Dear customer

ROHM Co., Ltd. ("ROHM"), on the 1st day of April, 2024,
has absorbed into merger with 100%-owned subsidiary of LAPIS Technology Co., Ltd.

Therefore, all references to "LAPIS Technology Co., Ltd.", "LAPIS Technology"
and/or "LAPIS" in this document shall be replaced with "ROHM Co., Ltd."
Furthermore, there are no changes to the documents relating to our products other than
the company name, the company trademark, logo, etc.

Thank you for your understanding.

ROHM Co., Ltd.
April 1, 2024

ML22Q294

ADPCM Speech Synthesis LSI for Automotive

■ GENERAL DESCRIPTION

ML22Q294 is a speech synthesis LSI supporting an in-vehicle quality that incorporates Flash for storing voice code data, and can be controlled with a I^2C interface.
By integrating D-class speaker amplifier, solution required for voice output is made possible with single chip.

- Playback time : (Maximum number of phrases 30 When a phrase is selected)

Product name	Flash capacity (bit)	Maximum playback time (sec) (at fs = 6.4 kHz)	
		4bitADPCM2	16bitPCM
ML22Q294	692K	27.6	6.9

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

- Speech synthesis method: 4-bit ADPCM2
  8-bit Nonlinear PCM
  8-bit PCM , 16-bit PCM
  (Method can be specified for each phrase)
- Flash capacity: 692 Kbit (30 phrases selection),688 Kbit (62 phrases selection)
- Sampling frequency (Fs): 8.0/16.0/32.0 kHz, 6.4/12.8/25.6 kHz, 10.7/21.3 kHz
  (Can be specified for each phrase)
- Speaker driving amplifier: D-class amplifier (driven by 8 Ω)
- CPU command interface: I2C interface
- Maximum number of pharases: 30 phrases or 62 phrases
- Disconnection detection function /Speaker pin short detection function
- Source oscillation frequency: 4.096 MHz (Typ) (internal)
- Power supply voltage: 2.0 to 5.5 V
- Flash memory rewritable time: 80 times
- Operating temperature range: –40 °C to +105 °C
- AEC-Q100: Compliant

■ Applications

● Automotive equipment (e.g., AVAS(Acoustic Vehicle Alerting System), Meter cluster, Various warning sounds) .
● Consumer and Industrial equipment (e.g., Household appliances, Housing equipment, Office equipment, Measurement instrumentation, etc.).

【NOTE】
This product cannot be applicable for automatic train control systems, and railway safety systems. Please contact ROHM sales office in advance if contemplating the integration of this product into applications that requires high reliability, such as transportation equipment for ships and railways, communication equipment for trunk lines, traffic signal equip.

■ Table format

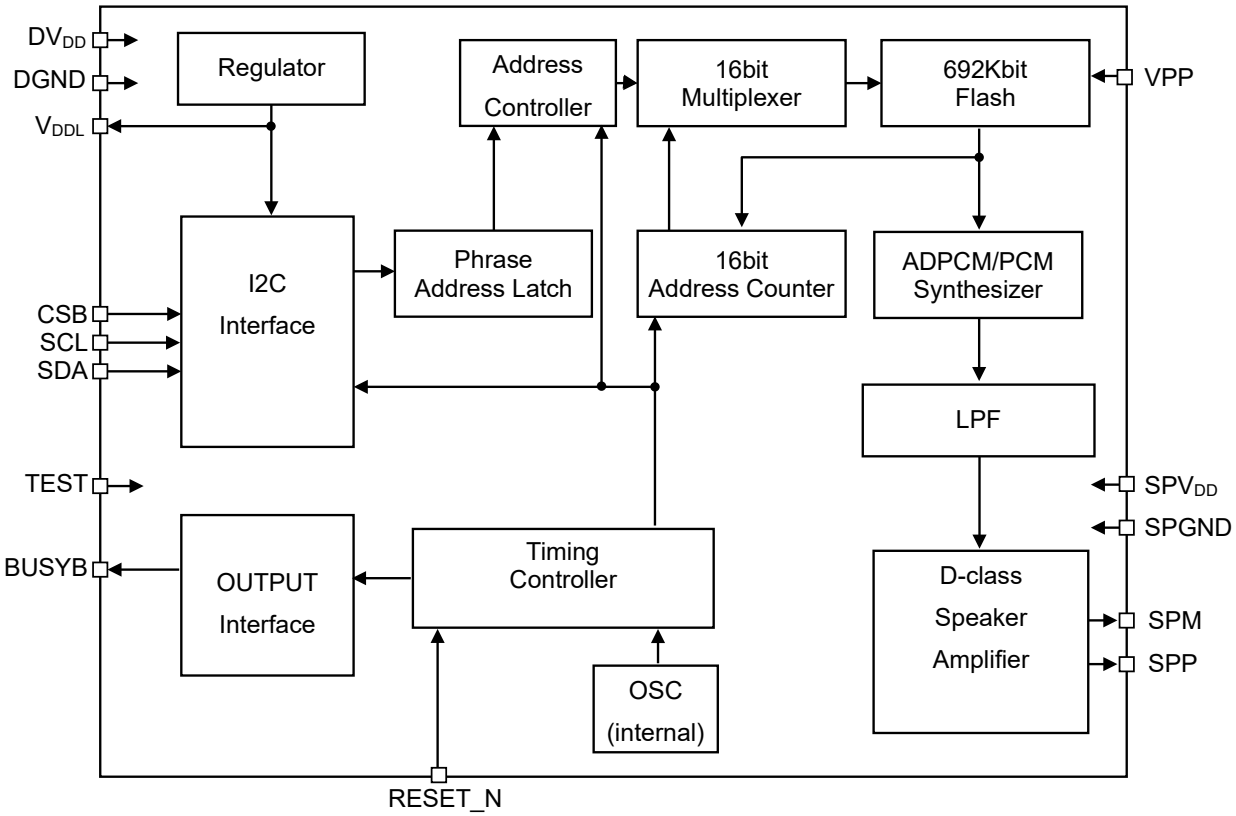
Package	Body size (including lead) [mm × mm]	Pin pitch [mm]	Packing form and Product name*1	
			Tray	Tape & Reel
20 pin plastic TSSOP	6.5 × 4.4 (6.5 × 6.4)	0.65	ML22Q294-NNNTDZ0ARL ML22Q294-xxxTDZ0ARL	ML22Q294-NNNTDZ0ATL ML22Q294-xxxTDZ0ATL

*1 “NNN” is a blank product. “xxx” denotes ROM code number.

The following table shows the differences from ML22Q274, ML22Q284.

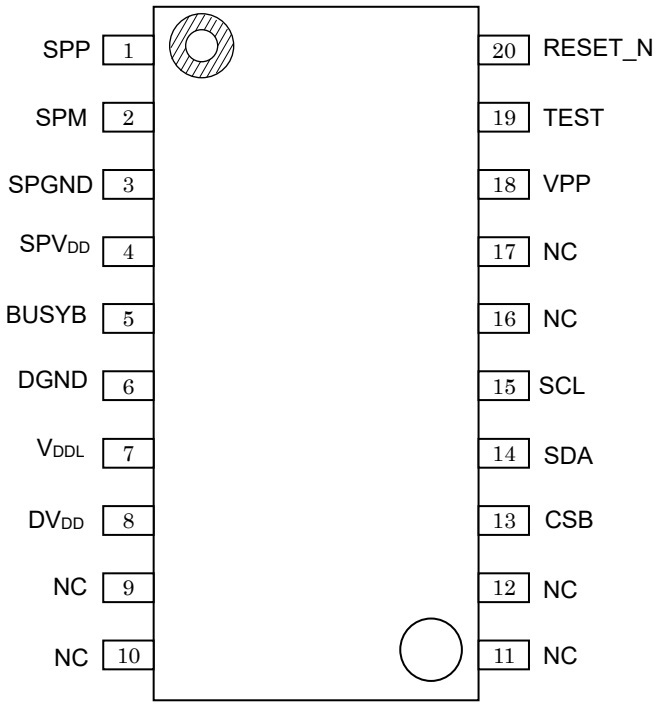
Parameter	ML22Q294	ML22Q274	ML22Q284
MCU interface	I2C	Clock synchronization Serial	Standalone
Flash capacity	692 Kbit (when 30 phrases are selected) 688 Kbit (when 62 phrases are selected)	←	692 Kbit
Playback method	4-bit ADPCM2 8-bit Nonlinear PCM 8-bit PCM 16-bit PCM	←	←
Maximum number of phrases:	30/62	←	30
Sampling frequency (kHz)	6.4/8.0/10.7/12.8/ 16.0/21.3/25.6/32.0	←	←
Clock frequency	4.096 MHz (internal oscillation)	←	←
Low-pass filter	FIR interpolation filter	←	←
Speaker driving amplifier	D-class amplifier	←	←
Speaker driving amplifier output load	8Ω	←	←
Speaker driving amplifier output voltage	1 W (Ta = -40 to +85°C) 0.8 W (Ta = -40 to +105°C)	←	←
Edit ROM function	Yes	←	←
Volume control	32 levels	←	←
Silence insertion	4 ms to 1024 ms (4 ms/step)	←	←
Repeat function	Yes	←	←
Power supply voltage	2.0 to 5.5 V	←	←
Operating temperature range	-40 to +105°C	←	←
Package	20-pin TSSOP	←	←

■ BLOCK DIAGRAMS



■ PIN CONFIGURATIONS (TOP VIEW)

20-Pin Plastic TSSOP



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 0.1 μF 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. When disconnection is detected with disconnection detection function, the "L" level is outputted. BUSYB unused mode and logic inversion can be set with Speech LSI Utility.
6	DGND	—	—	—	Digital ground pin.
7	V_{DDL}	—	—	—	Regulator output pin for internal logic circuitry. Connect a capacitor of 10 μF or more between this pin and DGND pin
8	DV_{DD}	—	—	—	Digital power supply pin. Connect a capacitor of 0.1 μF or more between this pin and DGND pin.
13	CSB	I	1	1	Chip select pin in a case where CSB use mode is set. Internal oscillation starts in response to turning “H” level down to “L” level, and input through I^2C becomes available. Fix to “H” level or “L” level when CSB use mode is not set.
14	SDA	I	1	1	I^2C serial data input pin. Used for writing slave address and data. Pull-up resistor must be inserted between this pin and DV_{DD}
15	SCL	I	1	1	I^2C serial clock input pin. Pull-up resistor must be inserted between this pin and DV_{DD}
18	VPP	—	—	—	Power supply pin for rewriting Flash memory. Fix this pin to GND except when rewriting Flash memory
19	TEST	I	0	0	Test pin. Fix this pin to DGND.
20	RESET_N	I	0	1	Reset pin. Input “L” level for initialization, when power is turned on, or when voltage falls below recommended operation power supply voltage range. After the power supply voltage is stable, drive this pin to “H” level.
9 10 11 12 16 17	N.C.	—	—	—	Unused pin. Leave this pin open.

■ ABSOLUTE MAXIMUM RATINGS

(DGND = 0 V)

Parameter	Symbol	Condition	Rating	Unit
Power supply voltage	DV_{DD} SPV_{DD}	Ta = 25 °C	-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_{DD} +0.3	V
Power dissipation	P_D		1	W
Output short-circuit current	I_{SC1}	Applied to pin other than SPP or SPM	-12 to +11	mA
	I_{SC2}	SPP pin, SPM pin	600	mA
Storage temperature	T_{STG}	-	-55 to +150	°C

■ RECOMMENDED OPERATING CONDITIONS

(DGND = 0 V)

Parameter	Symbol	Condition	Range	Unit
Power supply voltage	DV_{DD} SPV_{DD}	-	2.0 to 5.5	V
		Flash memory write	2.7 to 5.5	
Flash power supply voltage	VPP	Flash memory write	7.7 to 8.3	V
Flash memory rewrite cycles	N	-	80	times
Operating temperature range	T_{OP1}	-	-40 to +105	°C
	T_{OP2}	Flash memory write	0 to +40	

■ ELECTRICAL CHARACTERISTICS

● DC Characteristics

DV_{DD} = SPV_{DD} = 2.0 to 5.5 V, DGND = SPGND = 0 V, Ta = -40 to +105°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
"H" input voltage	V_{IH}	-	0.7 x DV_{DD}	-	DV_{DD}	V
"L" input voltage	V_{IL}	-	0	-	0.3 x 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} = 0.5mA	-	-	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 terminal pull-up input is set	-250	-30	-2	µA
"H" output current 1	I_{OOH1}	VOH= DV_{DD}= SPV_{DD} (High impedance) BUSYB, SPP, SPM pin	-	-	1	µA
"H" output current 2	I_{OOH2}	VOH= DV_{DD} (Nch Open drain) BUSYB pin	-	-	1	µA
"L" output current 1	I_{OOL1}	VOL=DGND=SPGND (High impedance) BUSYB, SPP, SPM pin	-1	-	-	µA
"L" output current 2	I_{OOL2}	VOL=DGND (Pch Open drain) BUSYB pin	-1	-	-	µA
Supply current during playback	I_{DD1}	No output load DV_{DD}= SPV_{DD}=3.0V	-	4.0	6.0	mA
	I_{DD2}	No output load DV_{DD}= SPV_{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°C	-	0.5	3.0	µA
	I_{DDS2}	Ta ≤ +85°C	-	0.5	8.0	
	I_{DDS3}	Ta ≤ +105°C	-	0.5	16.0	
Oscillation frequency	f_{OSC}	-10 to +50°C	4.034	4.096	4.158	MHz
		-40 to +105°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 +105°C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
SPM, SPP output load resistance	R_{LSP}	-	8	-	-	Ω
Speaker amplifier output voltage	P_{SPO}	SPV_{DD} = 5.0 V, Sin wave f = 1 kHz R_{LSP} = 8 Ω, THD ≥ 10% Ta = -40 to +85°C	-	1.0	-	W
		SPV_{DD} = 5.0 V, Sin wave f = 1 kHz R_{LSP} = 8Ω, THD ≥ 10% Ta = -40 to +105°C	-	0.8	-	W

- AC Characteristics

DV_{DD} = SPV_{DD} = 2.0 to 5.5 V, DGND = SPGND = 0 V, Ta = -40 to +105°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}	-	-	-	65	ms
SCL Clock frequency	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 clock “L” level pulse width	t_{LOW}	I²C Fast mode	1.3	-	-	µs
SCL clock “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
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 x DV_{DD}	-	-	V
Noise margin at a “H” level in each device connected (including hysteresis)	V_{nH}	I²C Fast mode	0.1 x DV_{DD}	-	-	V
Pulse width of spikes which must be suppressed by the input filter	t_{SP}	I²C Fast mode	0	-	50	ns
Clock stretch time	t_{CKST}	-	-	-	1	ms
Data 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}	-	-	-	400	µs
CSB “H” level pulse width	t_{CSW}	CSB use mode	1	-	-	ms
Oscillation stop time, after playback	t_{OSST}	-	-	-	500	µs
Next command transmit time	t_{NCM1}	-	0	-	-	ms
Next command transmit time in the case of the playback	t_{NCM2}	-	-	-	10	ms
Next command input time after transition to standby	t_{CMS}	When CSB use mode is not set	500	-	-	µs
Disconnection judging by the DISCONNECT command start time	t_{DCDS}	-	1.5	-	-	ms
Disconnection judging by the DISCONNECT command end time	t_{DCDE}	-	-	-	1	s
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 (max.)

■ FUNCTIONAL DESCRIPTION

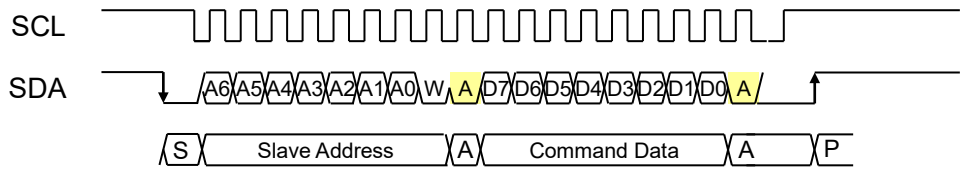
- I²C interface

  Serial interface that is compliant with I²C bus specification. It supports Fast mode and enables data reception at 400 kbps.
  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. Then, the communication is made in the unit of byte. Acknowledge is needed for each byte.

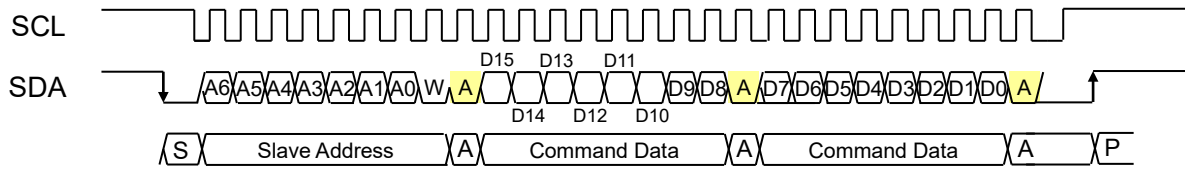
  Communication flow/timing chart with I²C is described below.

