

MS87V1021

Recording and Playback IC with Built-in 2-Mbit DRAM

GENERAL DESCRIPTION

The MS87V1021 is a single chip recording and playback IC that is controlled by the microcontroller in serial mode, compresses voice with the 4-bit OKI ADPCM algorithm or 4-bit OKI ADPCM2 algorithm with high tone quality, and has 2-Mbit DRAM in which recorded data is stored and 512-Kbit mask ROM in which fixed messages reside. The MS87V1021 includes such features as Normal Recording and Playback, Delayed playback, Retroactive playback, Fast forwarding, and Rewinding.

The internal memory in which voice data is stored allows a recording/playback system to be constructed merely by externally connecting it to a microphone, a speaker driving amplifier, and a speaker.

FEATURES

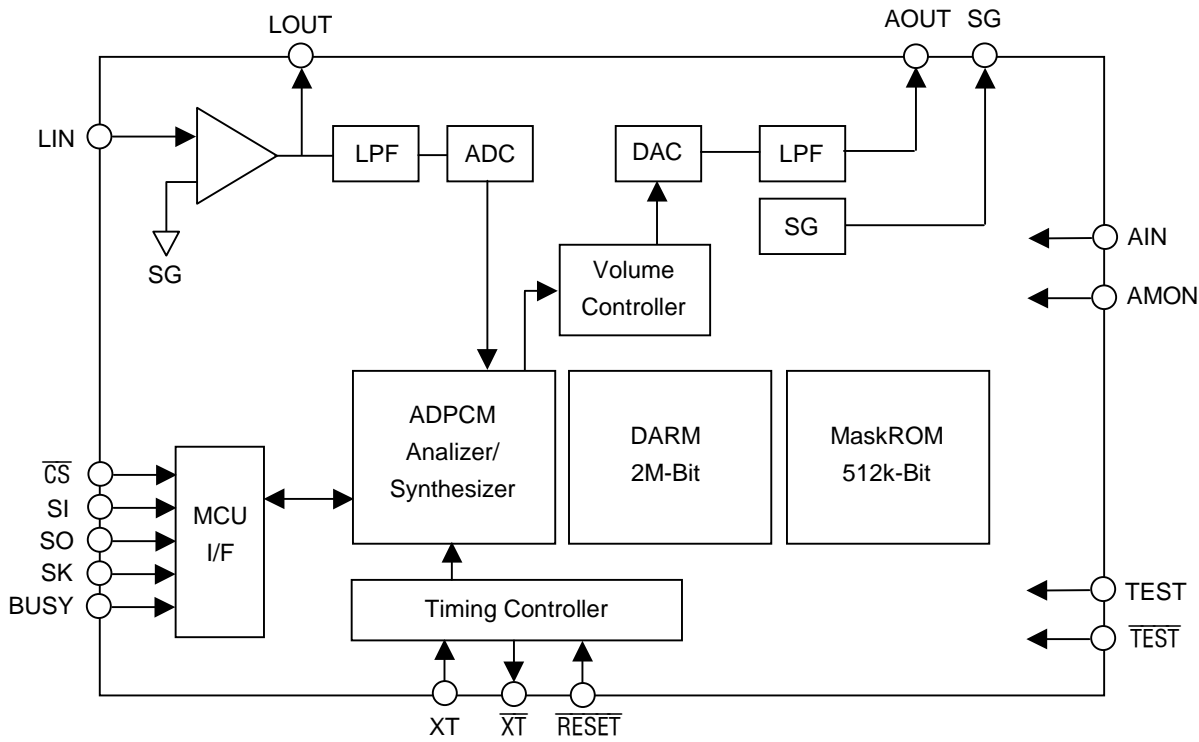
- Serial microcontroller interface (clock synchronized)
- Built-in 512-Kbit mask ROM for fixed messages
ROM playback time :
Approx. 15 seconds (Fsam = 8.0 kHz)
Approx. 20 seconds (Fsam = 6.4 kHz)
Approx. 30 seconds (Fsam = 4.0 kHz)
- Voice analyzing and synthesizing system :
4-bit OKI ADPCM or 4-bit OKI ADPCM2 algorithm
8-bit OKI non-linear PCM algorithm (for ROM playback only)
- Sampling frequency (source oscillation frequency: 4.096 MHz) :
4.0 kHz, 5.3 kHz, 6.4 kHz, 8.0 kHz, or 10.6 kHz
- Recording time:
Approx. 60 seconds (Fsam = 8.0 kHz)
Approx. 80 seconds (Fsam = 6.4 kHz)
Approx. 120 seconds (Fsam = 4.0 kHz)
- Built-in 14-bit A-to-D and D-to-A converters
- Built-in LPF: Attenuation rate -40 dB/oct
- Number of phrases
Variable message: 255 phrases
Fixed phrases: 255 phrases
- Source oscillation frequency: 4.096 MHz
- Supply voltage: 2.7 to 3.6 V
- Operating current:
15 mA max. (source oscillation frequency : 4.096 MHz, Supply voltage : 3.6 V)
- Operating temperature: -20 to +70° C
- Package: 32-pin TSOP Type I

