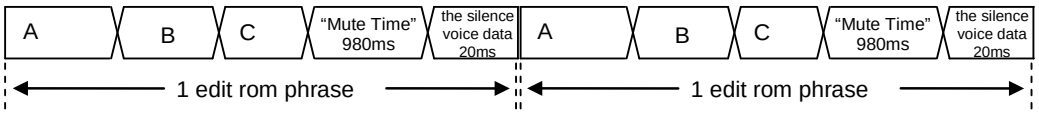
Example 4) Phrase coposition in the case of countinuous playback using silence insertion function

The case of continuous playback using Scheduled play mode.



When "Mute Time"(1s silence) is used at the end of phrase, the continuous playback of that phrase isn't done.

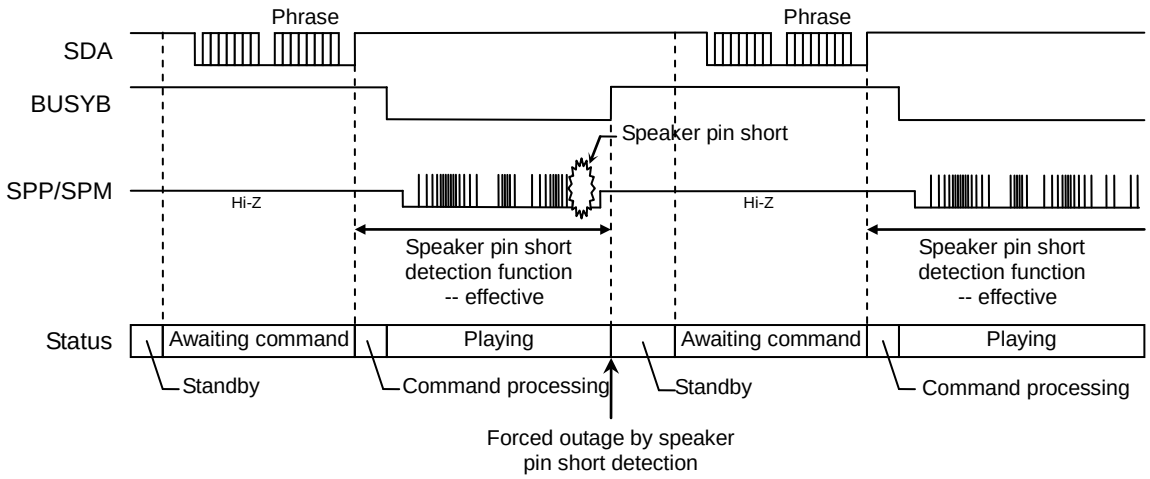
Change "Mute Time"(1s silence) to the combination of " "Mute Time"(980ms silence) and the silence voice data*1 of 20ms".



*1 : The data that sound-less was made by the voice data are the silence voice data.
In the case of 20ms, it can be realized with 128Byte by choosing sampling frequency 6.4kHz, the 8bit PCM mode.

Speaker Pin Short Detection Function

The speaker pin short detection function detect the short-circuit between SPP pin and SPM pin, or between SPP/SPM pin and GND during playback. When short-circuit of a speaker pin is detected, the playback will be stopped automatically, BUSYB pin will become "H" level, and LSI will become in a standby state.
In addition, this function can be set up with the option screen of Speech Utilty.
Please refer to a "Mask Option Setting setting item" for the option screen of Speech Utilty.



Description of Command Functions

1. STOP command

・command

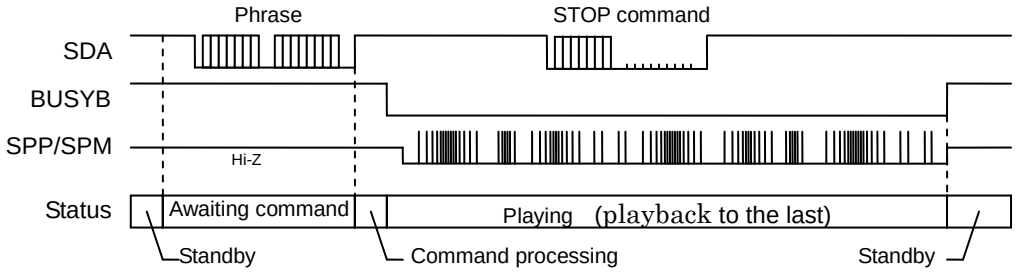
0	0	0	0	0	0	0	0

The STOP command is used to stop the playback. BUSYB pin will become "H", if the playback is stopped.
The STOP command becomes effective except the phrase in Play Once mode and Scheduled Play Once mode.
When you use Play Once mode or Scheduled Play Once mode, the STOP command is ignored.