  S: Start condition
  A: Acknowledge
  Command Data: Command
  P: Stop condition

  Timing chart for 1-byte configuration command input



  Timing chart for 2-byte configuration command input



  Slave address can be set up with the option screen of Speech LSI Utility.
  Please refer to "Code Option Setting Item" for details.

- Speech synthesis method

Supporting four types of speech synthesis methods, which are 4bit ADPCM2, 8-bit nonlinear PCM, 8-bit PCM, and 16-bit PCM. Any of these can be selected based on the characteristics of the voice to be played back.

Speech synthesis method	Compression rate*1	Suitable waveform	Characteristics
4-bit ADPCM2	1/4	Normal voice sound wave	Unique scheme which is a refined version of 4bit ADPCM Offers higher sound quality with better waveform followability.
8-bit Nonlinear PCM	1/2	Sound including high frequency components (such as sound effects)	A part around the center of the waveform is played back with a sound quality equivalent to 10 bits.
8-bit PCM	1/2		Normal 8-bit PCM.
16-bit PCM	1		Normal 16-bit PCM.

Note 1: When the same sampling frequency is used.

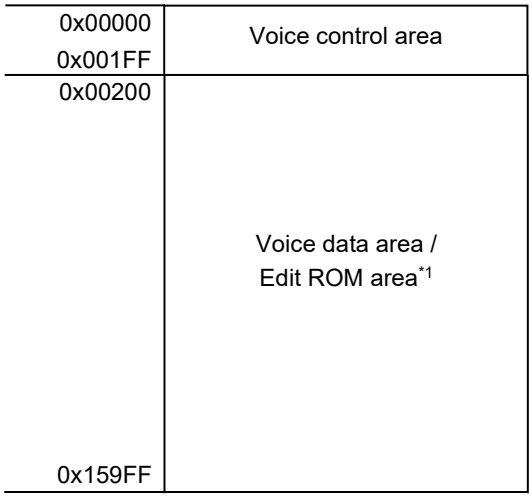
- Memory Allocation and Creating Voice Data

The voice code data consists of a voice management area, a voice data area, and an edit ROM area.
The voice control area manages voice data of 30 phrases or 62 phrases.
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 only available when the edit ROM is used.

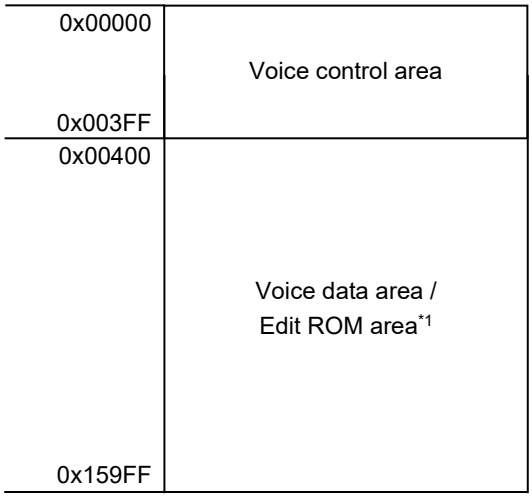
The ROM data is created using Speech LSI Utility.

The 30 or 62 phrases can be switched using the Speech LSI Utility.
Please refer to a "Code Option Setting Item" for details.

Voice code data configuration(30 phrase selection)



Voice code data configuration(62 phrase selection)



*1: Edit ROM area depends on creation of the data

- Playback Time and Flash 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.

$$\text{Playback time [sec]} = \frac{1.024 \times (\text{Voice data area/Edit ROM area})(\text{Kbit})}{\text{Sampling frequency [kHz]} \times \text{Bit length}}$$

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

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

$$\text{Playback time} = \frac{1.024 \times 692(\text{Kbit})}{8(\text{kHz}) \times 4(\text{bit})} \approx 22.1\ [\text{sec}])$$

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

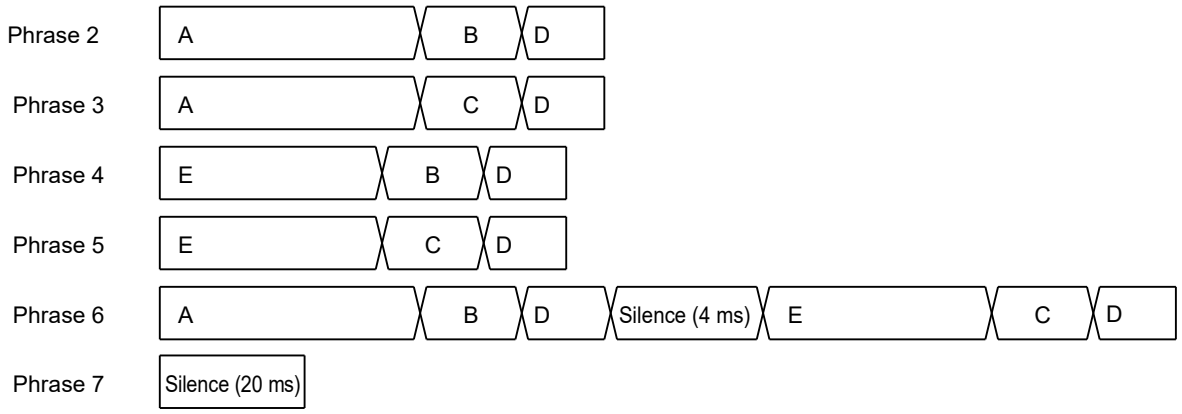
- Edit ROM function

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

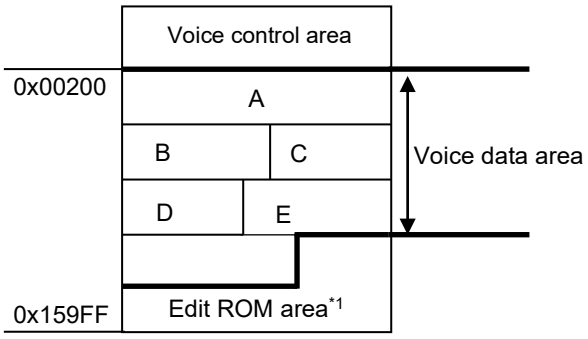
- Continuous playback: There is no limit to set the number of times of the continuous playback. It depends on the Flash capacity only.
- Silence insertion function: 4 ms to 1,024 ms
  *Note: Silent insertion time varies for ±1 ms depends on the sampling frequency.
  An independent phrase generated by edit ROM shall be 20 ms or longer.

It is possible to use voice ROM effectively to use the edit ROM function.
An example of the ROM structure, in a case of using the edit ROM function is as follows.

Example 1) Phrases using the Edit ROM Function



Example 2) Structure of the ROM storing contents of Example 1



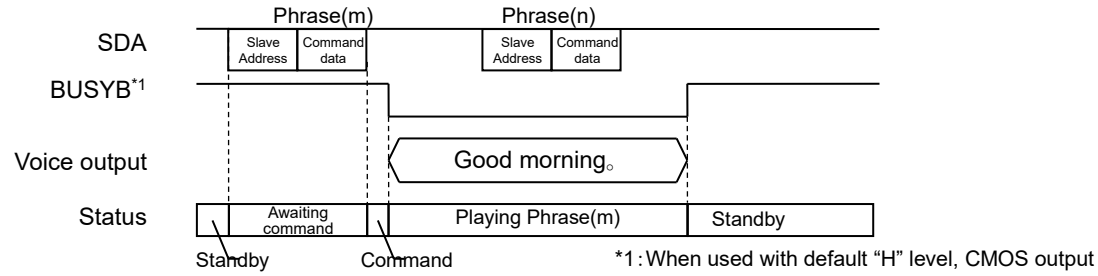
*1 : Information on phrases 2 to 7 stored

- Playback mode setup

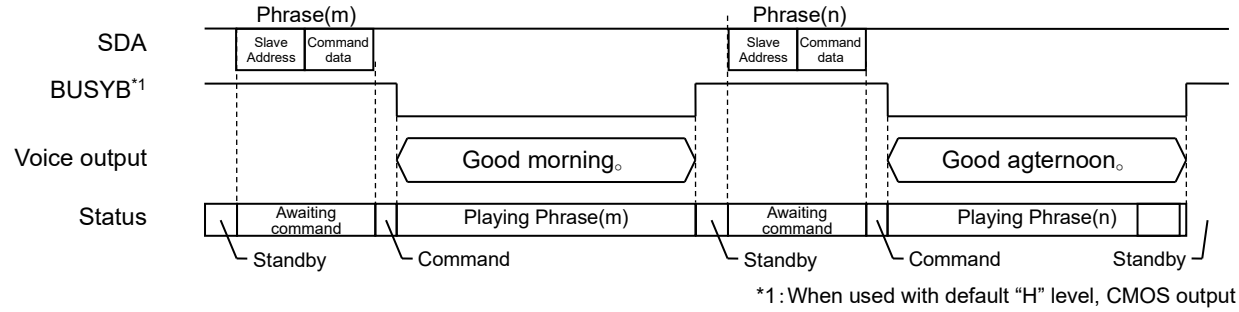
  Five playback modes are available. Can be set up for every phrase.
  Set when the voice code data is generated.

◆ Play Once mode

This mode is playback once.
All the commands become invalid during playback.

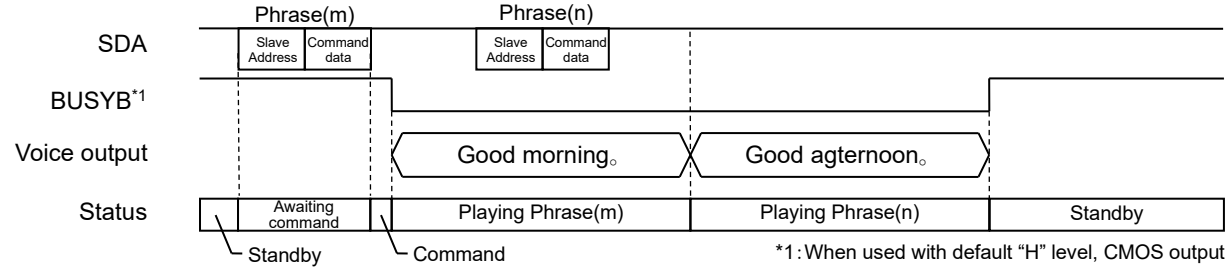


Next command must be input in the standby state after the playback ends.

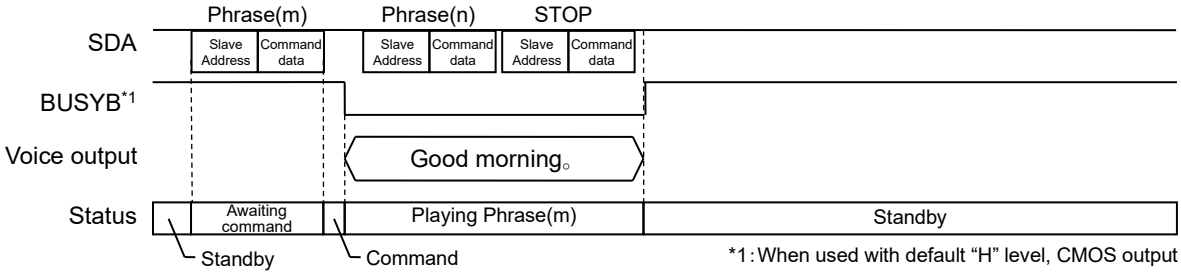


◆ Scheduled Play Once mode

This mode is playback once.
When the next phrase is inputted during playback, after playback of the present phrase ends, playback of the next phrase starts.When the following phrase is inputted into playback, after playback of the present phrase is completed, playback of th following phrase starts.

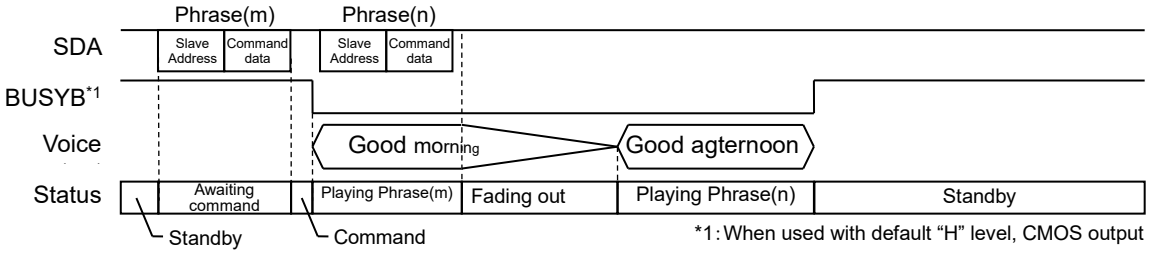


When a plurality of commands are input, the last command input at the end of the phrase is valid.
In the following case, the phrase (n) is not played back because the last command is STOP command.

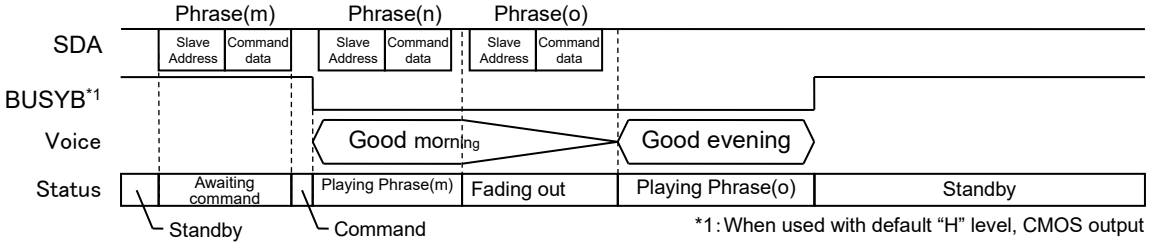


◆ Change Immediately Once mode

This mode is for playing back 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.

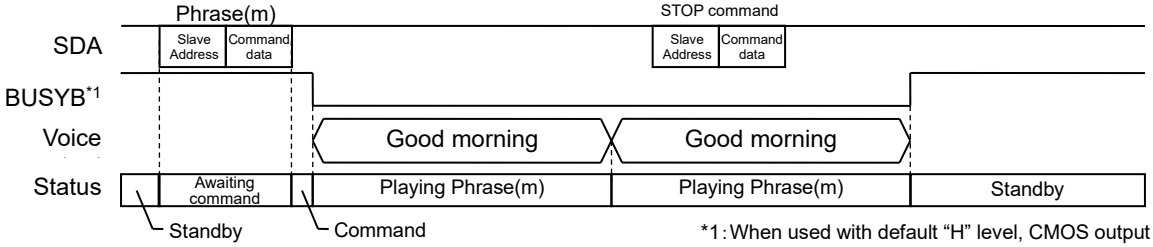


When a plurality of commands are input, the last command input at the end of the phrase is valid.
In the following case, the last input phrase (o) is played back.



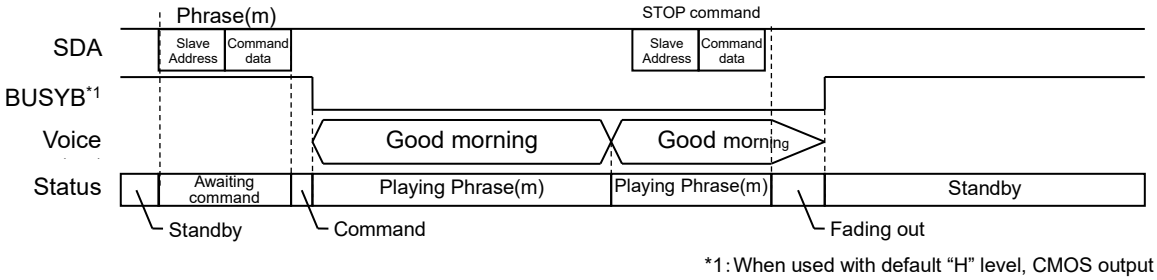
◆ Scheduled Play mode

Once the playback starts, it is repeated until the next command is input.
The next command input during the playback is executed after the playback ends.
When a plurality of commands are input, the last command input at the end of the phrase is valid, as in Scheduled Play Once.



◆ Change Immediately mode

Once the playback starts, it is repeated until the next command is input.
When the next command is input, the phrase being played back is terminated, and the next command is executed.When the following command is inputted into playback, playback of the present phrase is ended on the way, and playback of the following command starts.
When a plurality of commands are input, the last command input at the end of the phrase is valid, as in Change Immediately Once.