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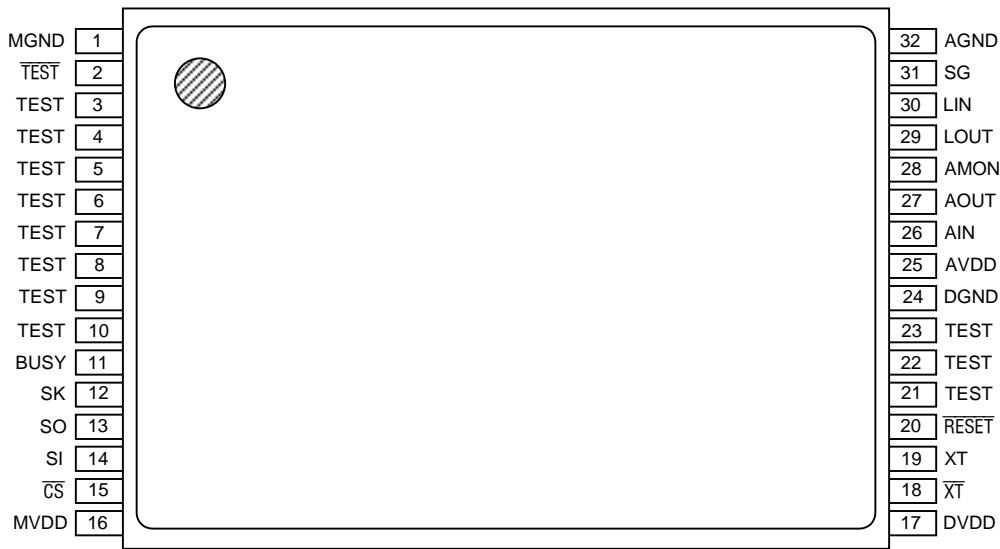
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BLOCK DIAGRAM



PIN CONFIGURATION (TOP VIEW)

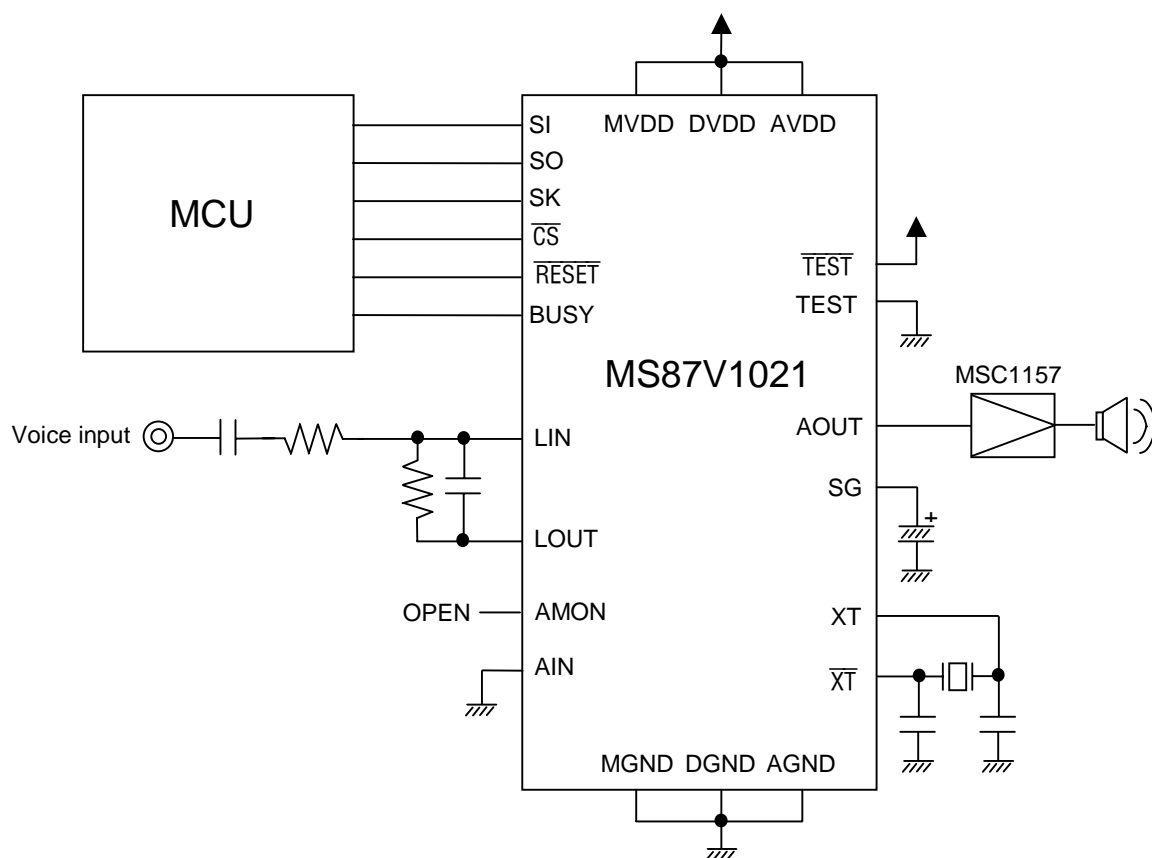


32-pin plastic TSOP Type I (TSOP32-P814-K)