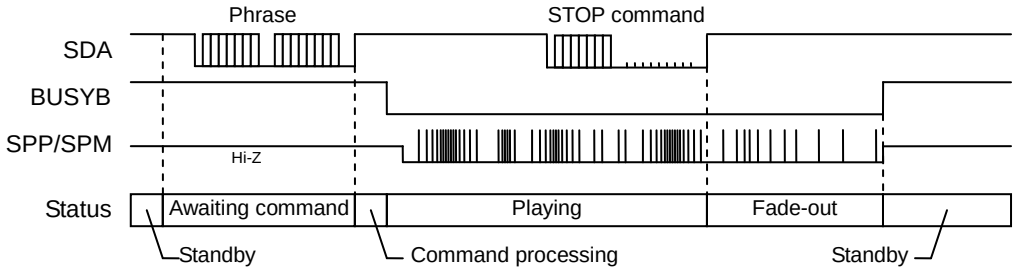
When you use Scheduled Play mode, a phrase is played back to the last and the playback is stopped, after the STOP command is inputted. Furthermore, when you use Change Immediately Once mode or Change Immediately mode, fade-out of the playback is carried out and the playback is stopped, after the STOP command is inputted.

Confirm the completion (BUSYB= "H") of the playback after input of a STOP command. Next, input the next command (PHRASEn command).

・STOP command operation in the case of Scheduled Play mode



・STOP command operation in the case of Change Immediately Once mode or Change Immediately mode

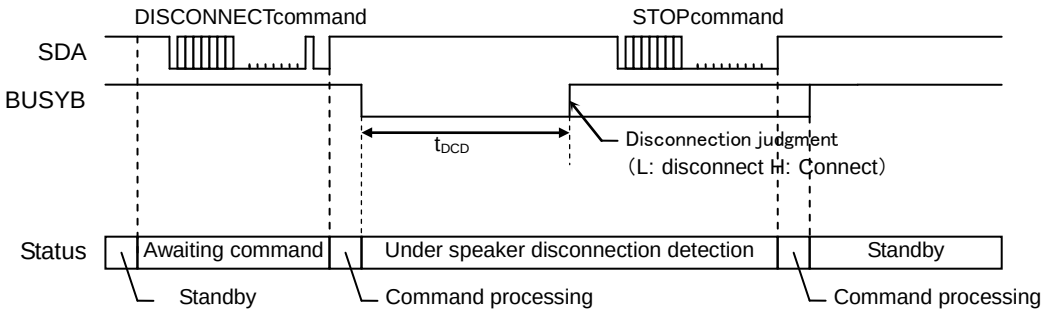


2. DISCONNECT command

・command

0	0	0	0	0	0	0	1

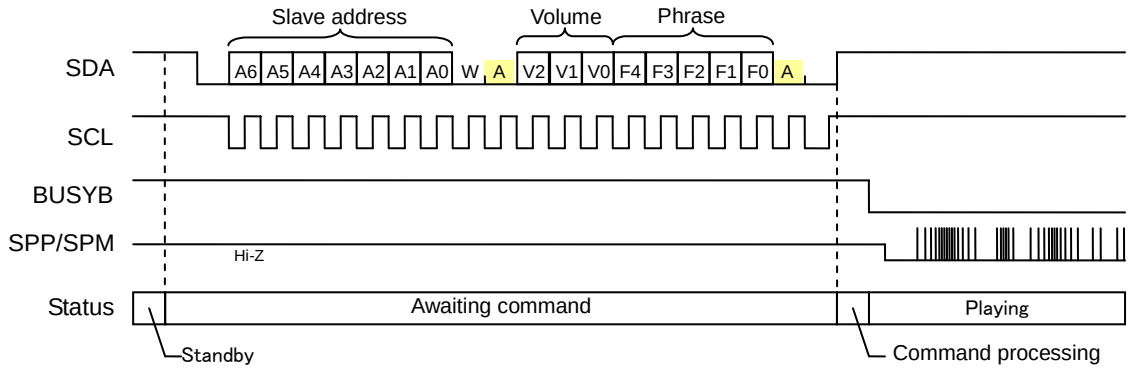
The DISCONNECT command is used to diagnose whether the speaker is disconnected or not. When the speaker is disconnected, BUSYB pin outputs "L". Please input the STOP command, after you use the DISCONNECT command.



3. PHRASEn (n = 2 to 31) command

・command	V2	V1	V0	F4	F3	F2	F1	F0

The PHRASEn (n = 2 to 31) command is used to start playback phrase. When you create the voice data, please set up the phrase address using Speech Utility.
The timing in the case of the playback a phrase address below is shown.