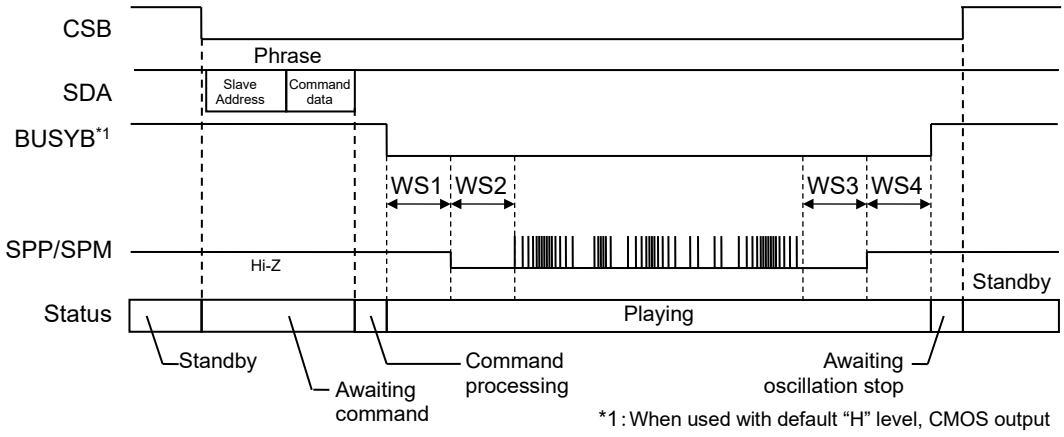
- Volume setup function

Each phrase can set up the volume setup.
The volume is set when voice code data is generated and when PHRASE command is input.
For the setting of volume when PHRASE command is input, refer to “PHRASE command” in Description of Command Functions.
The relationship between the setting and volume at the time of generating voice code data is as follows.

Value	Volume [dB]	Value	Volume [dB]	Value	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

- Function of setting wait time before and after playback (WS1, WS2, WS3, WS4)

Wait time before playback (WS1, WS2) and after playback (WS3, WS4) can be set for each phrase.
Set when the voice code data is generated.

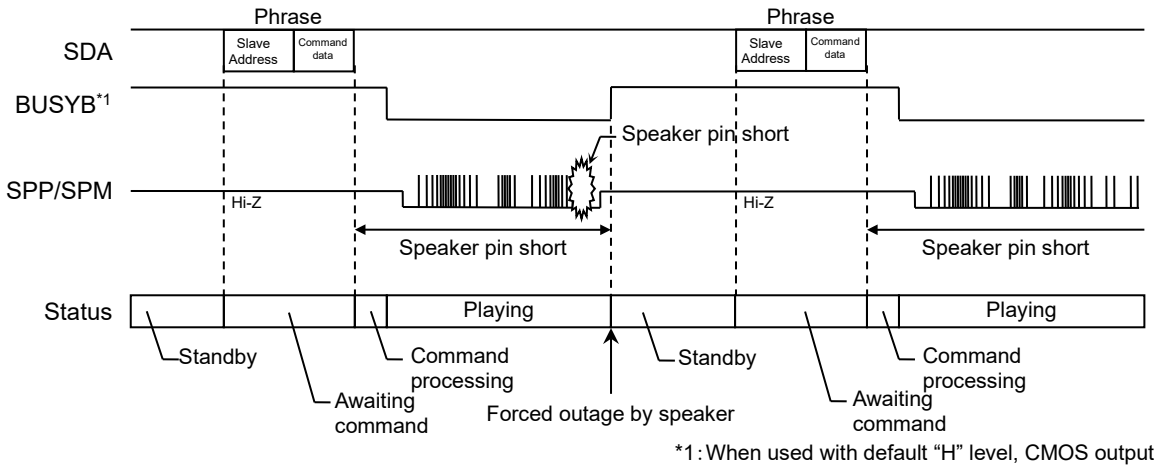


WS1: Time after inputting a phrase address, until SPP/SPM pins are enabled.
WS2: Time after SPP/SPM pins are enabled, until playback is started.
WS3: Time after playback is completed, until SPP/SPM pins are disabled.
WS4: Time after SPP/SPM pins are disabled, until it will be in a standby state.

WS1-WS4 can be arbitrarily set up between 0 to1020 ms (4 ms unit).

- 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.
Speaker short detection prevents IC destruction, but the detection circuit is effective to prevent destruction caused by sudden accidents, and is not intended for use in the condition like short detection occurs continuously.
This function can be set up with the option screen of Speech Utility.
Please refer to a "Code Option Setting Item" for details.



■ Commands

The following commands are used for the LSI. After setting the voice code data in the flash memory of this LSI, be sure to use the voice playback command.

Command	Description
STOP	Stop command. The STOP command becomes effective for phrase other than those in Play Once mode and Scheduled Play Once mode.
DISCONNECT	Disconnection detection command. Speaker disconnection is detected. The STOP command must be input after using the DISCONNECT command.
PHRASE	Playback command. Playback phrase is selected from 30 phrases.

● Command configuration

1-byte command and 2-byte command can be selected.
When the 2-byte command is selected, the volume can be expanded to 32 levels and the number of phrases can be expanded to 62 phrases.
PHRASE command is allocated with a bit sequence other than the set values for STOP command and DISCONNECT command.

These are set when the voice code data is generated.
Please refer to a "Code Option Setting Item" for details.

The command configuration when the initial value (STOP command is set to be 00000b and DISCONNECT command is set to be 00001b) is as follows.

① 1-byte command (eight levels of volume and 30 phrases)

Command	First byte							
	D7	D6	D5	D4	D3	D2	D1	D0
STOP	*	*	*	0	0	0	0	0
DISCONNECT	*	*	*	0	0	0	0	1
PHRASE	V2	V1	V0	0	0	0	1	0
	:							
	V2	V1	V0	1	1	1	1	1

② 2-byte command (initial value: 32 levels of volume and 62 phrases)

Command	First byte								Second byte							
	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
STOP	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
DISCONNECT	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	1
PHRASE[*1]	*	*	*	V4	V3	V2	V1	V0	*	*	0	0	0	0	1	0
	:								:							
	*	*	*	V4	V3	V2	V1	V0	*	*	1	1	1	1	1	1

Note: This bit is not used for command identification, so any value can be set.
Note 1: When using a 2-byte command, the combination of 0xff in the 1st byte and 0xff in the 2nd byte is ignored. For the phrase number 111111b, set the "*" part (arbitrary value) to "0".

Any bit sequence can be set for STOP command and DISCONNECT command.

The following shows examples of a case where a non-initial value is set.
When STOP command is changed from the initial value, the number of phrase available decreases by one.

① 1-byte command (when STOP command is set to be 11111b and DISCONNECT command is set to be 00001b)

Command	First byte							
	D7	D6	D5	D4	D3	D2	D1	D0
-*1	*	*	*	0	0	0	0	0
DISCONNECT	*	*	*	0	0	0	0	1
PHRASE	V2	V1	V0	0	0	0	1	0
	:							
	V2	V1	V0	1	1	1	1	0
STOP	*	*	*	1	1	1	1	1

Note 1: 00000b cannot be set to PHRASE command. 29 phrases from 00010b to 11110b can be set to PHRASE command.

② 2-byte command (when STOP command is set to be 111110b and DISCONNECT command is set to be 000010b)

Command	First byte								Second byte							
	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
-*1	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0
PHRASE	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	1
DISCONNECT	*	*	*	*	*	*	*	*	*	*	0	0	0	0	1	0
PHRASE	*	*	*	V4	V3	V2	V1	V0	*	*	0	0	0	0	1	1
	*	*	*	V4	V3	V2	V1	V0	*	*	:					
	*	*	*	V4	V3	V2	V1	V0	*	*	1	1	1	1	0	1
STOP	*	*	*	*	*	*	*	*	*	*	1	1	1	1	1	0
PHRASE*2	*	*	*	V4	V3	V2	V1	V0	*	*	1	1	1	1	1	1

Note: This bit is not used for command identification, so any value can be set.
Note 1: 00000b cannot be set to PHRASE command. 29 phrases from 00010b to 11110b can be set to PHRASE command.
Note 2: When using a 2-byte command, the combination of 0xff in the 1st byte and 0xff in the 2nd byte is ignored. For the phrase number 111111b, set the "*" part (arbitrary value) to "0".

- STOP command

① 1-byte command selection (initial value)

・command

*	*	*	0	0	0	0	0

② 2-byte command selection (initial value)

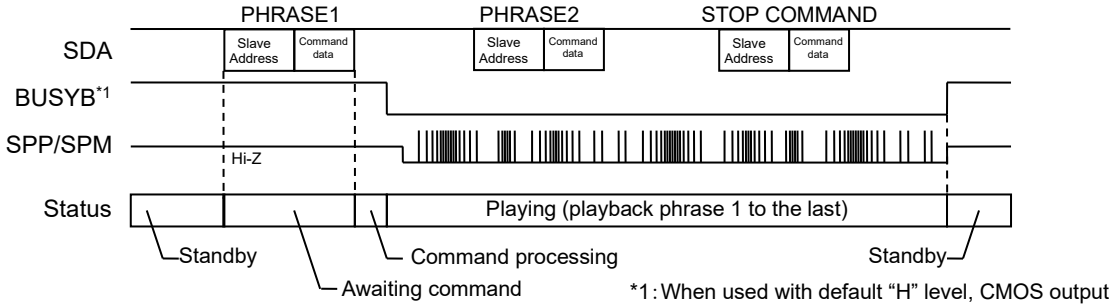
・command

*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0

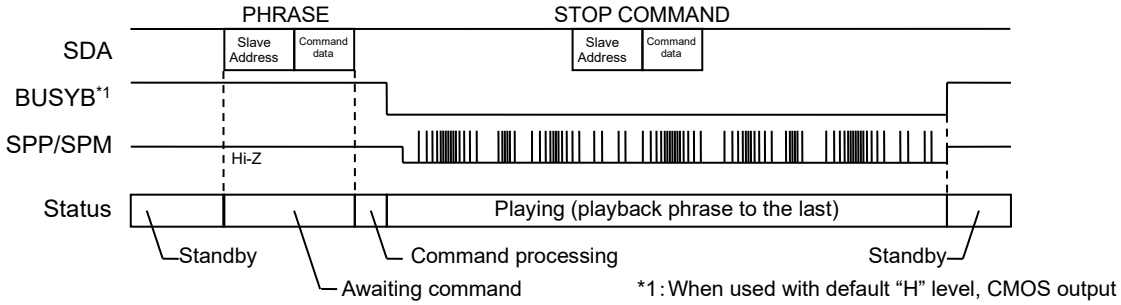
*: Since it is a bit that is not used to identify the command, it can be set to any value.

The STOP command is used to stop the playback. BUSYB pin will become "H", if the playback is stopped.
The STOP command becomes effective for the phrase waiting to be played in Scheduled Play Once mode, and in Scheduled Play modem, Change Immediately Once mode, and Change Immediately mode.
STOP command used for phrases played back in Play Once mode or Scheduled Play Once mode, the STOP is ignored.
When STOP command is input in Scheduled Play mode, the playback stops after the phrase is played back to the end.
When STOP command is input in Change Immediately Once mode or Change Immediately mode, the voice fades out, and the playback stops.
When CSB is not used, input a phrase playback request (PHRASEn command) after the STOP command, after confirming the end of the phrase being played (BUSYB="H"), and after $t_{OSST}+t_{CMS}$ has elapsed.
Operations where STOP command is effective are described below.

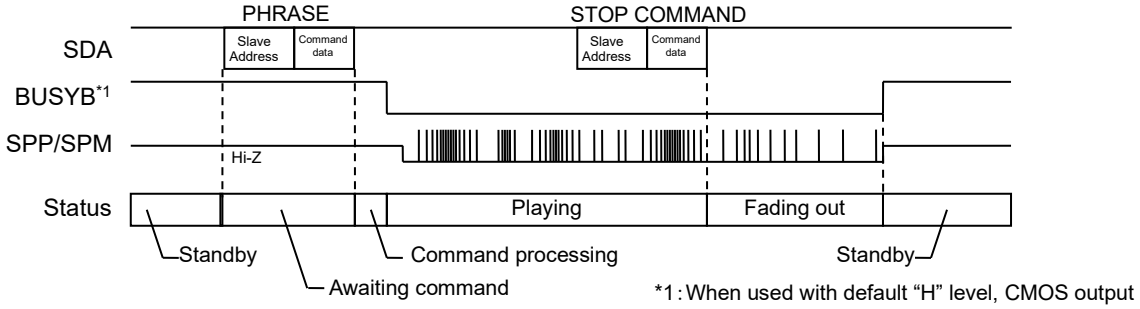
◆ STOP command operation in the case of Scheduled Play Once mode



◆ 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



- DISCONNECT command

① 1-byte command selection (initial value)

・command

*	*	*	0	0	0	0	1

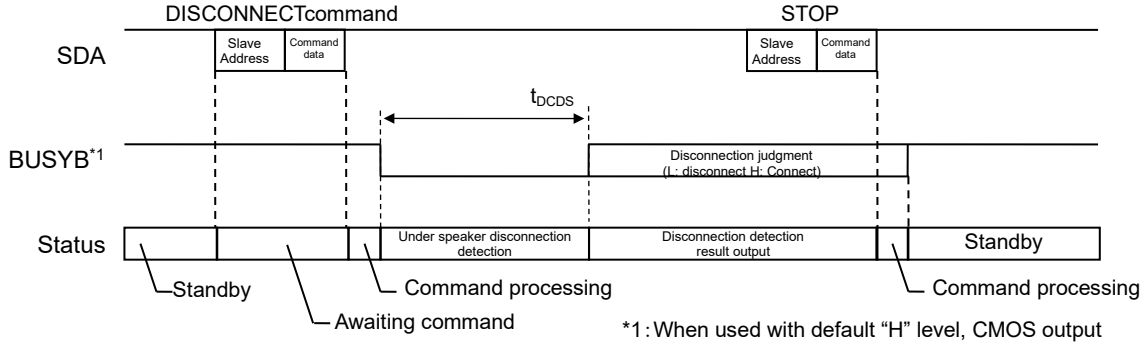
② 2-byte command selection (initial value)

・command

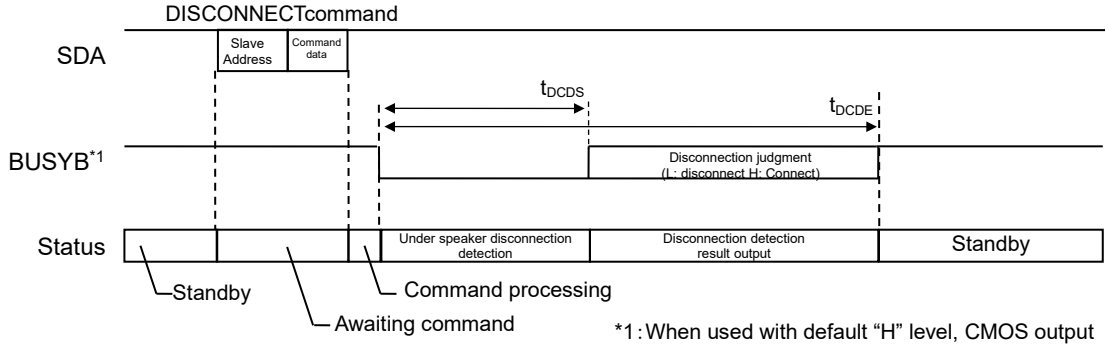
*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	1

*: Since it is a bit that is not used to identify the command, it can be set to any value.

The DISCONNECT command is used to diagnose whether the speaker is disconnected or not.
The command cannot be used during voice playback. The command shall be used during standby (no playback).
Disconnection detection result is output to BYSYB pin. "L" is output when the speaker is disconnected, and outputs "H" when the speaker is not disconnected. Please input the STOP command to transition to standby state, after you use the DISCONNECT command.



When no STOP command is input after the execution of DISCONNECT command, the disconnection detection automatically stops in one second, and transition to standby occurs.