PIN DESCRIPTION

| Pin No. | Symbol | I/O | Description |
|---------------------|----------------------------------|--------|---|
| 14 | SI | I | Inputs 8-bit command or data. |
| 13 | SO | O | Outputs 8-bit status or data. |
| 12 | SK | I | Data transfer clock for SI and SO. |
| 15 | $\overline{\text{CS}}$ | I | The SK pulse is accepted when this pin is "L". The SK pulse is not accepted when this pin is "H". |
| 11 | BUSY | O | Outputs "H" level during command execution. At that time, do not input a command from the external microcontroller. |
| 19 18 | XT $\overline{\text{XT}}$ | I O | Crystal oscillator connection pins. When using an external clock, input the clock via the XT pin and leave the $\overline{\text{XT}}$ pin unconnected. When an external clock is used in power down mode, fix the XT pin at the GND level. |
| 20 | $\overline{\text{RESET}}$ | I | The device is reset when "L" level is input. When oscillation starts, set this pin to "L" level until oscillation becomes stable, and set to "H" level after oscillation becomes stable. Data stored in the internal DRAM is cleared when "L" level is input, while data is not erased when a reset signal is input for the purpose of releasing the Pdown1 mode. |
| 31 | SG | O | Analog reference voltage (signal ground). Connect a 1 μF capacitor between AGND and this pin. |
| 30 | LIN | I | Inverting input pin for internal OP amplifier. The non-inverting input pin is internally connected to SG. |
| 29 | LOUT | O | Output pin for internal OP amplifier |
| 27 | AOUT | O | Output pin for playback LPF. This pin outputs playback waveforms and is connected to the speaker driving amplifier. |
| 2 3-10, 21-23 | $\overline{\text{TEST}}$ TEST | I | Testing pin. The $\overline{\text{TEST}}$ pin is fixed at the V_{DD} level and the TEST pins are fixed at the GND level. |
| 28 | AMON | O | Output pin for analog testing. Leave it unconnected. |
| 26 | AIN | I | Input pin for analog testing. Fix it at the GND level. |
| 17 | DVDD | — | Digital power supply pin. Connect a 0.1 μF or more bypass capacitor between DGND and this pin. |
| 24 | DGND | — | Digital GND pin |
| 16 | MVDD | — | Power supply pin for DRM. Connect a 0.1 μF or more bypass capacitor between MGND and this pin. |
| 1 | MGND | — | Ground pin for DRAM |
| 25 | AVDD | — | Analog power supply pin. Connect a 0.1 μF or more bypass capacitor between AGND and this pin. |
| 32 | AGND | — | Analog GND pin |

APPLICATION CIRCUIT EXAMPLE



ABSOLUTE MAXIMUM RATINGS

(GND = 0 V)

| Parameter | Symbol | Condition | Rated value | Unit |
|-----------------------------|-----------|--------------------------|----------------------|------------------|
| Power supply voltage | V_{DD} | $T_a = 25^\circ\text{C}$ | -0.5 to 4.6 | V |
| Pin voltage | V_T | $T_a = 25^\circ\text{C}$ | -0.5 to $V_{DD}+0.5$ | V |
| Output shortcircuit current | I_{OS} | $T_a = 25^\circ\text{C}$ | 50 | mA |
| Power dissipation | P_D | $T_a = 25^\circ\text{C}$ | 1 | W |
| Operating temperature | T_{OPR} | — | -20 to +70 | $^\circ\text{C}$ |
| Storage temperature | T_{STG} | — | -55 to +150 | $^\circ\text{C}$ |

RECOMMENDED OPERATING CONDITIONS

(Ta = -20 to +70°C)

| Parameter | Symbol | Min. | Max. | Unit |
|------------------------------|-----------|--------------|----------|------|
| Power supply voltage | V_{DD} | 2.7 | 3.6 | V |
| Power supply voltage | GND | 0 | 0 | V |
| “H” input voltage | V_{IH} | $V_{DD}-0.2$ | V_{DD} | V |
| “L” input voltage | V_{IL} | -0.2 | 0.2 | V |
| Source oscillation frequency | f_{OSC} | 4.096 | | MHz |

ELECTRICAL CHARACTERISTICS**DC Characteristics**

(Ta = -20 to +70°C)

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-----------------------------------|------------|---|--------------|------|------|---------------|
| “H” output voltage | V_{OH} | $I_{OH} = -1\text{ mA}$ | $V_{DD}-0.3$ | — | — | V |
| “L” output voltage | V_{OL} | $I_{OL} = +1\text{ mA}$ | — | — | 0.3 | V |
| Input leakage current (Note 1) | I_{LI1} | $0\text{ V} < V_{IN} < V_{DD}$ Non-measured pins are at 0 V. | -10 | — | 10 | μA |
| Input leakage current (Note 2) | I_{LI2} | $0\text{ V} < V_{IN} < V_{DD}$ Non-measured pins are at 0 V. | -20 | — | 20 | μA |
| Operating current | I_{DD} | $f_{OSC} = 4.096\text{ MHz}$ no load | — | 10 | 15 | mA |
| Standby current 1 | I_{DDS} | When powered down, no load, with DRAM refreshing | — | — | 70 | μA |
| Standby current 2 | I_{DDS2} | When powered down, no load, without DRAM refreshing | — | — | 40 | μA |

Notes: 1. Applicable to input pins excluding XT and $\overline{\text{XT}}$.
 2. Applicable to XT and $\overline{\text{XT}}$.