The PHRASEn(n=2 to 31) command can perform a volume setup.
When V2-V0 is “000”, the volume setup of voice cntrol area is used.

V2	V1	V0	Volume [dB]
0	0	0	The volume setup of voice control area is used.
0	0	1	+2.98
0	1	0	+1.78
0	1	1	0
1	0	0	-2.25
1	0	1	-5.28
1	1	0	-9.99
1	1	1	-21.04

Each phrase can set up the wait time before and after playback, a volume setup, and playback mode using Speech Utility.

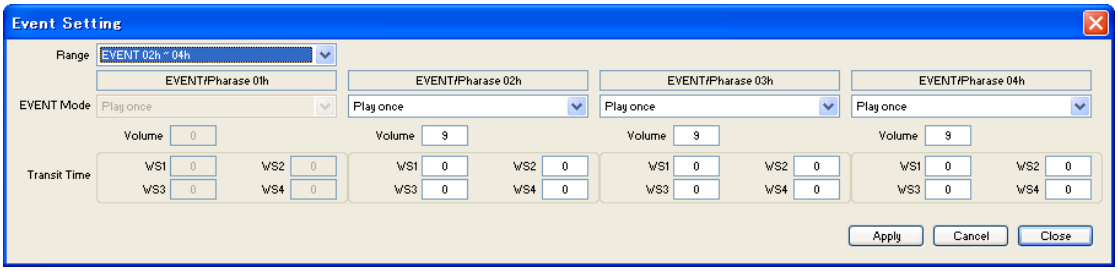
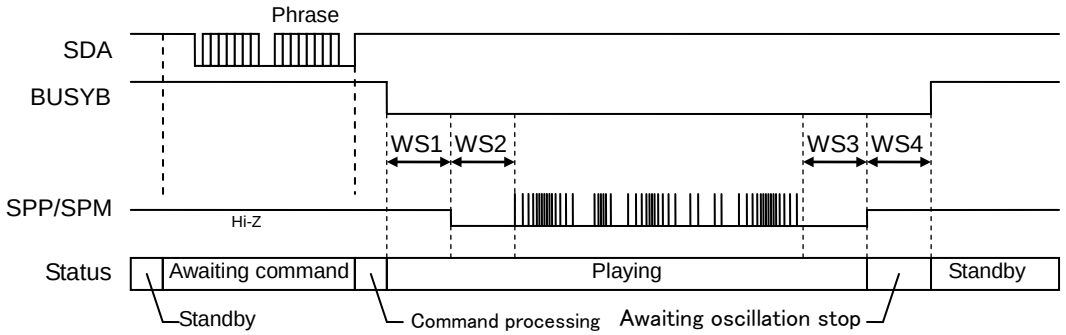


Figure .2 The option screen for every phrase of Speech Utility

1) Wait time setting before and after playback (WS1, WS2, WS3, WS4)

Each phrase can set up the wait time before and after playback. Since it is an option setup, change will be impossible once it sets up.



WS1: Time after inputting a phrase address, until SPP/SPM pins are enabled.
WS2: Time after SPP/SPM pins are enabled, until playback is started.
WS3: Time after playback is completed, until SPP/SPM pins are disabled.
WS4: Time after SPP/SPM pins are disabled, until it will be in a standby state.

WS1-WS4 can be arbitrarily set up between 0 to1020ms (4ms unit).

2) Volume setup (Volume)

Each phrase can set up the volume setup. Since it is an option setup, change will be impossible once it sets up.

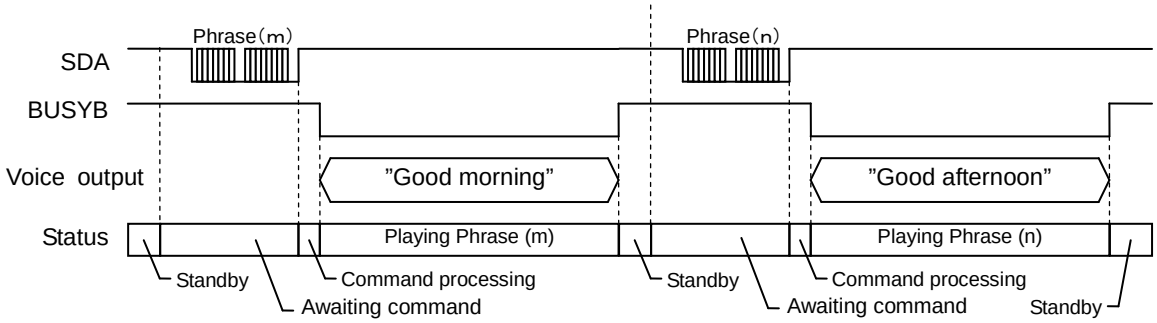
Value [hex]	Volume [dB]	Value [hex]	Volume [dB]	Value [hex]	Volume [dB]
00h	+2.98	0Ah	-0.41	15h	-6.87
01h	+2.70	0Bh	-0.83	16h	-7.79
02h	+2.40	0Ch	-1.28	17h	-8.82
03h	+2.10	0Dh	-1.75	18h	-9.99
04h	+1.78	0Eh	-2.25	19h	-11.34
05h	+1.45	0Fh	-2.77	1Ah	-12.94
06h	+1.11	10h	-3.34	1Bh	-14.90
07h	+0.76	11h	-3.94	1Ch	-17.44
08h	+0.39	12h	-4.58	1Dh	-21.04
09h	+0.00	13h	-5.28	1Eh	-27.31
		14h	-6.04	1Fh	OFF