- PHRASE command

① 1-byte command selection

・command

V2	V1	V0	F4	F3	F2	F1	F0

② 2-byte command selection

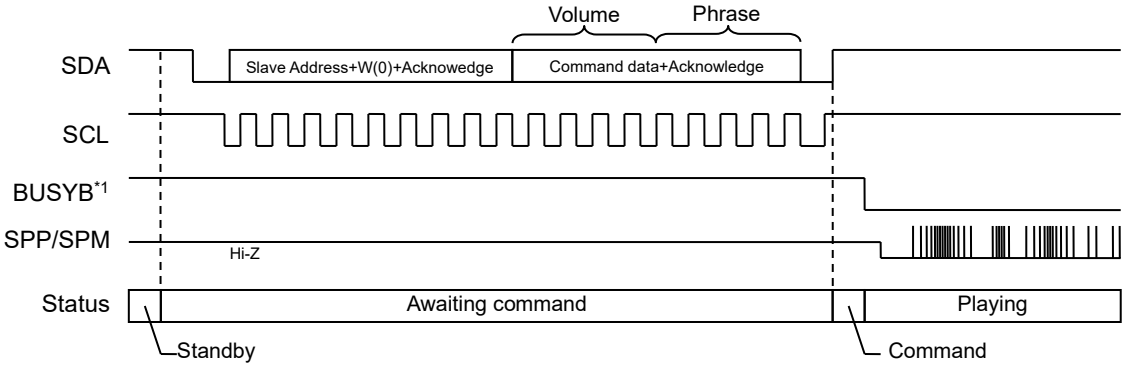
・command

*	*	*	V4	V3	V2	V1	V0	*	*	F5	F4	F3	F2	F1	F0

*：Since it is a bit that is not used to identify the command, it can be set to any value.

PHRASE command is playback command. Specifies an address of a phrase to be played back.
Command that is not set to be STOP command or DISCONNECT command is set to be PHRASE command.
An address of phrase to be played back is set when voice code data is generated with Speech LSI Utility.

Timings of PHRASE command are shown below.



*1：When used with default “H” level, CMOS output

Set the playback Phrase with F4-F0 or F5-F0.

① 1-byte command selection（initial value）

F4	F3	F2	F1	F0	Playing Phrase
0	0	0	1	0	Phrase0
		:			:
1	1	1	1	1	Phrase29

② 2-byte command selection（initial value）

F5	F4	F3	F2	F1	F0	Playing Phrase
0	0	0	0	1	0	Phrase0
			:			:
1	1	1	1	1	1	Phrase61

The volume can be set up with V2-V0 or V4-V0 set.
This is used to playback voice with a volume other than one set when the voice code data is generated.

① When 1-byte command is selected.

V2	V1	V0	Volume [dB]
0	0	0	Volume set at the time of generating voice code data is used*1
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

*Note 1: For edited phrase, volume set for each registered phrase is used

② When 2-byte command is selected.

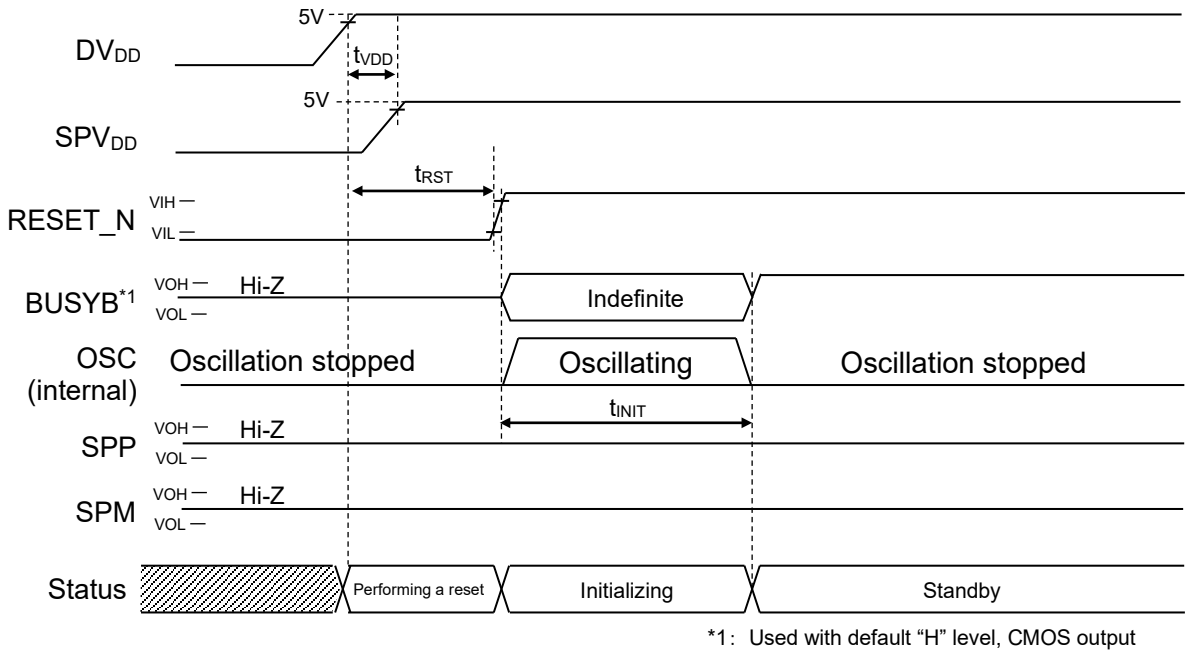
V4	V3	V2	V1	V0	Volume [dB]
0	0	0	0	0	+2.98
0	0	0	0	1	+2.70
0	0	0	1	0	+2.40
0	0	0	1	1	+2.10
0	0	1	0	0	+1.78
0	0	1	0	1	+1.45
0	0	1	1	0	+1.11
0	0	1	1	1	+0.76
0	1	0	0	0	+0.39
0	1	0	0	1	+0.00
0	1	0	1	0	-0.41
0	1	0	1	1	-0.83
0	1	1	0	0	-1.28
0	1	1	0	1	-1.75
0	1	1	1	0	-2.25
0	1	1	1	1	-2.77

V4	V3	V2	V1	V0	Volume [dB]
1	0	0	0	0	-3.34
1	0	0	0	1	-3.94
1	0	0	1	0	-4.58
1	0	0	1	1	-5.28
1	0	1	0	0	-6.04
1	0	1	0	1	-6.87
1	0	1	1	0	-7.79
1	0	1	1	1	-8.82
1	1	0	0	0	-9.99
1	1	0	0	1	-11.34
1	1	0	1	0	-12.94
1	1	0	1	1	-14.90
1	1	1	0	0	-17.44
1	1	1	0	1	-21.04
1	1	1	1	0	-27.31
1	1	1	1	1	Volume set at the time of generating voice code data is used*1

*Note 1: For edited phrase, volume set for each registered phrase is used

■ TIMING DIAGRAMS

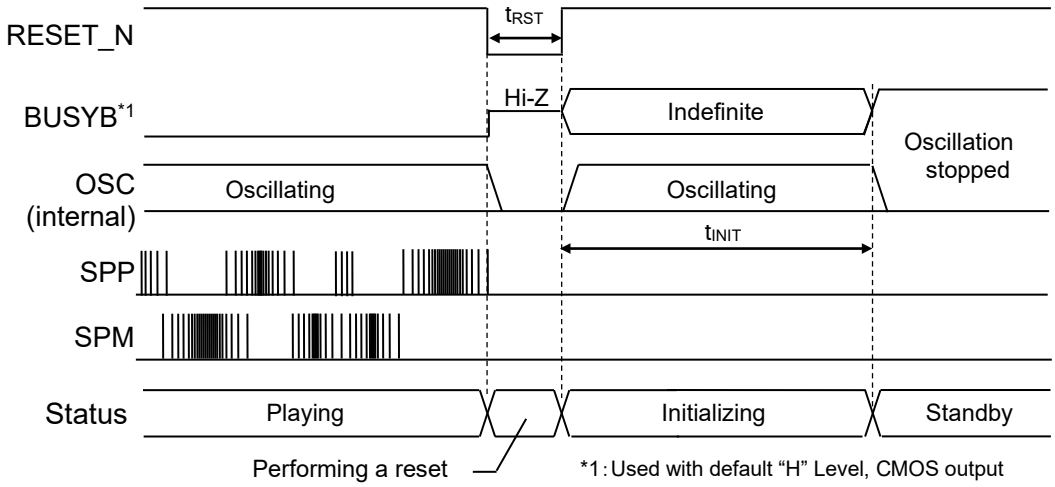
- Power-On Timing



*1: Used with default “H” level, CMOS output

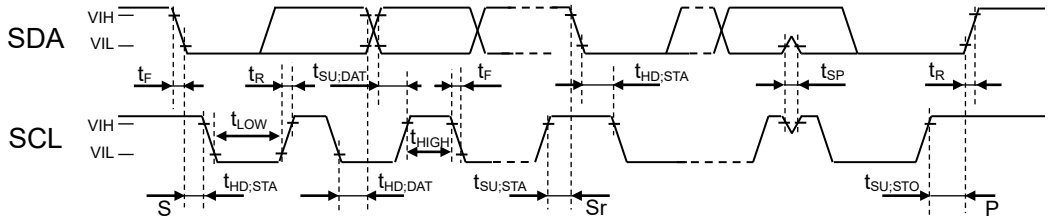
Turn on DVDD and SPVDD simultaneously, or turn on SPVDD after turning on DVDD.
Turn on DVDD and SPVDD simultaneously, or turn on SPVDD after turning on DVDD.
When DV_{DD} or SPV_{DD} falls below recommended operation power supply voltage range, “L” level must be input to RESET_N pin.

- Power down timing (RESET_N pin)



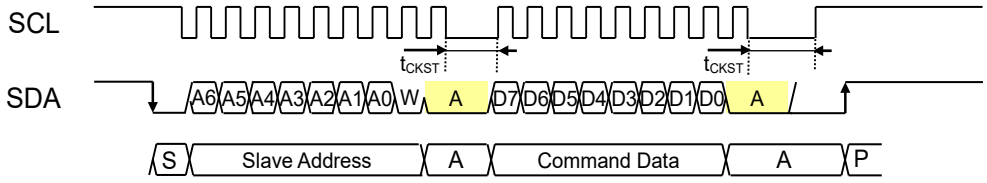
When DV_{DD} or SPV_{DD} falls below recommended operation power supply voltage range, “L” level must be input to RESET_N pin.

- I²C interface timing

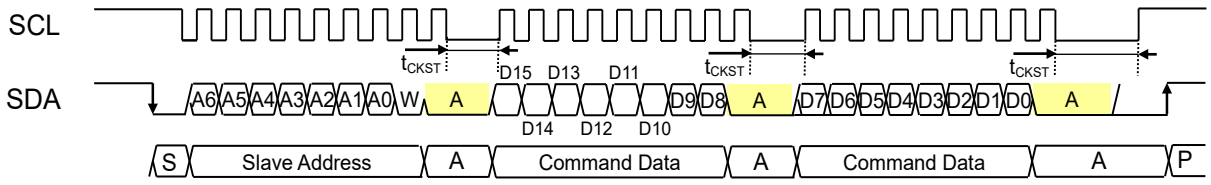


S: Start condition
Slave Address: Slave Address
A: Acknowledge
Command Data: Command
P: Stop condition

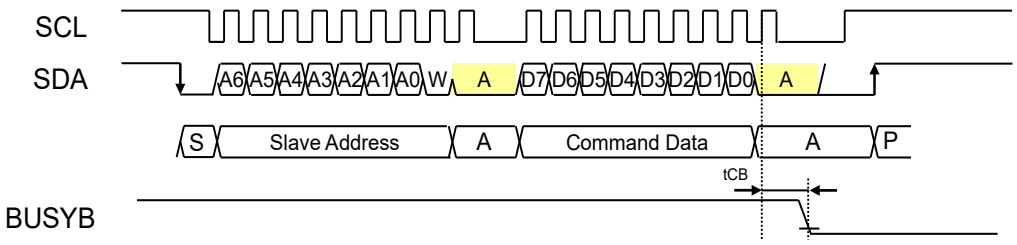
Timing chart for 1-byte configuration command input