AC Characteristics

1. Microcontroller interface mode

(V_{DD} = 2.7 to 3.6 V, Ta = -20° to +70°C)(f_{OSC} = 4.096 MHz Fsam = 8.0 kHz)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|----------------------------------|-------------------|------|------|------|------|------|
| RESET pulse width | t _{RST} | 1 | — | — | μs | 1 |
| RESET execution time | t _{REX} | — | — | 5 | ms | |
| Setup and hold time of SK for CS | t _{SKS} | 500 | — | — | ns | |
| SK pulse width "H" | t _{SKH} | 1000 | — | — | ns | |
| SK pulse width "L" | t _{SKL} | 1000 | — | — | ns | |
| Setup time of SI for SK rise | t _{DS} | 250 | — | — | ns | |
| Hold time of SI for SK rise | t _{DH} | 250 | — | — | ns | |
| Data valid time from fall of CS | t _{CSE} | — | — | 200 | ns | |
| Data Hi-Z time from rise of CS | t _{CSF} | — | — | 200 | ns | |
| Data valid time from fall of SK | t _{DD} | — | — | 200 | ns | |
| BUSY rise time from rise of CS | t _{BSY} | — | — | 200 | ns | |
| Source oscillation duty cycle | t _{DUTY} | 40 | 50 | 60 | % | |

2. BUSY time when a command is executed

(V_{DD} = 2.7 to 3.6 V, Ta = -20 to +70°C)(f_{OSC} = 4.096 MHz Fsam = 8.0 kHz)

V_{DSC} = 1.000 MHz, f_{cam} = 0.0 kHz

| Parameter | | | Symbol | Min. | Max. | Unit | Note |
|---|-----------------------|-----------------------|-------------------|------|------|------|------|
| BUSY time after input of command | | | t _{BR} | — | 300 | μs | |
| BUSY time after input of mode setting command | | | t _{MODB} | — | 300 | μs | |
| BUSY time after input of Area1 command (3) | Normal mode | | t _{AR1B} | — | 1 | ms | |
| BUSY time after input of Area2 command (3) | Delayed play mode | | t _{AR2B} | — | 1 | ms | |
| | Retroactive play mode | | | | | | |
| | Normal mode | | | | | | |
| BUSY time after input of Delay command (3) | Retroactive play mode | | t _{DLYB} | — | 1 | ms | |
| | Normal mode | | | | | | |
| BUSY time after input of Rec command (2) | Delayed play mode | | t _{RECB} | — | 65 | ms | 2 |
| | Retroactive play mode | | | — | 1 | ms | |
| | Normal mode | | | | | | |
| BUSY time after input of Play command (2) | During recording | Delayed play mode | t _{PLYB} | — | 65 | ms | 2 |
| | | Retroactive play mode | | | | | |
| | During pause | Delayed play mode | t _{PLYB} | — | 1 | ms | |
| | | Retroactive play mode | | | | | |
| | | Normal mode | | | | | |

($V_{DD} = 2.7$ to 3.6 V, $T_a = -20$ to $+70^{\circ}\text{C}$)
($f_{OSC} = 4.096$ MHz $F_{sam} = 8.0$ kHz)

| Parameter | | | Symbol | Min. | Max. | Unit | Note |
|--|--|-----------------------|--------------------|------|------|---------------|--------|
| BUSY time after input of Play2 command (2) | During recording | Retroactive play mode | t_{PLAYB} | — | 65 | ms | 2 |
| | During pause | | | — | 1 | ms | |
| | | Normal mode | | — | 1 | ms | |
| BUSY time after input of Stop command | | | t_{SPB} | — | 65 | ms | 2 |
| | After input of Stop command during pause | | | — | 1 | ms | |
| | During ROM playback (Non-linear) | | | | | | |
| BUSY time after input of Pause command | | | t_{PB} | — | 65 | ms | 2 |
| BUSY time after input of Adrrd command (2) | | Retroactive play mode | t_{ADRB} | — | 300 | μs | |
| | | Normal mode | | — | 1 | ms | |
| BUSY time after input of Adrrd command (8) | | | | | — | 1 | ms |
| BUSY time after input of Adrwr command (8) | | | t_{ADWB} | — | 1 | ms | |
| BUSY time after input of Cue/Rew command (2) | | | t_{CRB} | — | 65 | ms | 2 |
| BUSY time after input of Del command (2) | | | t_{DELB} | — | 65 | ms | 2 |
| BUSY time after input of Dtrw command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Bytew command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Byter command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of End command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Copy command (7) | | | t_{CPYB} | — | 10 | ms | 1 page |
| BUSY time after input of Vol command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Rply command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Status command | | | t_{BR} | — | 300 | μs | |
| BUSY time after input of Nop command | | | t_{BR} | — | 300 | μs | |

A number in parenthesis indicates the number of bytes of each command.