3) Playback mode setup

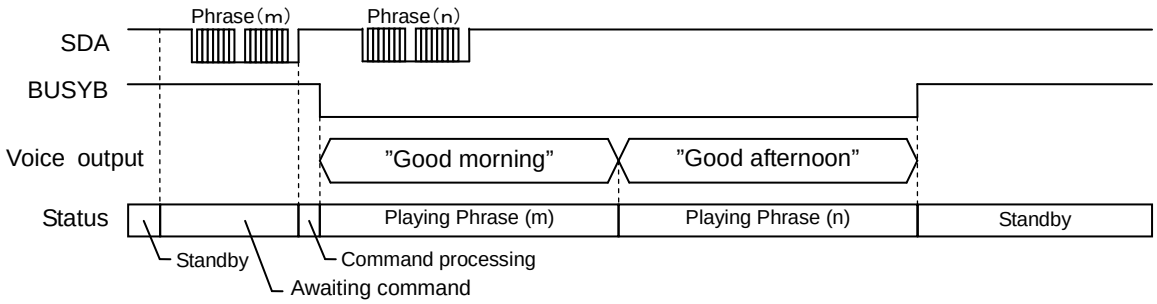
Playback mode can be set up for every phrase. Since it is an option setup, change will be impossible once it sets up.

Playback mode	Operation
Play Once	This mode is playback once. All the commands become invalid during playback.
Scheduled Play Once	When the following phrase is inputted into playback, after playback of the present phrase is completed, playback of th following phrase starts. Even if STOP command is inputted during playback, it will be ignored.
Change Immediately Once	When the following phrase is inputted into playback, playback of the present phrase is ended on the way, and playback of the following phrase starts.
Scheduled Play	The playback continues until the following command will be inputted, if playback starts. When the following command is inputted into playback, after playback of the present phrase is completed, the following command is executed.
Change Immediately	The playback continues until the following command will be inputted, if playback starts. When the following phrase is inputted into playback, playback of the present phrase is ended on the way, and playback of the following phrase starts.