Timing chart for 2-byte configuration command input

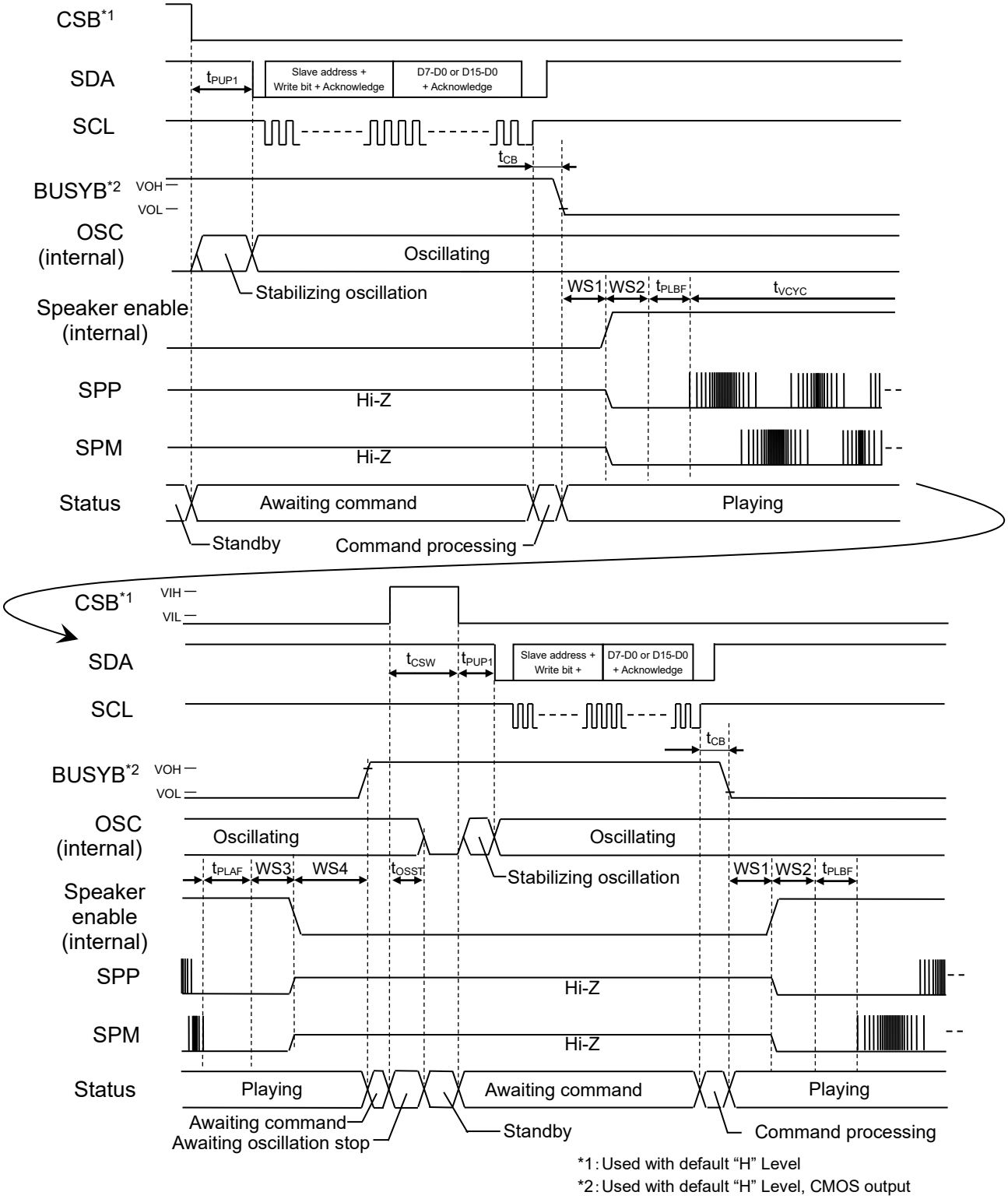


BUSYB output timing



- CSB use mode
  - ◆ Play Oncemode timing

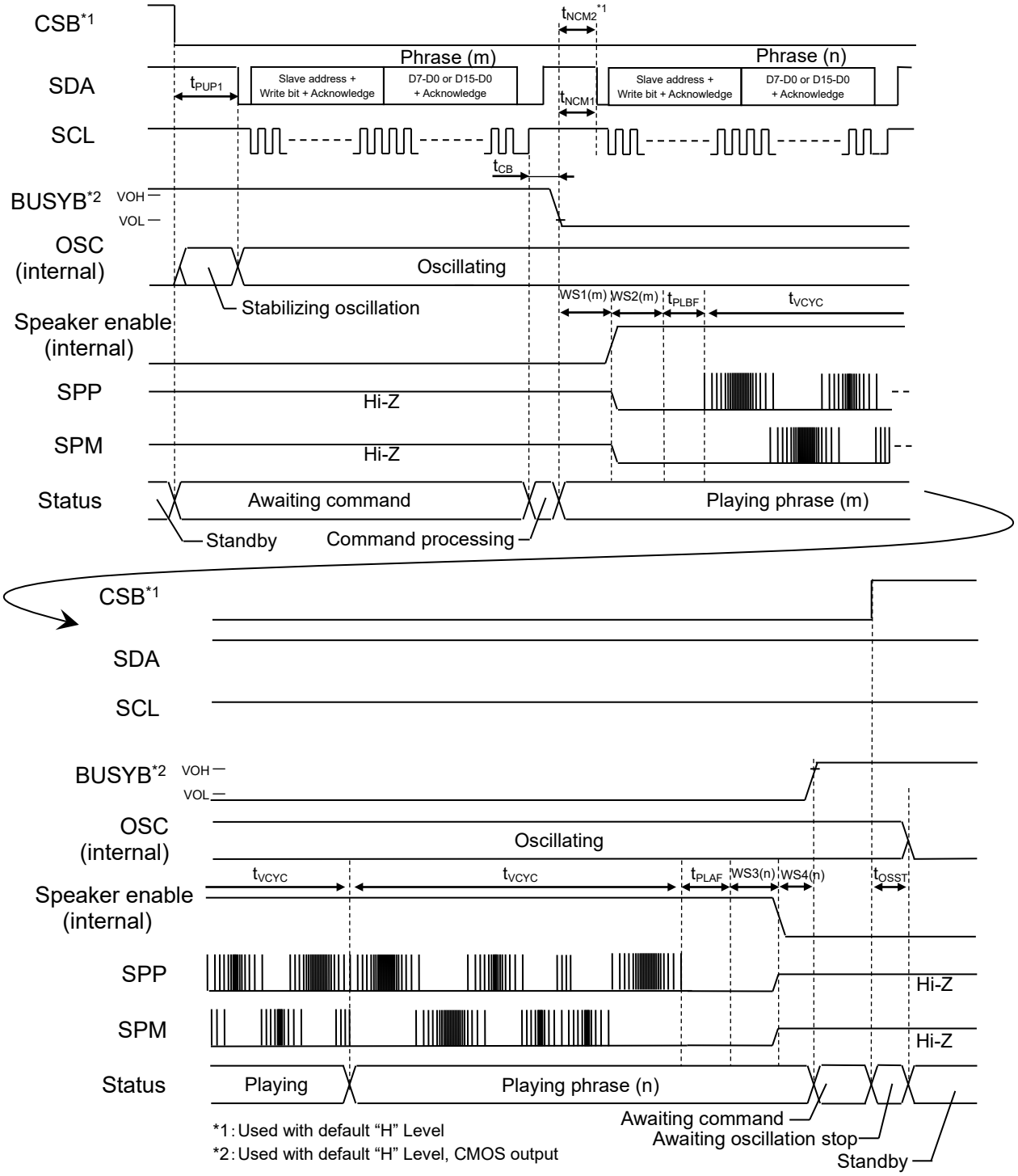
After playback of phrase (m) ends, playback request for the next phrase (n) is accepted and the phrase (n) is played back. All the commands become invalid during playback of phrase (m).



*1 : Used with default “H” Level
*2 : Used with default “H” Level, CMOS output

◆ 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 the Phrase (n) playback is started.

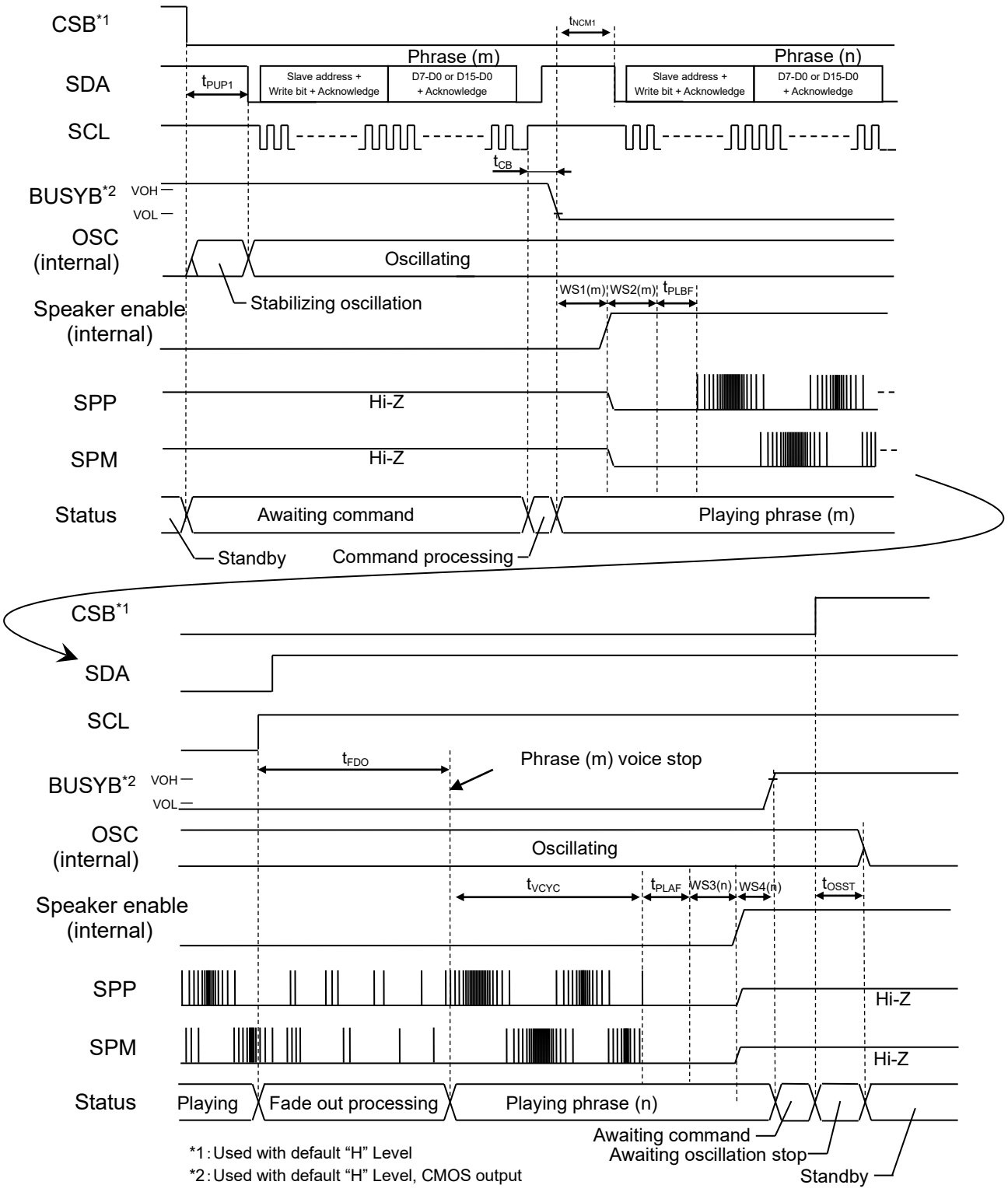


・Under Scheduled Play mode, playback is stopped by STOP command.

*1: In Scheduled Play Once mode, the phrase (n) is played back immediately after the end of the playback of the phrase (m), in response to an input of a playback request (PHRASE command) for the next phrase (phrase (n)) within t_{NCM}.

◆ 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.

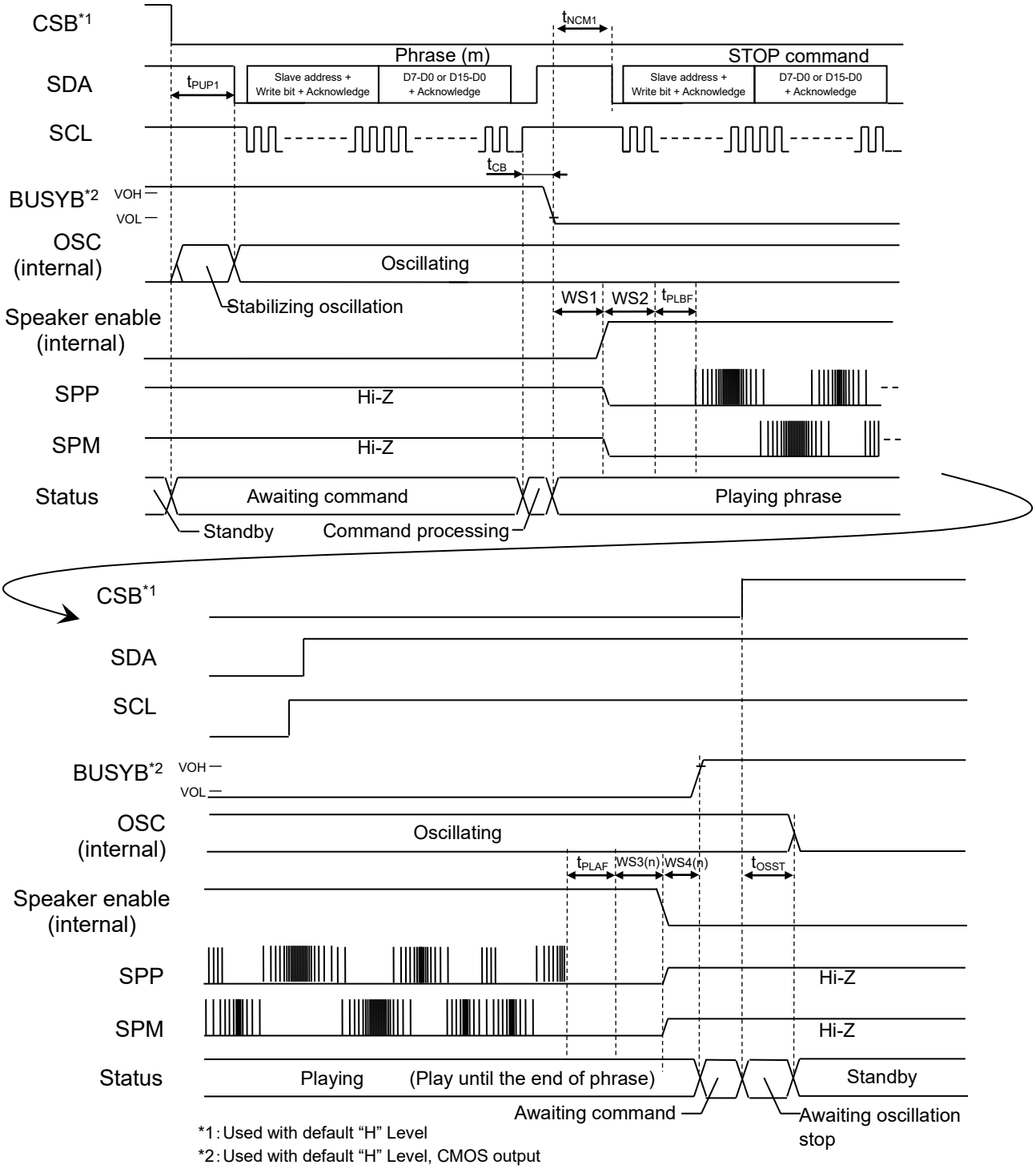


*1 : Used with default "H" Level
*2 : Used with default "H" Level, CMOS output

・Under Change Immediately mode, playback is stopped by STOP command.

- Scheduled Play Once mode and Scheduled Play mode Timing voice stop timing

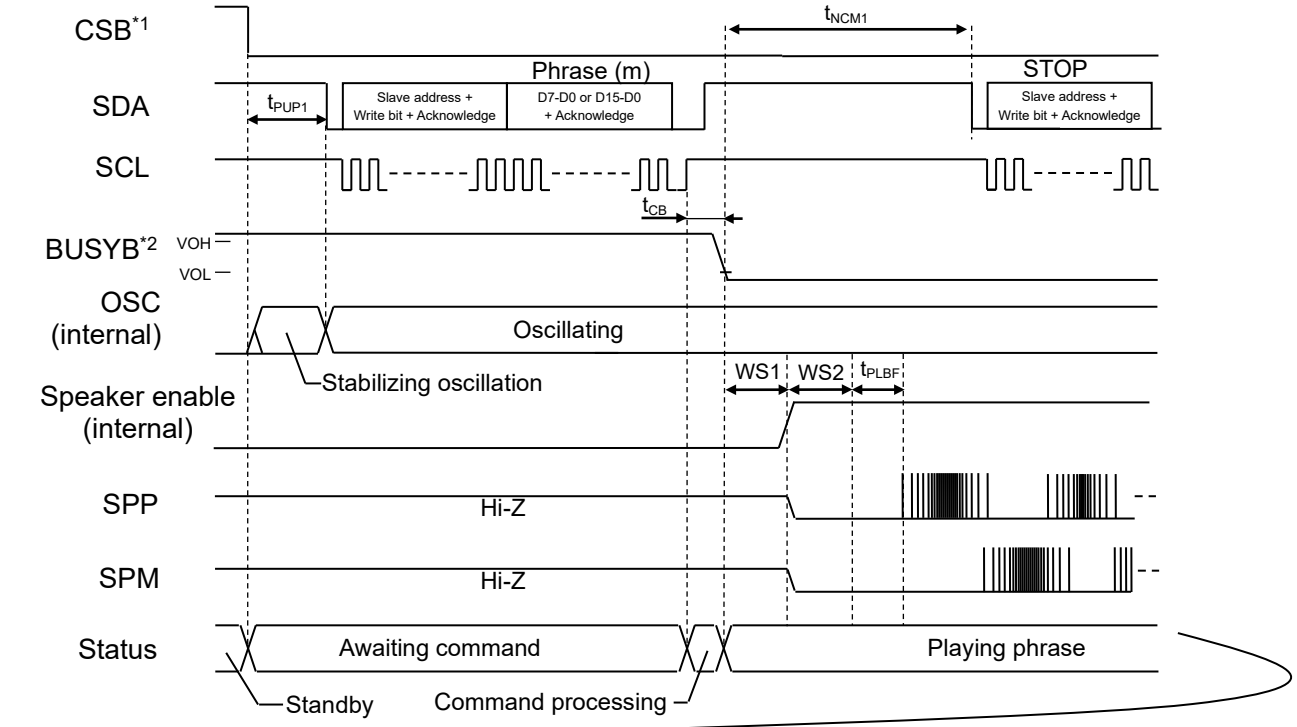
After STOP command is input, the phrase is played back until the end, and the playback stops.

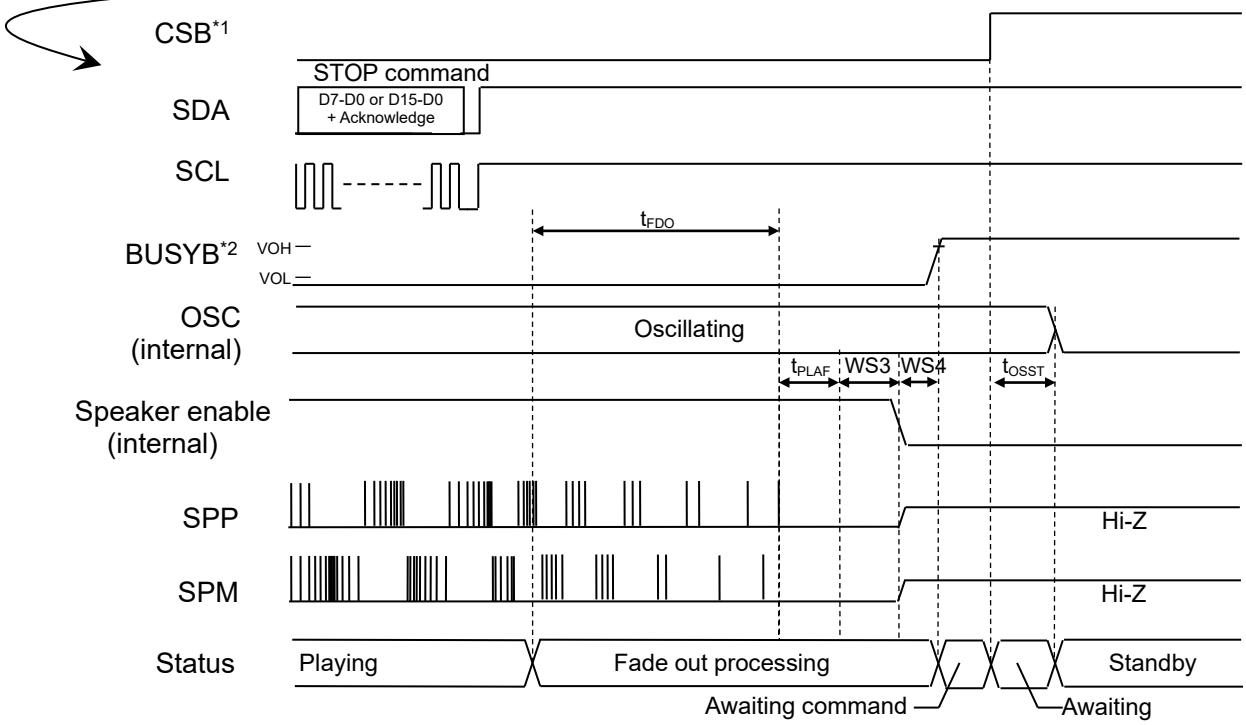


*1: Used with default "H" Level
*2: Used with default "H" Level, CMOS output

◆ Timing which stops the playback in Change Immediately mode and Change Immediately Once mode