3. Status flag time when a command is executed

($V_{DD} = 2.7$ to 3.6 V, $T_a = -20$ to $+70^\circ\text{C}$)
($f_{OSC} = 4.096$ MHz $F_{sam} = 8.0$ kHz)

| Parameter | | Symbol | Min. | Max. | Unit | Note |
|--|-----------------------|--------------------|------------------|------|------|------|
| Rec command to RPM bit set | | t _{RECR} | — | 1 | ms | |
| Play command to RPM bit set | | t _{PLYR} | — | 1 | ms | |
| | During ROM playback | t _{RPLYR} | — | 2 | ms | |
| Play2 command to RPM bit set | | t _{PLYR} | — | 65 | ms | 2 |
| Stop command to RPM bit set | | t _{SPR} | — | 2 | ms | |
| | During ROM playback | t _{RSPR} | — | 1 | ms | |
| STOP command (during pause) to RPM bit set | | t _{PSPR} | — | 1 | ms | |
| Rec command to REC bit set | | t _{REC} | — | 1 | ms | |
| Play command to PLY bit set | Delayed play mode | t _{PLY} | — | 65 | ms | 2 |
| | Retroactive play mode | | | | | |
| | | | During recording | — | 1 | ms |
| During pausing | | | | | | |
| | Normal mode | | | | | |
| Pause command to PAUSE bit set | | t _{PUS} | — | 65 | ms | 2 |
| Pause command to PAUSE bit reset | | t _{PUSR} | — | 300 | μs | |
| Address control time during repeated ROM playback | | t _{AD} | — | 2 | ms | |
| Oscillation stop from rise of \overline{CS} after input of Pwdn1 command | | t _{PXT} | — | 65 | ms | |
| | During ROM playback | | — | 1 | ms | |
| Oscillation stop from rise of \overline{CS} after input of Pwdn2 command | | | — | 65 | ms | |
| | During ROM playback | | — | 1 | ms | |

- Note 1: When powering on or releasing the power down mode, input “L” level to the RESET pin until crystal oscillation becomes stable. Moreover, when powering on, input again “L” level to the RESET pin for more than t_{RST} to initialize the internal circuit.
- 2: Depending on sampling frequency F_{sam} .

Analog Characteristics

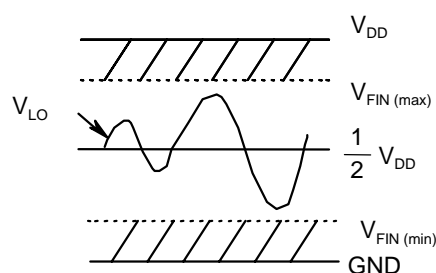
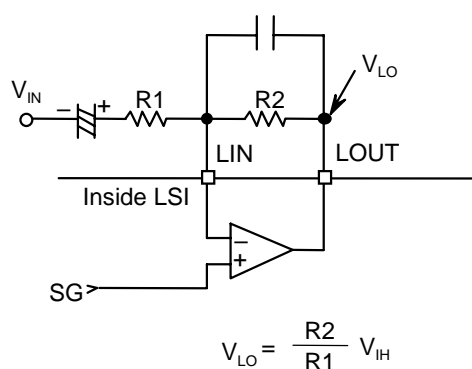
($V_{DD} = 2.7$ to $3.6V$, $T_a = -20$ to $+70^{\circ}C$)

| Parameter | Symbol | Condition | Min. | Max. | Unit |
|--------------------------|-------------|-------------------------|---------------------|---------------------|------------|
| DA output relative error | $ V_{DAE} $ | No load | — | 5 | mV |
| LPF input voltage range | V_{FIN} | — | $1/4 \times V_{DD}$ | $3/4 \times V_{DD}$ | V |
| OP-amp open loop gain | G_{OP} | $f_{IN} = 0$ to 4 kHz | 10 | | dB |
| OP-amp input impedance | R_{INA} | — | 1 | — | M Ω |
| OP-amp load resistance | R_{OUTA} | — | 100 | — | k Ω |
| AOUT load resistance | R_{AOUT} | — | 100 | — | k Ω |

Analog Input Amplifier Circuit

This IC contains an OP amplifier with the inverting input pin and output pin.

The analog circuit reference voltage (signal ground) is internally input as the non-inverting input. When amplification is required, adjust the amplification factor using an external resistor after constructing the inverting amplifier circuit.



The output pin, LOUT, of OP amplifier is internally input to LPF (Low Pass Filter). Adjust the gain using the external resistor so that the V_{LO} is within the accessible input voltage range V_{FIN} . If V_{LO} is over the V_{FIN} , the LPF output waveform will be distorted.

The example of SCF input voltage range is shown below.

| Model | Supply voltage V_{DD} | SCF admissible voltage range | | SCF admissible input voltage |
|-----------|-------------------------|------------------------------|--------|------------------------------|
| | | Min. | Max. | |
| MS87V1021 | 3 V | 0.75 V | 2.25 V | 1.5 Vp-p |

The minimum value of OP-amp load resistance is 100 k Ω . The feedback resistance R2 of inverting amplifier circuit must be larger than 100 k Ω .