・Play Once mode

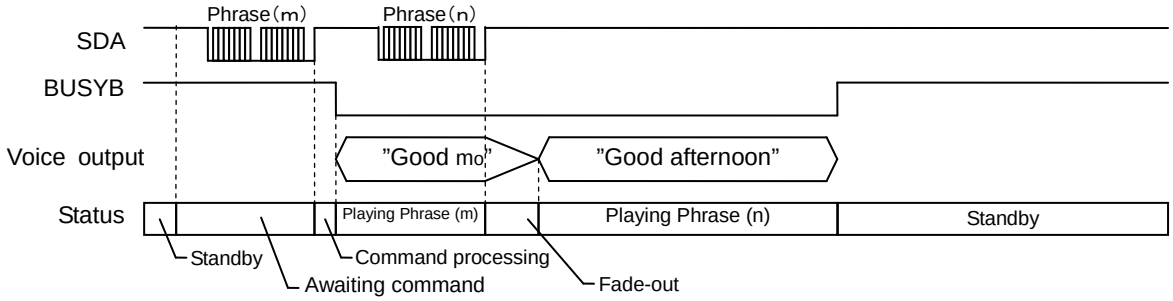


・Scheduled Play Once mode

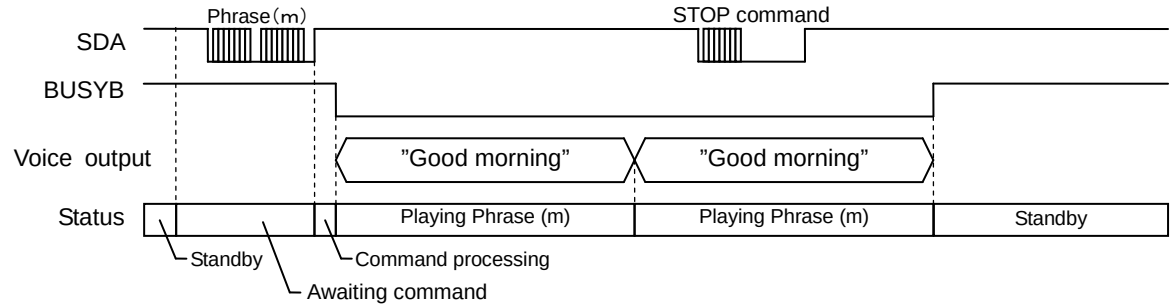


Start the next PHRASEn command within the tNCM. When it can't start, confirm the completion (BUSYB= "H") of the playback. Next, input the next command (PHRASEn command).

・Change Immediately Once mode

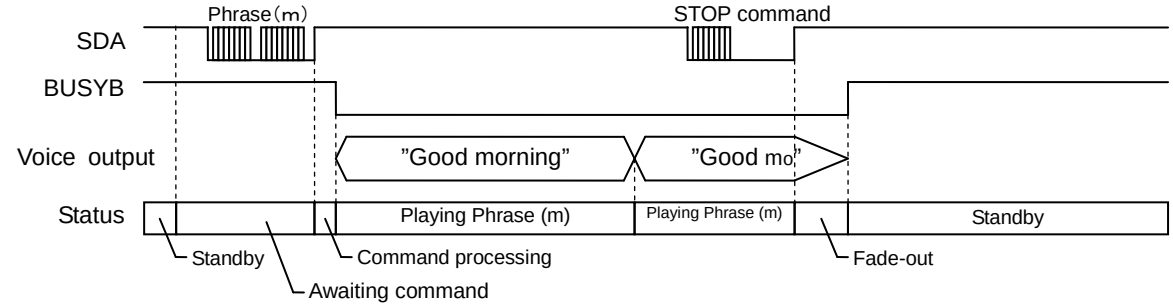


・Scheduled Play mode



Confirm the completion (BUSYB= "H") of the playback after input of a STOP command. Next, input the next command (PHRASEn command).

・Change Immediately mode



Confirm the completion (BUSYB= "H") of the playback after input of a STOP command. Next, input the next command (PHRASEn command).

Mask Option Setting

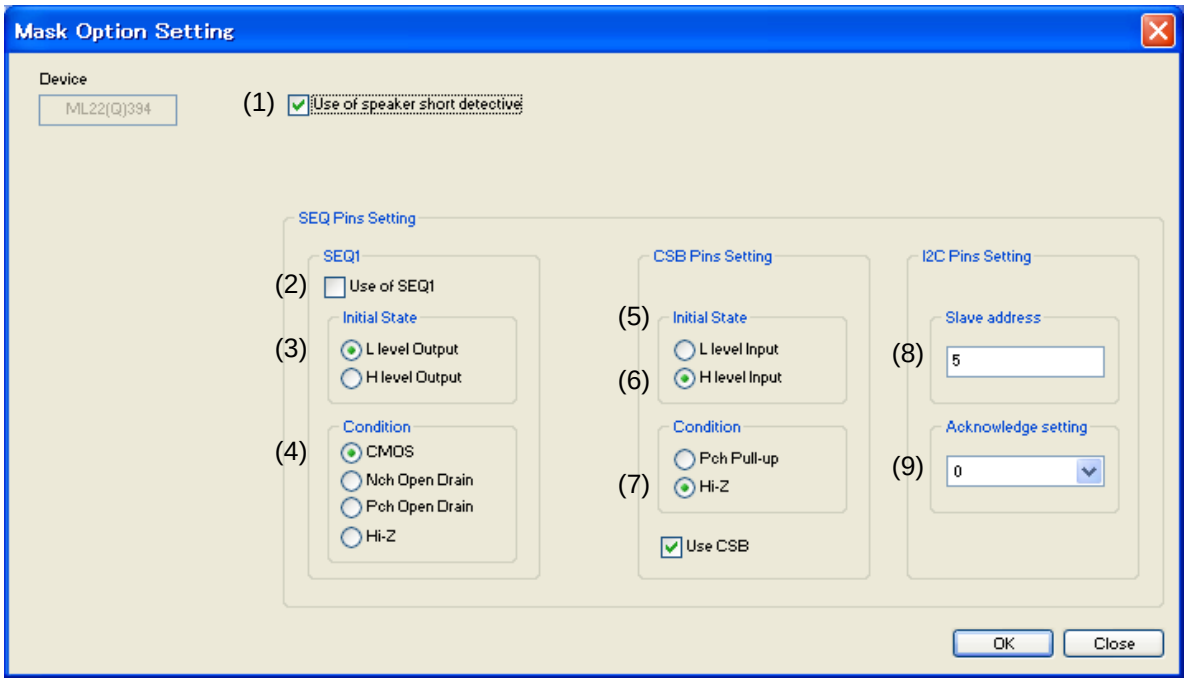


Figure .3 The Mask Option Setting screen of Speech Utility

Explanation of each option is shown in the following page.