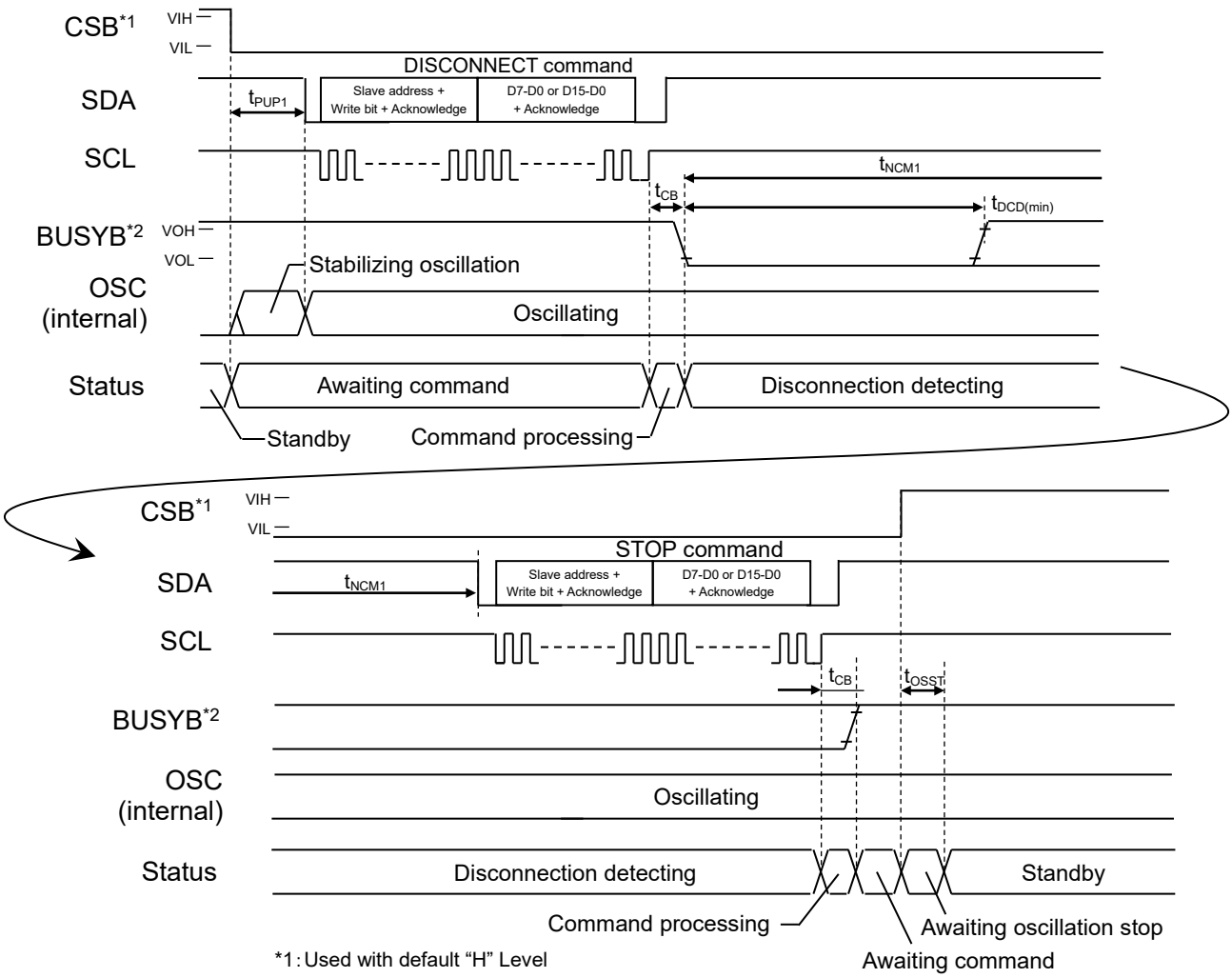
After STOP command is input, the voice fades out, and the playback stops.





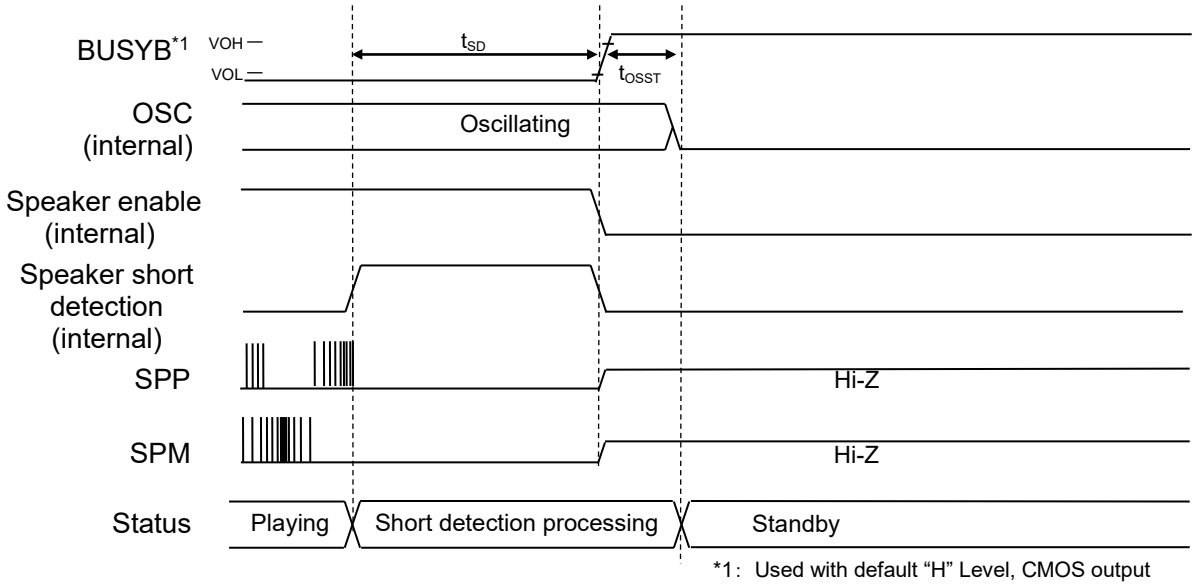
*1 : Used with default “H” Level
*2 : Used with default “H” Level, CMOS output

◆ Disconnection detection timing



*1: Used with default "H" Level
*2: Used with default "H" Level, CMOS output

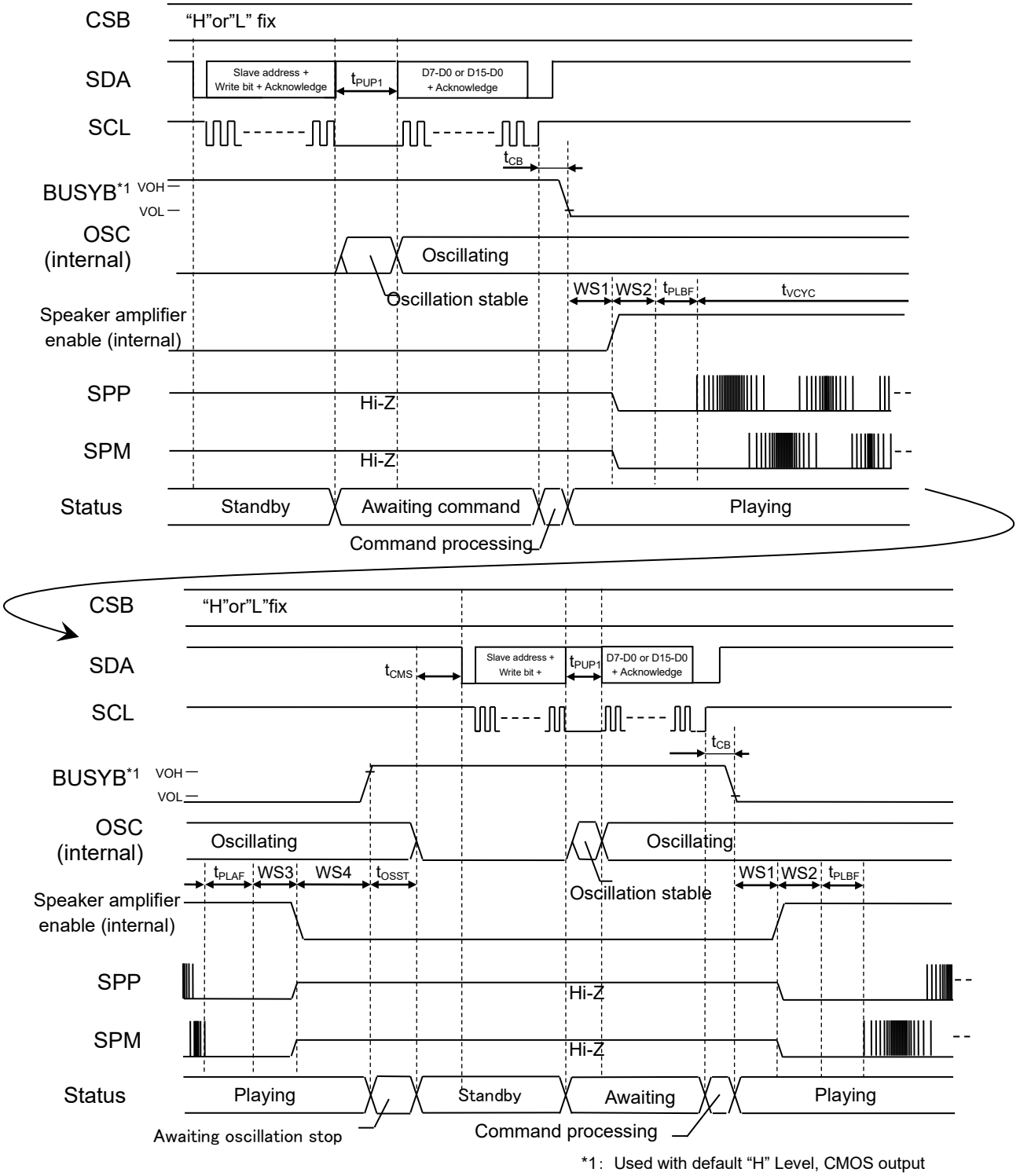
◆ Speaker short detection timing



*1: Used with default "H" Level, CMOS output

- CSB unused mode
  - ◆ Play Oncemode/Scheduled Play Once/Change Immediately Once timing

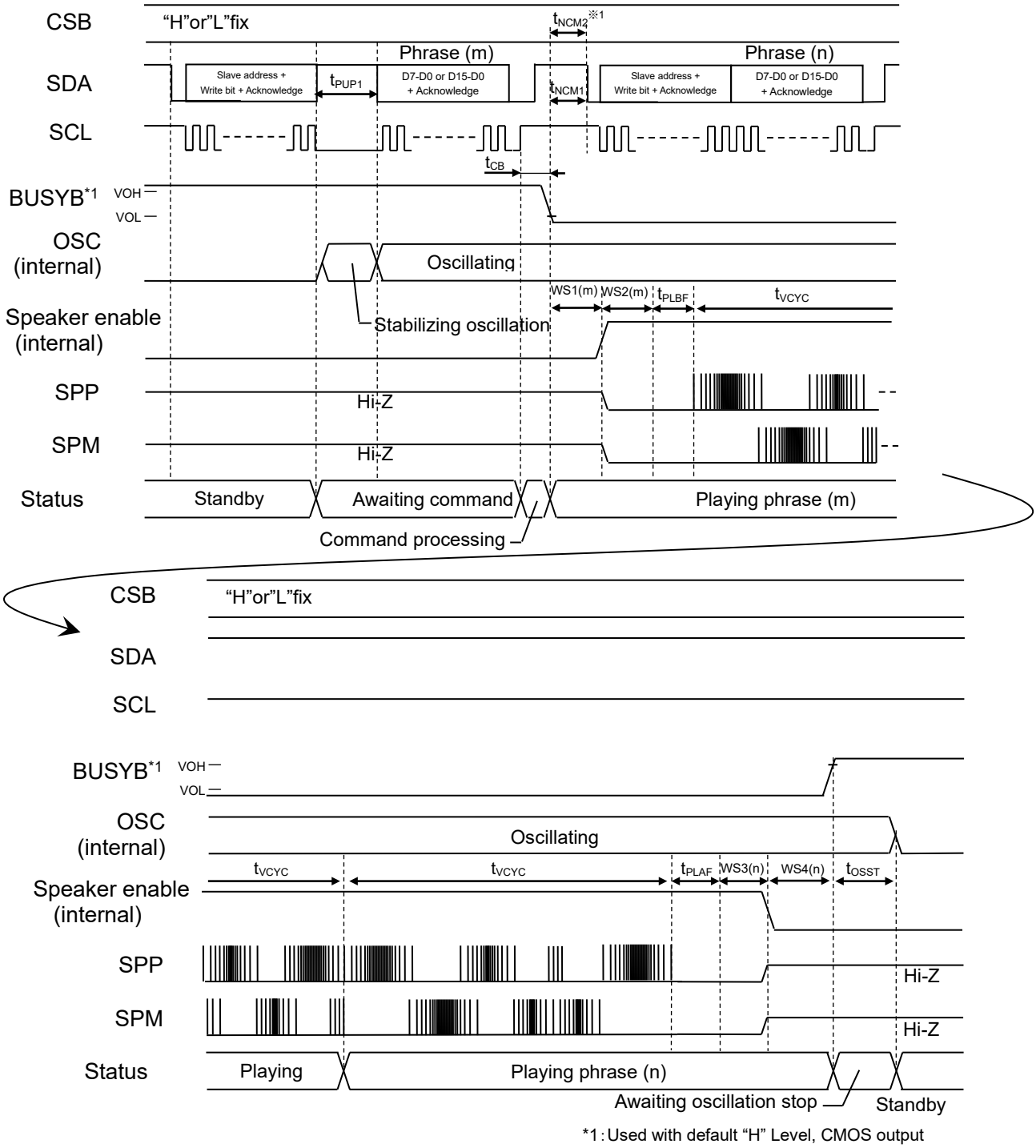
After playback of phrase (m) ends, playback request for the next phrase (n) is accepted and the phrase (n) is played back.
All the commands become invalid during playback of phrase (m).
After BUSYB has shifted to "H" level, input the PHRASE command after $t_{OSST}+t_{CMS}$ has elapsed.



*1: Used with default "H" Level, CMOS output

◆ 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 the Phrase (n) playback is started.