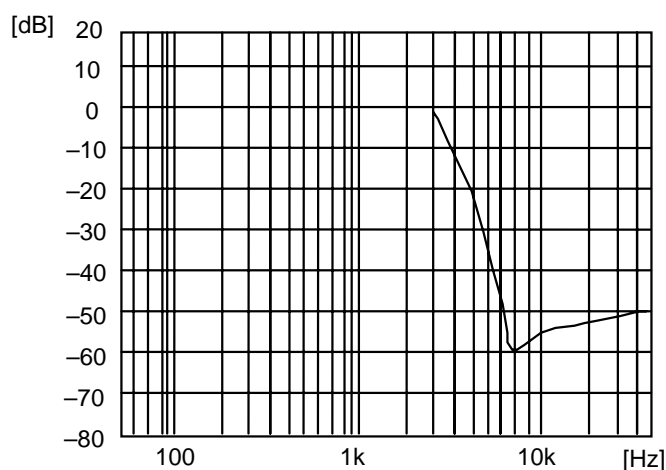
LPF Characteristics

The MS87V1021 contains a 4-th order LPF in which the switched capacitor filter technique is adopted. The LOUT pin is internally connected to the input of LPF.

The attenuation rate is -40 dB/oct. The cut-off frequency and frequency characteristics vary in proportion to sampling frequency (F_{sam}).

The cut-off frequency is designed to $4/10$ of sampling frequency.

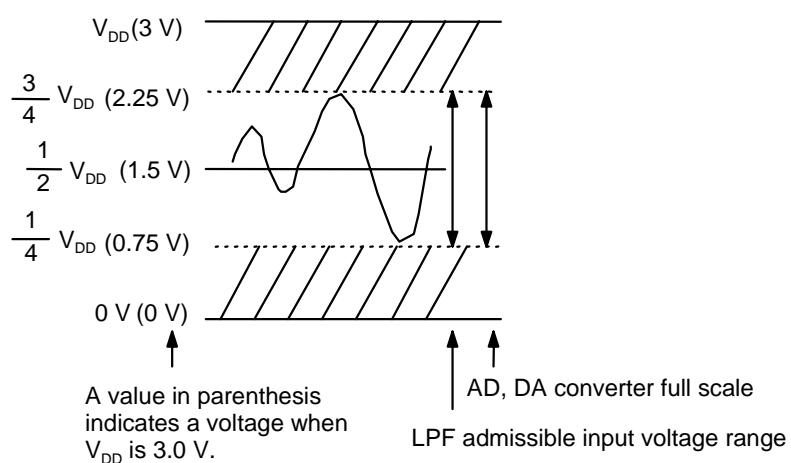
The characteristics of LPF when $F_{sam} = 8$ kHz are shown below.



LPF characteristics ($F_{sam} = 8.0$ kHz)

AD, DA Converter Full Scale

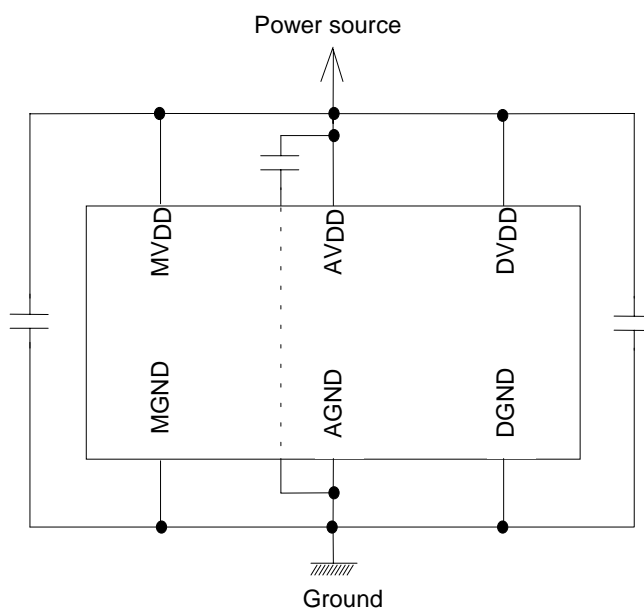
| Model | AD, DA converter full scale | | |
|-----------|-----------------------------|---------------------|---------------------|
| | Min. (V) | Max. (V) | Amplitude (Vp-p) |
| MS87V1021 | $1/4 \times V_{DD}$ | $3/4 \times V_{DD}$ | $1/2 \times V_{DD}$ |