Parameter	Function	Explanation
(1) Use of speaker short detective	ON or OFF selection of a short detection function	If a check box is turned on, a short detection circuit will become effective.
SEQ Pins Setting	Interface setup	
SEQ1	BUSYB setup	
(2) Use SEQ1	Use or unuse selection of BUSYB	If a check box is turned on, a BUSYB pin can be used. If a check box is turned off, a BUSYB pin does not function but the fixed output of the initial value is carried out.
(3) Initial State	Initial output level selection of BUSYB	The initial value of a BUSYB pin at voice stop can be chosen.
L Level Output	L Level Output	The "L" level is outputted at voice stop.
H Level Output	H Level Output	The "H" level is outputted at voice stop.
(4) Condition	BUSYB condition setup	BUSYB condition can be chosen.
CMOS	CMOS output	a BUSYB pin become a CMOS output. Usually, please use this setup.
Nch Open Drain	Nch Open Drain output	The "L" level is outputted at the “L” level. High impedance is outputted at the H" level.
Pch Open Drain	Pch Open Drain output	The "H" level is outputted at the “H” level. High impedance is outputted at the L" level.
Hi-Z	High impedance output	High impedance is always outputted. When BUSYB use mode is set up, please do not use it.
CSB Pins Setting	CSB setup	
(5) Initial State	CSB input level	The initial value of a CSB pin at standby can be chosen.
L Level Input	L Level Input	The "L" level is inputted at standby.
H Level Input	H Level Input	The "H" level is inputted at program operation.
(6) Condition	CSB condition setup	CSB condition can be chosen.
Pch Pull-up	Pch Pull-up input	Built-in Pull-up resistance can be used.
Hi-Z	High impedance input	It is used at CMOS connection. Usually, please use this setup.
(7) Use CSB	Use or unuse selection of CSB	If a check box is turned on, the interface using a CSB pin is attained. If a check box is turned off, two terminal interface of SCL and SDA is attained.
I2C Pins Setting	I2C setup	The I2C condition can be set up.
(8) Slave address	Slave address setting	7-bits slave address can be set up.
(9) Acknowledge Setting	Acknowledge level setup	The level of the acknowledge signal outputted at the time of termination of reception can be set up.

THE PULL-UP RESISTOR VALUE OF SCL AND SDA PIN

The pull-up resistor value of SCL and SDA pin is computed as follows.

- Minimum Value (R_P.min):
  $R_P.min = (V_{DD}-V_{OL}.max)/I_{OL}$

  - V_{DD}: Power supply voltage
  - V_{OL}.max: The maximum output "L" level of a driver
  - I_{OL}: Sink current of a driver

  For example, in this case of V_{DD}=5V, V_{OL}.max=0.4V, and I_{OL}=3mA, it is calculated as follows.
  $R_P.min = (5V - 0.4V)/3mA \cong 1.5k\Omega$

- Maximum Value (R_P.max):
  $R_P.max$ = 300ns/[Maximum Capacitance of a Bus (F)]

  For example, in this case of the maximum capacitance of a bus is 100pF, it is calculated as follows.
  $R_P.max = 300ns/100pF \cong 3.0k\Omega$

TERMINATION OF THE V_{DDL} PIN

The V_{DDL} pin is the regulator output that is power supply pin for the internal logic circuits. Connect a capacitor between this pin and the ground in order to prevent noise generation and power fluctuation.
The recommended capacitance value is shown below. However, it is important to evaluate and decide using the own board.
Also, start the next operation after each output voltage is stabilized.