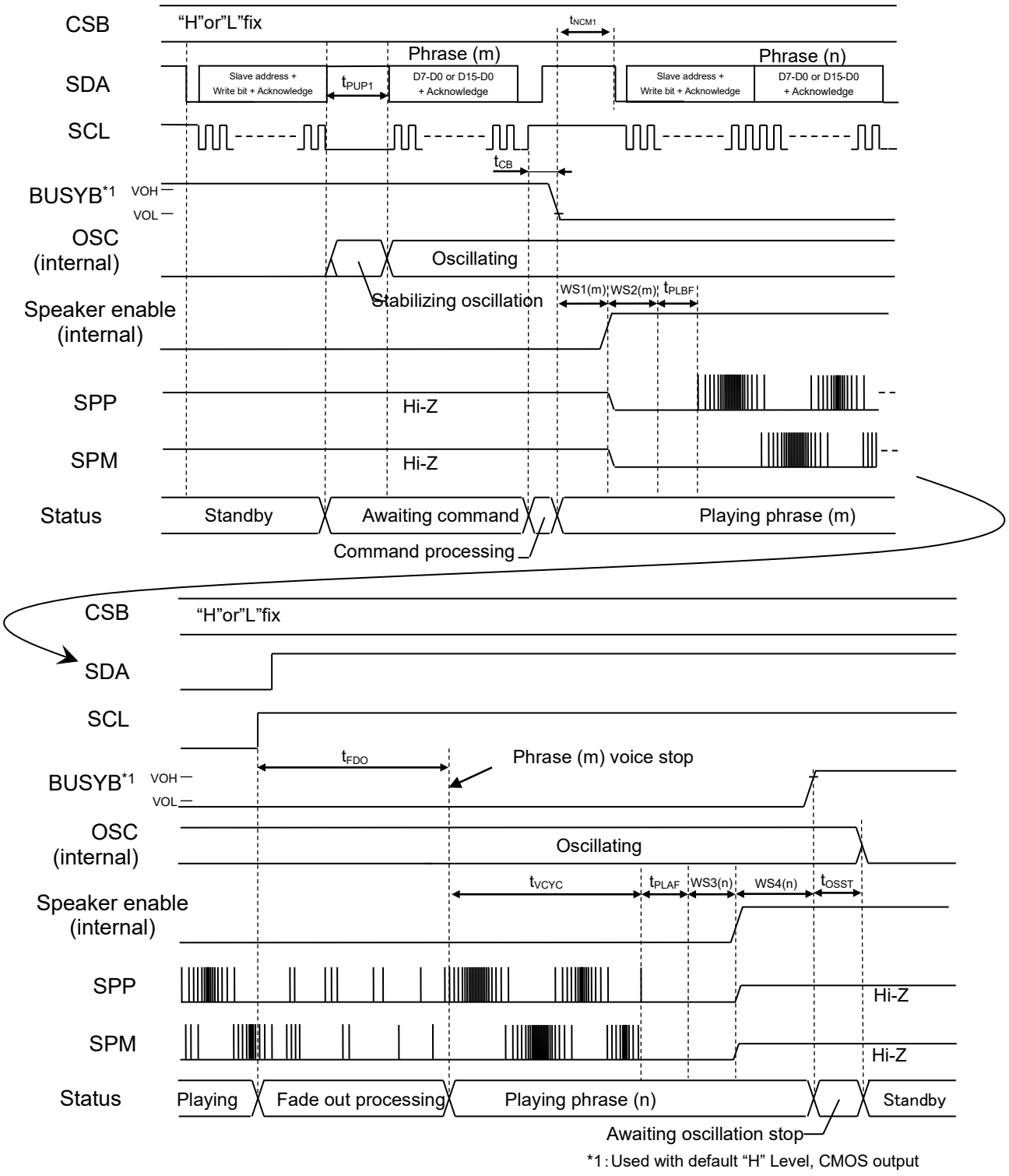


・・Under Scheduled Play mode, playback is stopped by STOP command.

*1: In Scheduled Play Once mode, the phrase (n) is played back immediately after the end of the playback of the phrase (m), in response to an input of a playback request (PHRASE command) for the next phrase (phrase (n)) within t_{NCM}.

◆ 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.

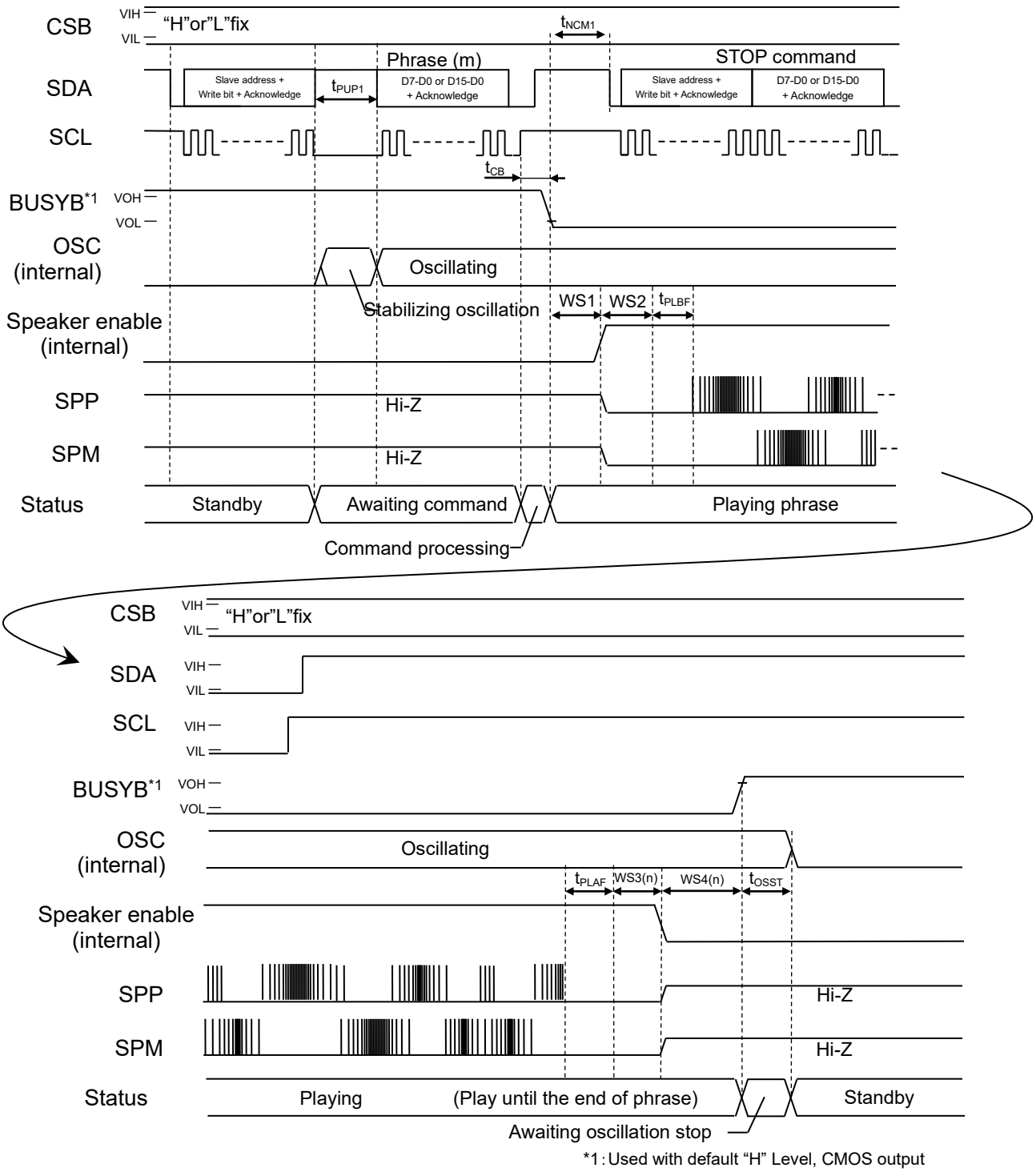


*1 : Used with default "H" Level, CMOS output

・Under Change Immediately mode, playback is stopped by STOP command.

- Scheduled Play Once mode and Scheduled Play mode Timing voice stop timing

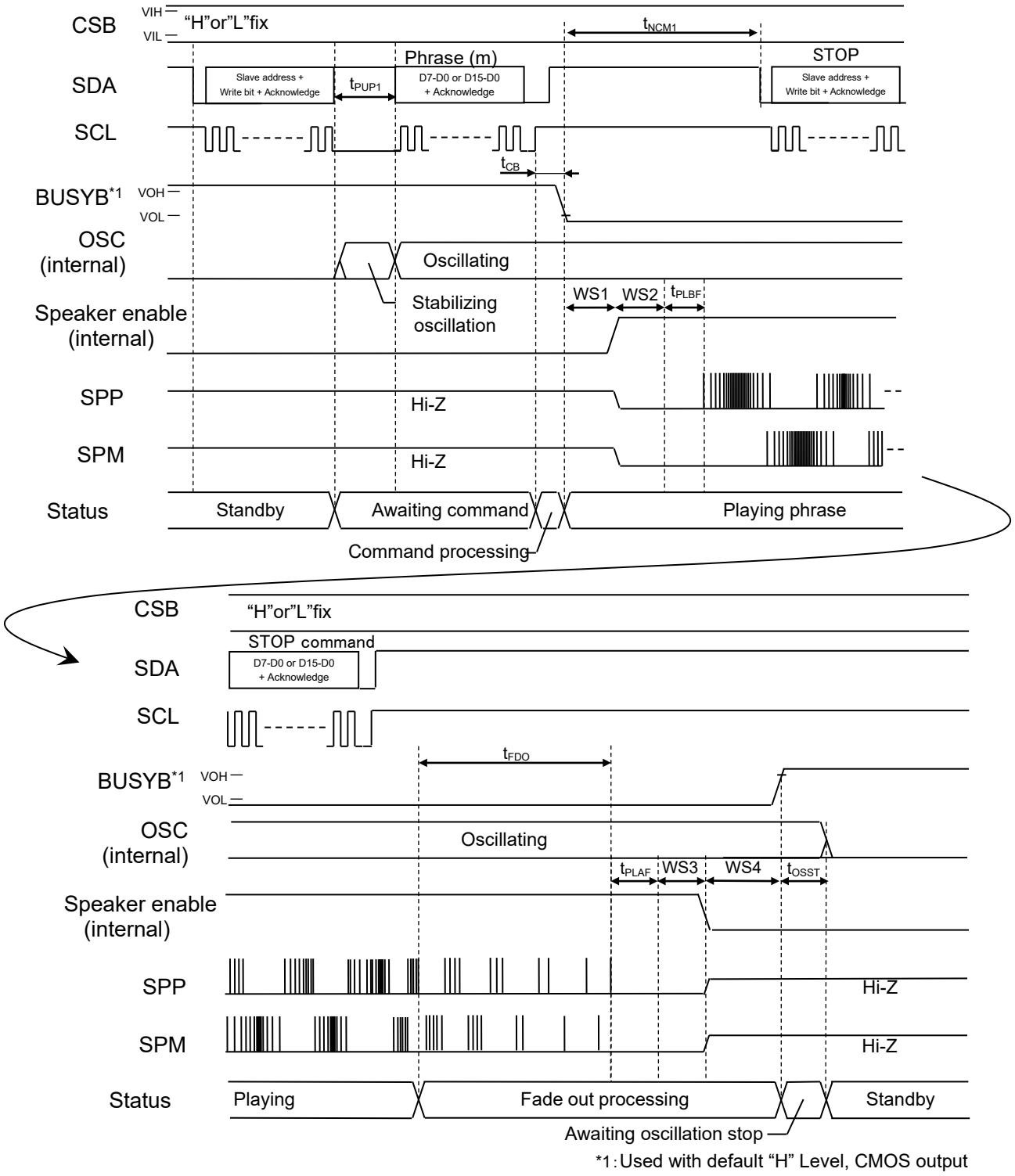
After STOP command is input, the phrase is played back until the end, and the playback stops.



*1 : Used with default "H" Level, CMOS output

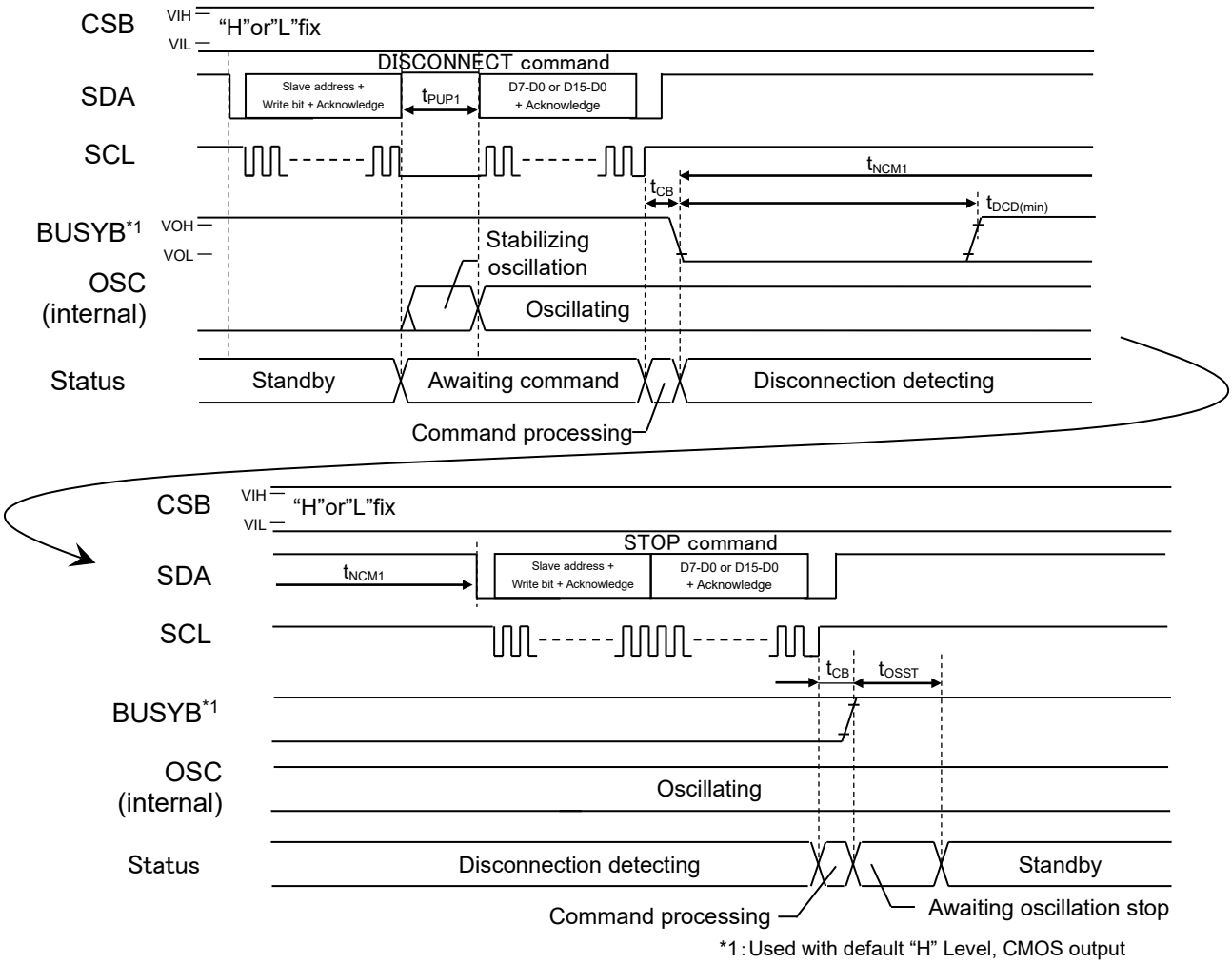
◆ Timing which stops the playback in Change Immediately mode and Change Immediately Once mode

After STOP command is input, the voice fades out, and the playback stops.



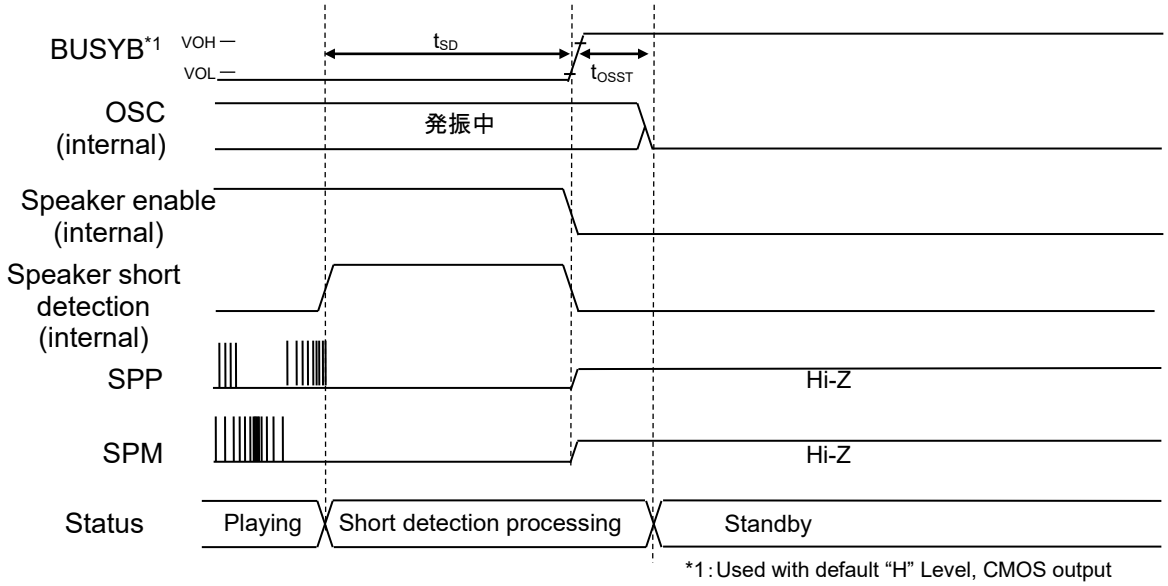
*1 : Used with default "H" Level, CMOS output

◆ Disconnection detection timing



*1 : Used with default "H" Level, CMOS output

◆ Speaker short detection timing



*1 : Used with default "H" Level, CMOS output

■ Code Option Setting Item

Items set on Code Option Setting screen for Speech LSI Utility are as follows.