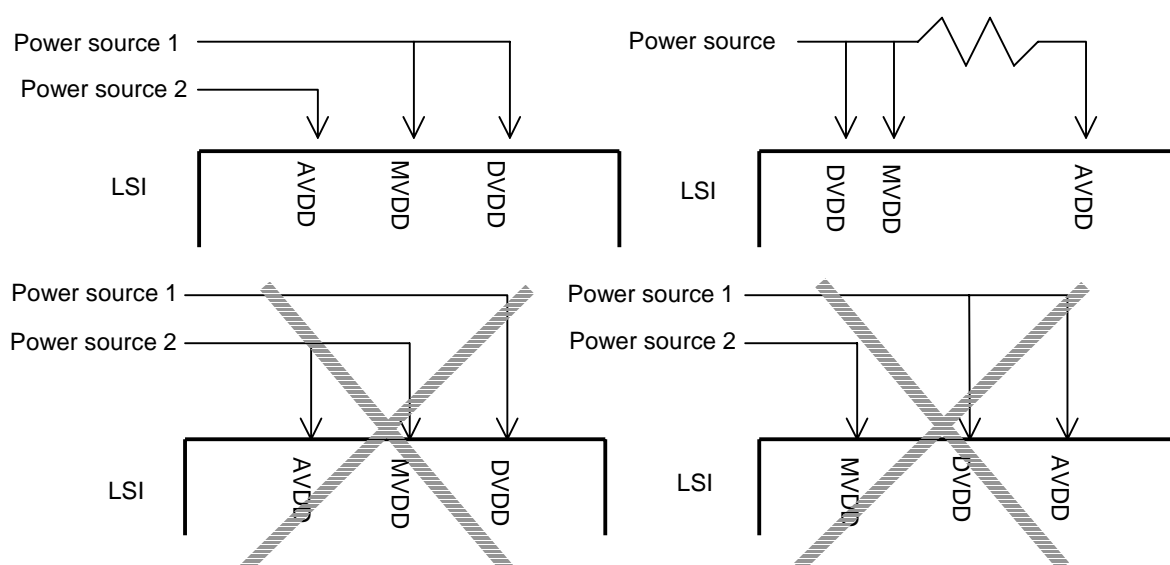
NOTICE

Power Supply Connection

The power of this IC is supplied from a single power supply as shown below, which should be connected to the analog section, logic section and memory section separately.



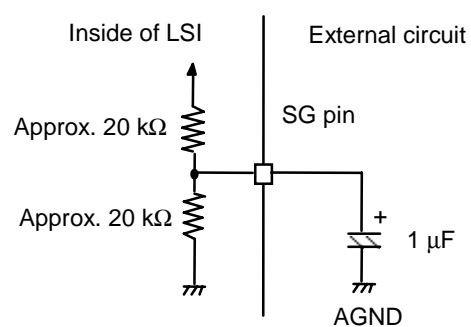
If the analog section, digital section and memory section are supplied from different power sources, a latch-up may occur. Be sure to avoid the power supply connections shown below.



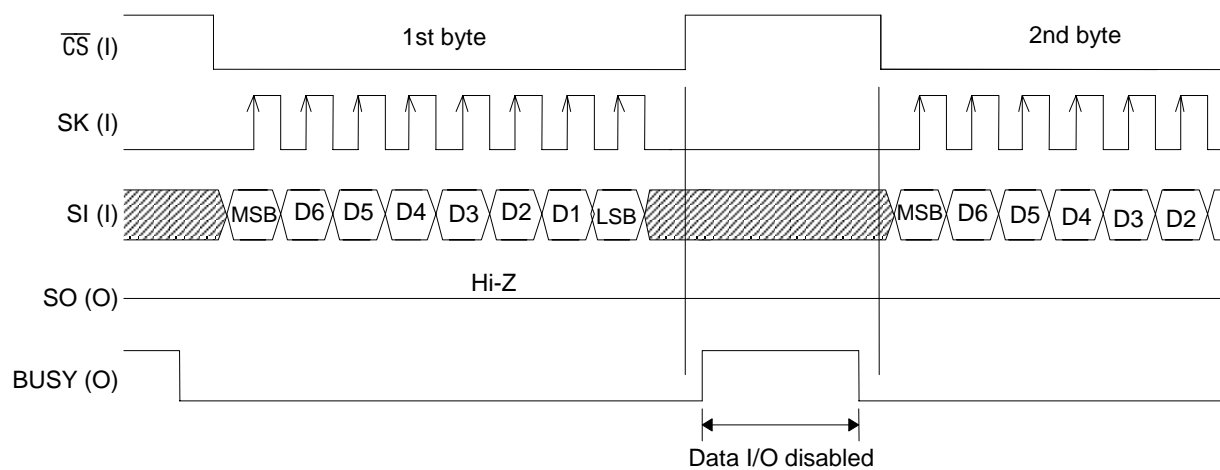
Supplementary Explanation on SG Pin

Connect a 1 μF electrolytic capacitor between the SG pin and AGND.

After reset or releasing the power down mode, do recording or playback after the voltage level of SG pin becomes stable. The voltage level becomes stable at $1/2$ of V_{DD} . The time to be stabilized is approximately 50 ms in case shown below.