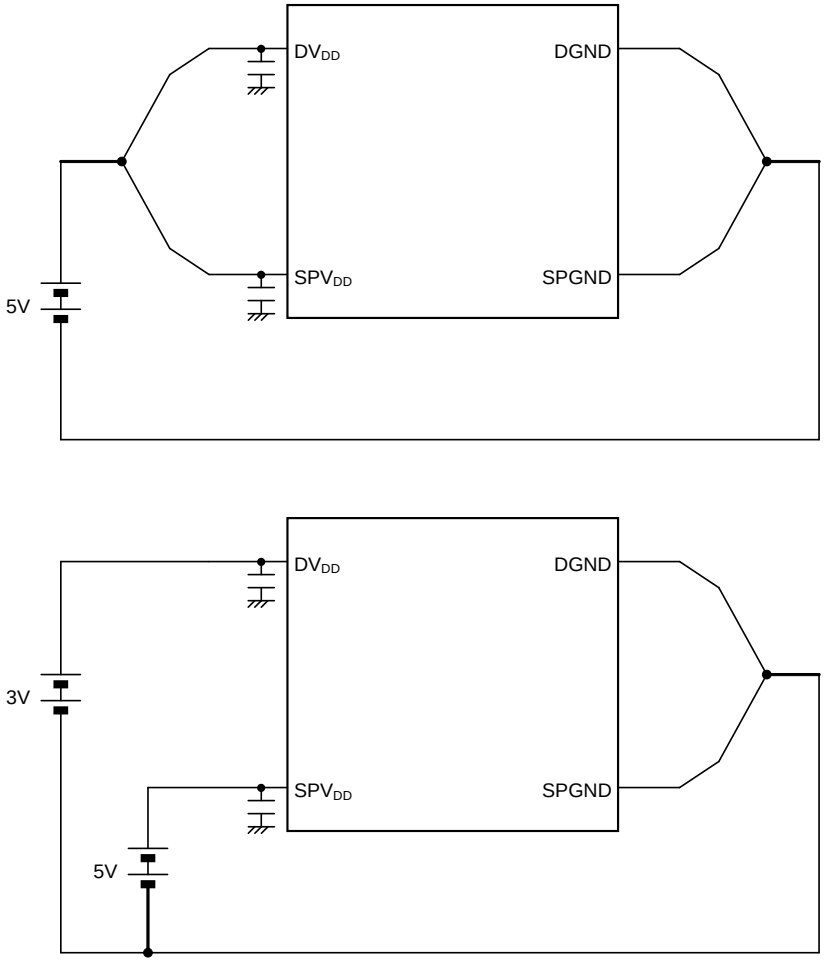
Pin	Recommended capacitance value	Remarks
V_{DDL}	10 µF ±20%	The larger the connection capacitance, the longer the settling time.

POWER SUPPLY WIRING

The power supplies of this LSI are divided into the following two:

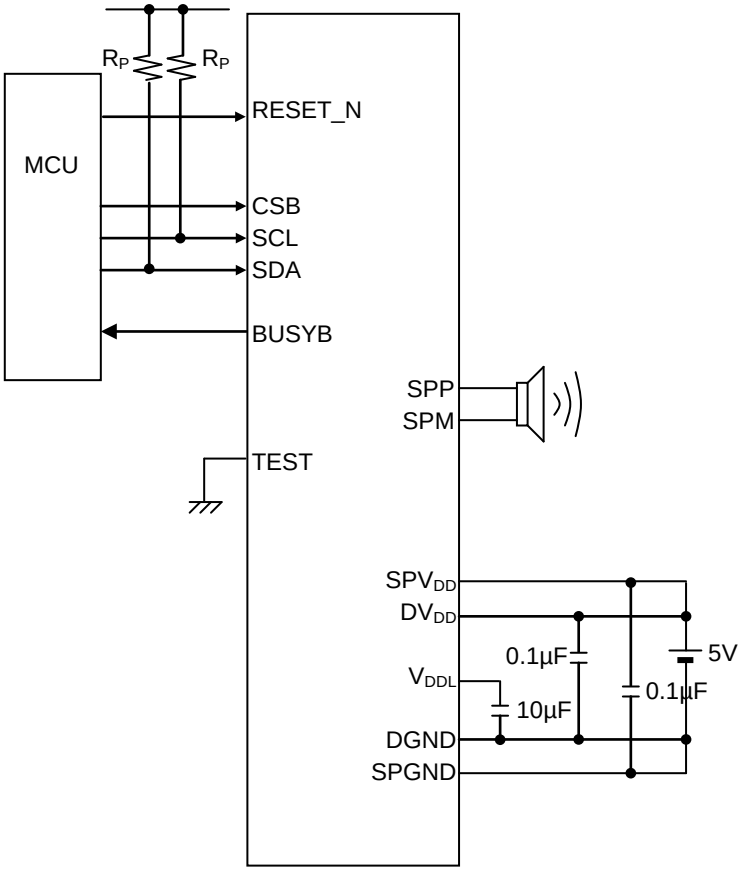
- Power supply for logic circuitry (: DV_{DD})
- Power supply for speaker amplifier (: SPV_{DD})

The example of power connection is shown below.