・Speaker pin short detection function

Use of speaker pin short detection function	☐ (Not used)
	☐ (Used)

・Command setting

Command type	○1 byte (communicate with 1-byte command)
	○2 byte (communicate with 2-byte command)

STOP/DISCONNECT Command	Command bit sequence	
○Standard	STOP command	Set 0_0000b (1-byte command) Set 00_0000b (2-byte command)
	DISCONNECT command	Set 0_0001b (1-byte command) Set 00_0001b (2-byte command)
○Custom	STOP command	Set any bit sequence
	DISCONNECT command	Set any bit sequence (Set value different from STOP command)

・BUSYB Pins Setting

Use of BUSYB	Initial State	Condition	BUSYB pin status
☐ (Not used)	○L level Output	*	Fixed to “L” output
	○H level Output	*	Fixed to “H” output
☐ (Used)	○L level Output	○CMOS	Output initial value “L” with CMOS output
		○Nch Open Drain	Output initial value “L” with Nch open drain output
		○Pch Open Drain	Output initial value HiZ with Pch open drain output
		○Hi-Z	Hiz output
	○H level Output	○CMOS	Output initial value “H” with CMOS output
		○Nch Open Drain	Output initial value HiZ with Nch open drain output
		○Pch Open Drain	Output initial value “H” with Pch open drain output
		○Hi-Z	Hiz output

*: Setting value invalid

・I²C Setting

Use CSB	Initial State	Condition	CSB pin status
☐ (Not used)	*	*	Not used Fix to “H” level or “L” level
☐ (Used)	○L level Input	○ Pch Pull-up	Used with pull-up input Start internal oscillation with pin input “H” level
		○Hi-Z	Used with high impedance input Start internal oscillation with pin input “H” level
	○H level Input	○ Pch Pull-up	Used with pull-up input Start internal oscillation with pin input “L” level
		○Hi-Z	Used with high impedance input Start internal oscillation with pin input “L” level

*: Setting value invalid

Slave address	Set any value from 00h to 7 Fh

■ Event Setting Item

Items set on Event Setting screen for Speech LSI Utility are as follows.

・Playback mode
Set playback mode suitable for target playback, with reference to “Playback mode” in FUNCTIONAL DESCRIPTION.

・Volume setup
Set playback mode suitable for target playback, with reference to “Volume setup function” in FUNCTIONAL DESCRIPTION.

・Setting Wait time before and after volume playback
Set desired Wait time with reference to “Function of setting wait time before and after playback (WS1, WS2, WS3, WS4)”.

■ 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} =5 V, V_{OL}.max=0.4 V, I_{OL} =3 mA,
$R_P.min = (5\ V - 0.4\ V)/3\ mA \approx 1.5k\Omega$
holds.

○Maximum Value (R_P.max)
$R_P.max$ = 300 ns/[maximum capacitance of bus (F)]

For example, when the maximum capacitance of the bus is 100 pF,
$R_P.max = 300\ ns/100\ pF = 3k\Omega$
holds.

Pull-up resistor must be inserted between this pin and DV_{DD}

■ TERMINATION OF THE V_{DDL} PIN

The VDDL 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
VDDL	10 μF ±20%	The larger the connection capacitance, the longer the settling time.

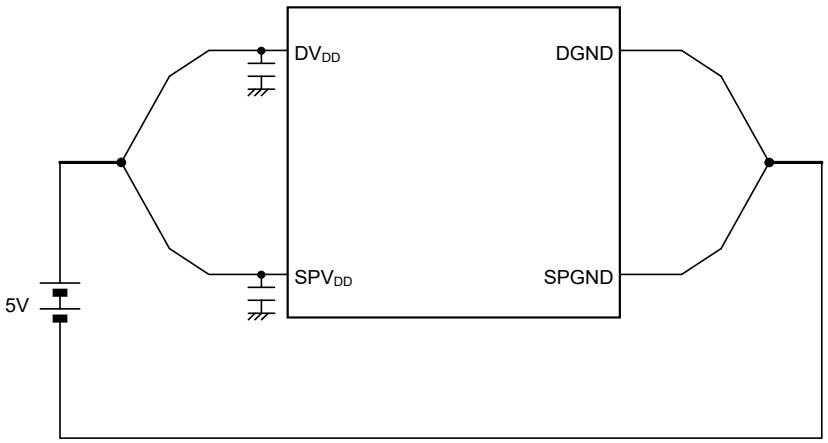
■ POWER SUPPLY WIRING

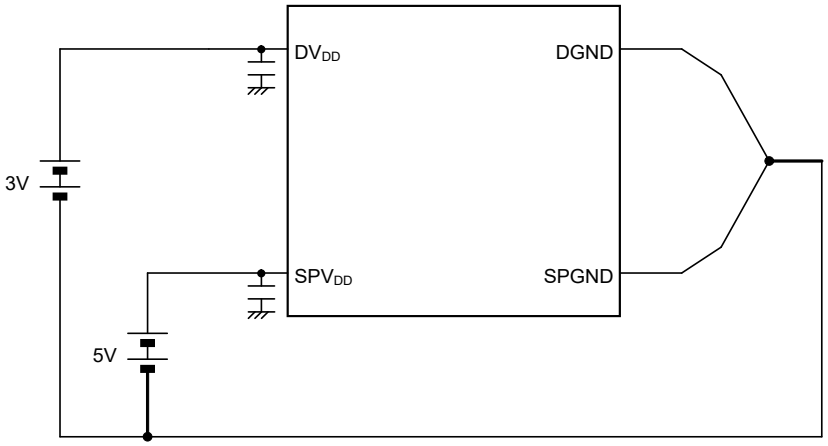
The power supplies of this LSI are divided into the following two:

· Power supply for logic circuitry (: DVDD)

· Power supply for speaker amplifier (: SPVDD)

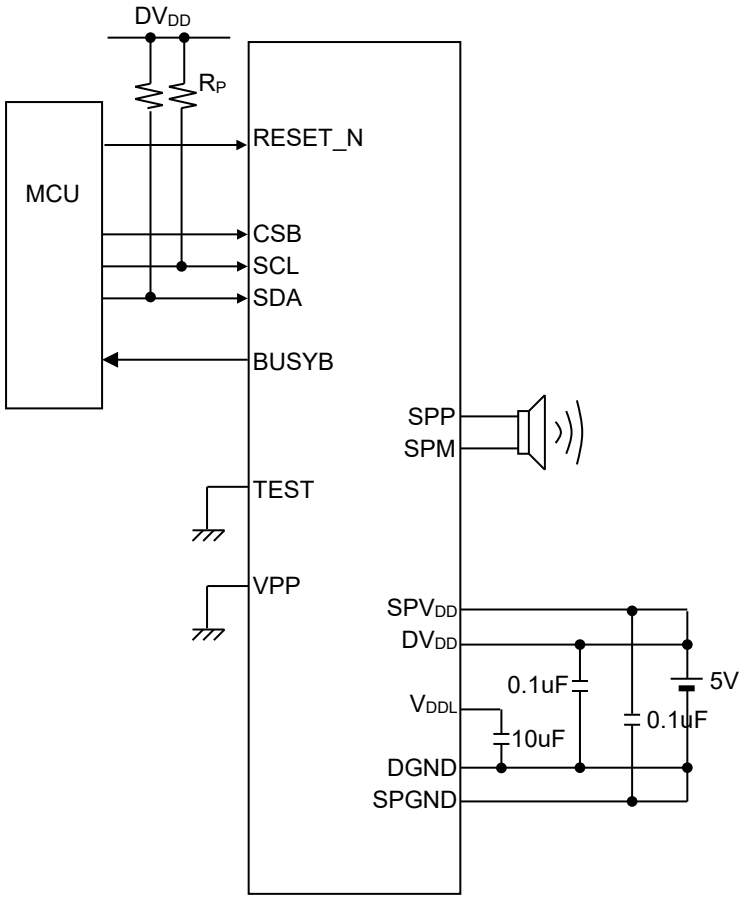
The example of power connection is shown below



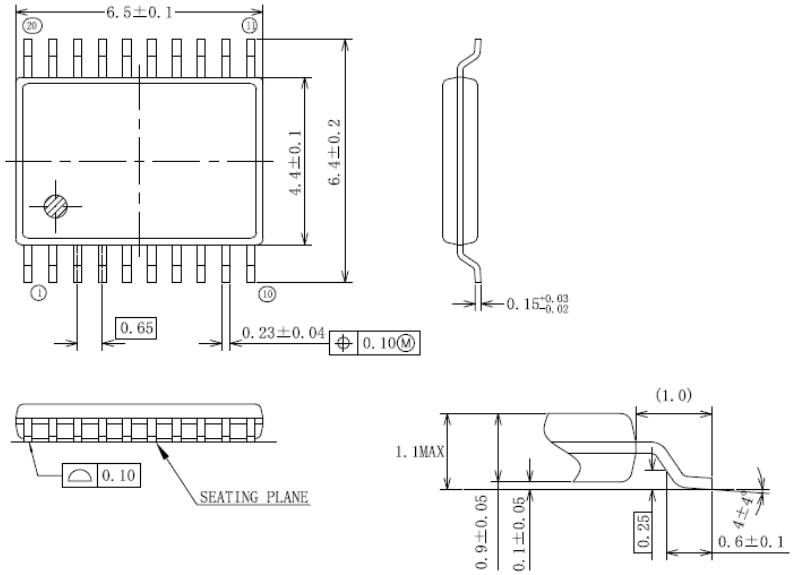


- Turn on DVDD and SPVDD simultaneously, or turn on SPVDD after turning on DVDD.
- Turn off DVDD and SPVDD simultaneously, or turn off DVDD after turning on SPVDD.

■ APPLICATION CIRCUIT



■ PACKAGE DIMENSION



注記
1. リード幅にはダムバーカット残りを含まない。
2. パッケージ幅にはモールド樹脂バリ及びサポートカット残りを含まない。
又モールドの上下のズレは含まない。
3. SEATING PLANEとは、パッケージを取り付ける面に対して、
パッケージが接触し合う面である。

NOTES:
1. LEAD WIDTH DOES NOT INCLUDE TRIM OFFSET.
2. PACKAGE WIDTH AND LENGTH DO NOT INCLUDE MOLD PROTRUSION, DIEPAD SUPPORT PROTRUSION AND CAVITY OFFSET BETWEEN TOP AND BOTTOM CAVITY.
3. THE SEATING PLANE IS THE SURFACE WHICH THE PACKAGE IS MOUNTED ON AND GETS IN CONTACT WITH.

LAPIS Technology Co., Ltd.			
PACKAGE CODE	P-TSSOP20-0225-0.65-TK6		
PACKAGE MATERIAL	EPOXY RESIN	UNIT	mm
LEAD FLAME MATERIAL	Cu ALLOY	DWG No.	QSL-68909
LEAD FINISH	Sn	REVISION	2
SOLDER THICKNESS	MORE THAN 5μm	1st ISSUE	Feb/04/2013
PACKAGE MASS (g)	0.08TYP.	REVISED	Oct/05/2020

Notes for Mounting the Surface Mount Type Package

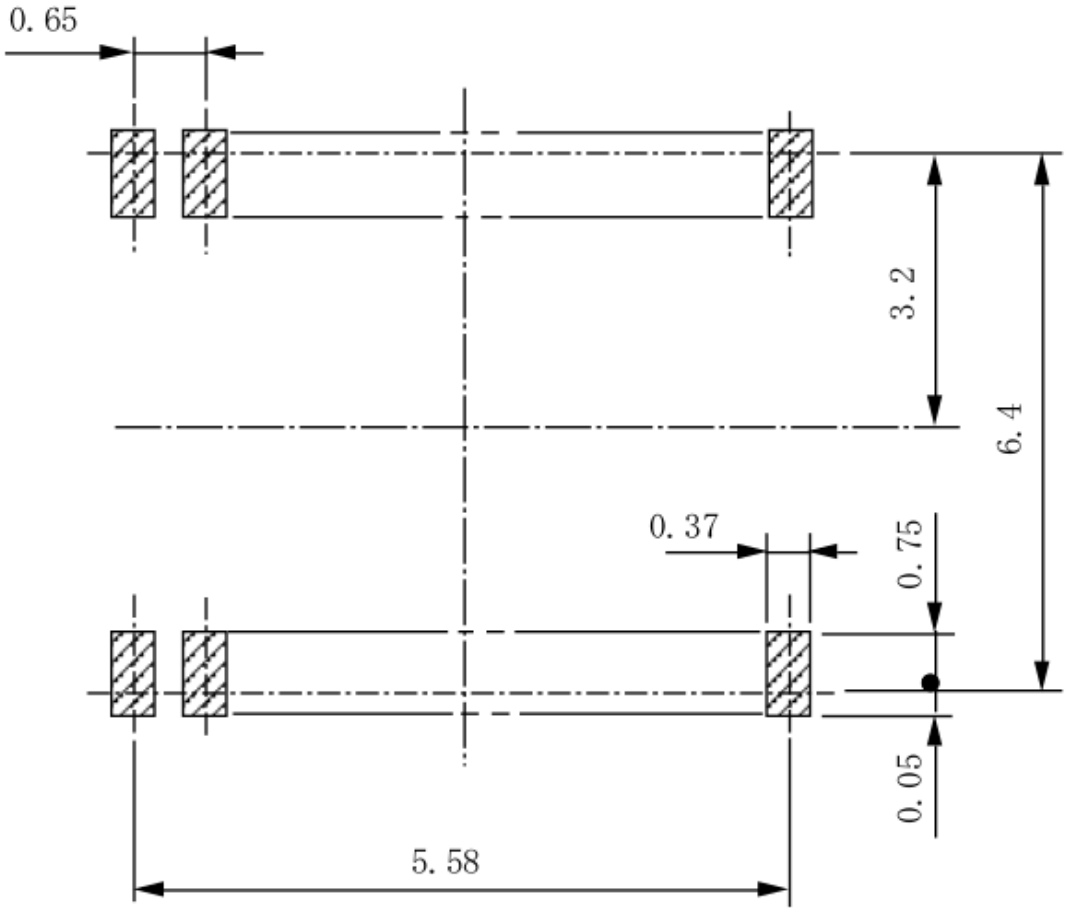
The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact a ROHM sales office for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature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

PCB Layer	JEDEC 4layers	JEDEC 2layers
PCB	(W/L/t= 76.2 / 114.3 / 1.6 (mm))	
Air cooling conditions	Calm(0m/sec)	
Heat resistance (θ ja)	63.7[°C /W]	69.4[°C /W]
Heat resistance (θ jc)	0.46[℃/W]	0.48[°C /W]
Maximum power consumption of LSI (PMax) At 1W into 8Ω playback	0.28[W]	

TjMax of this LSI is 125 °C. TjMax is expressed with the following formulas.
TjMax=TaMax+ θ ja×PMax

半田付け部端子存在範囲図

Mounting area for package lead soldering to PC boards



［単位/Unit:mm］

実装基板のフットパターンの設計の際には、実装の容易さ、接続の信頼性、配線の引き回し、半田ブリッジ発生のないことなどを十分考慮してください。

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When laying out PC boards, it is important to design the foot pattern so as to give consideration to ease of mounting, bonding, positioning of parts,reliability, wiring,and elimination of solder bridges.

The optimum design for the foot pattern varies with the materials of the substrate,the sort and thickness of used soldering paste,and the way of soldering. Therefore when laying out the foot pattern on the PC boards, refer to this figure which mean the mounting area that the package leads are allowable for soldering to PC boards.

■ REVISION HISTORY

Document No	Date	Page		Description
		Previous Edition	Current Edition	
FEDL22Q294-01	Mar 5, 2021	-	-	Formal 1st edition.
FEDL22Q294-02	Mar 30, 2021	6	6	SPP, SPM terminal output short-circuit current value change. (Before change) 300mA (After change) 600mA
FEDL22Q294-03	Oct 4, 2021	8	8	tSCL Fixed an error in the tSCL condition item. (Before change) I^2C high speed mode (After change) I^2C Fast mode
		8	8	Add clock stretch time tCKST.
		9	9	BUSYB signal deleted from I2C timing chart.
		15,16, 19,20	15,16, 19,20	Changed SI terminal to SDA terminal.
		16	16	Speaker short-circuit detection warning added.
		17	17	Added a note on using commands.
		19	19	Added a note on phrase playback after the STOP command.
		24	24	Clock stretch time Timing chart added
		24	24	BUSYB output timing added.
		31	31	Added a note for phrase playback after transitioning to BUSYB "H" level.
		43	43	Describe the thermal resistance information of the package
		-	44	Added "Mounting area for package lead soldering to PC boards".
FEDL22Q294-04	Feb 9, 2024	-	2	Added application information.
		1	2	Changed shipping form to table format.
		46	47	Revised the Note.

Notes

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