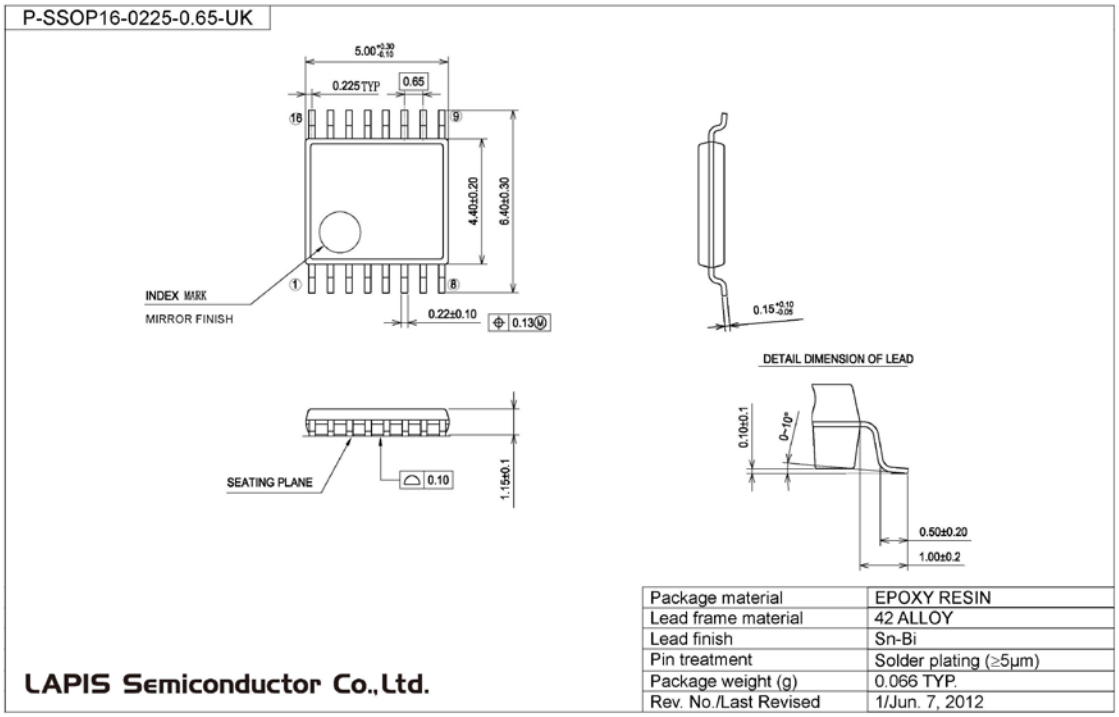
- Turn on DV_{DD} and SPV_{DD} simultaneously, or turn on SPV_{DD} after turning on DV_{DD}.
- Turn off DV_{DD} and SPV_{DD} simultaneously, or turn off DV_{DD} after turning on SPV_{DD}.

APPLICATION CIRCUIT



PACKAGE DIMENSIONS

(Unit: mm)



Package material	EPOXY RESIN
Lead frame material	42 ALLOY
Lead finish	Sn-Bi
Pin treatment	Solder plating (≥5μm)
Package weight (g)	0.066 TYP.
Rev. No./Last Revised	1/Jun. 7, 2012

Notes for Mounting the Surface Mount Type Package

The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact a ROHM sales office for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

REVISION HISTORY

Document No.	Date	Page		Description
		Previous Edition	Current Edition	
FEDL22Q394FULL-01	Oct. 23, 2012	–	–	Final edition 1
FEDL22Q394-02	Jun. 06, 2014	–	27	Add the notice of silence insertion function
FEDL22Q394-03	Mar. 16, 2015	8	8	Modify the explanation of t_{NCM}.
		12,18	12,18	Add the notice of the next PHRASEn command input.
		13,19	13,19	Delete the restriction of t_{NCM}.
		14,20	14,20	Delete the restriction of t_{NCM}. Add the notice of the next PHRASEn command input.
		15,21	15,21	Delete the restriction of t_{NCM}. Add the notice of the next PHRASEn command input.
		25	25	Add the notice of minimam playback time.
		27	27	Add the notice of the silence insertion function.
		29	29	Add the notice of the next PHRASEn command input.
		33-34	33-34	Add the notice of the next PHRASEn command input.

NOTES

1)The information contained herein is subject to change without notice.

2)Although LAPIS Semiconductor is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors. Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. LAPIS Semiconductor shall have no responsibility for any damages arising out of the use of our Products beyond the rating specified by LAPIS Semiconductor.

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6)The Products specified in this document are not designed to be radiation tolerant.

7)For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a LAPIS Semiconductor representative: transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.

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