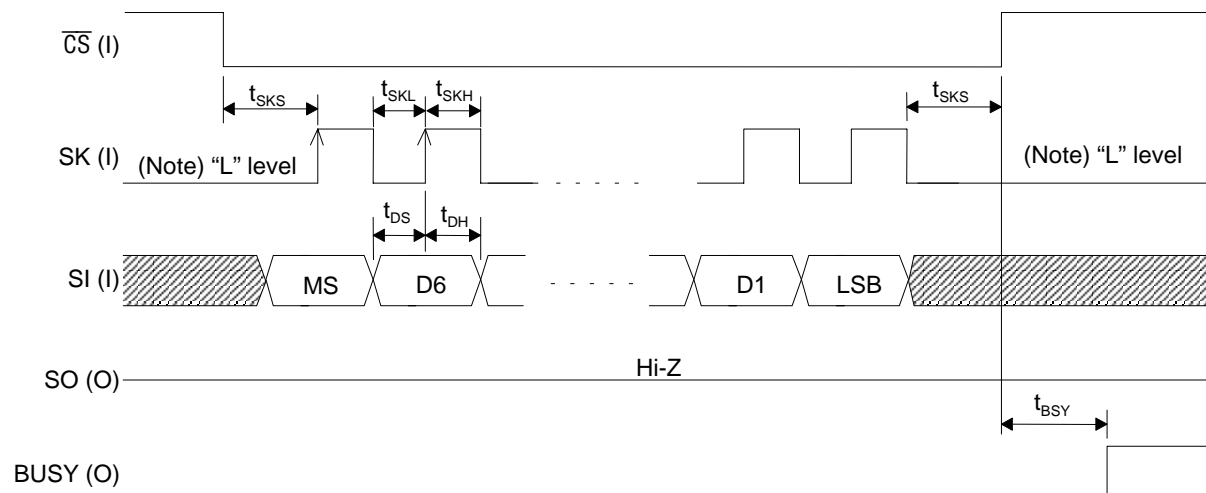


[Data write operation]



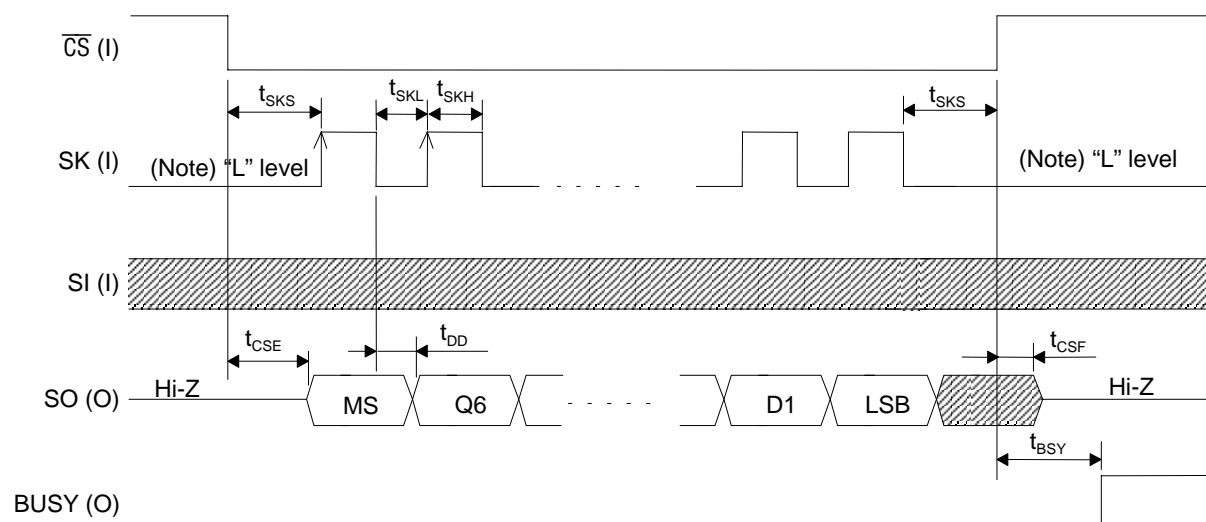
The timing diagram illustrates the sequence of operations for the AD7124. It shows the relationship between the chip select (\overline{CS}), serial clock (SK), serial input (SI), serial output (SO), and busy (BUSY) signals. The diagram is divided into two main sections: 'Data output' and 'Data input'. In the 'Data output' section, SK is high and SI is shaded, indicating that data is being sent from the device. In the 'Data input' section, SK is high and SI is low, indicating that data is being received by the device. The SO signal is Hi-Z (high impedance) during both phases. The BUSY signal is low during the 'Data I/O disabled' period, which occurs when CS is high.

[Data write operation]



(Note) Be sure to set SK to "L" when \overline{CS} is at "H" level.

[Data read operation]



(Note) Be sure to set SK to "L" when \overline{CS} is at "H" level.

Timing diagram for the Rec command sequence. The diagram shows four signals: \overline{CS} , SK, SI, and BUSY.

- \overline{CS} : A periodic square wave.
- SK: Shows two bursts of eight pulses each, corresponding to the two Rec commands.
- SI: Shows two shaded blocks for "Rec command (1)" and "Rec command (2)", each followed by a hatched block.
- BUSY: Shows two high periods. The first high period is labeled t_{BR} and the second is labeled t_{RECB} .

Below the BUSY signal, the states are labeled: Standby, Executing Rec command (1), Standby, Executing Rec command (2), and Standby.

Timing diagram for the playback command sequence. The diagram shows four signals: \overline{CS} , SK, SI, and BUSY.

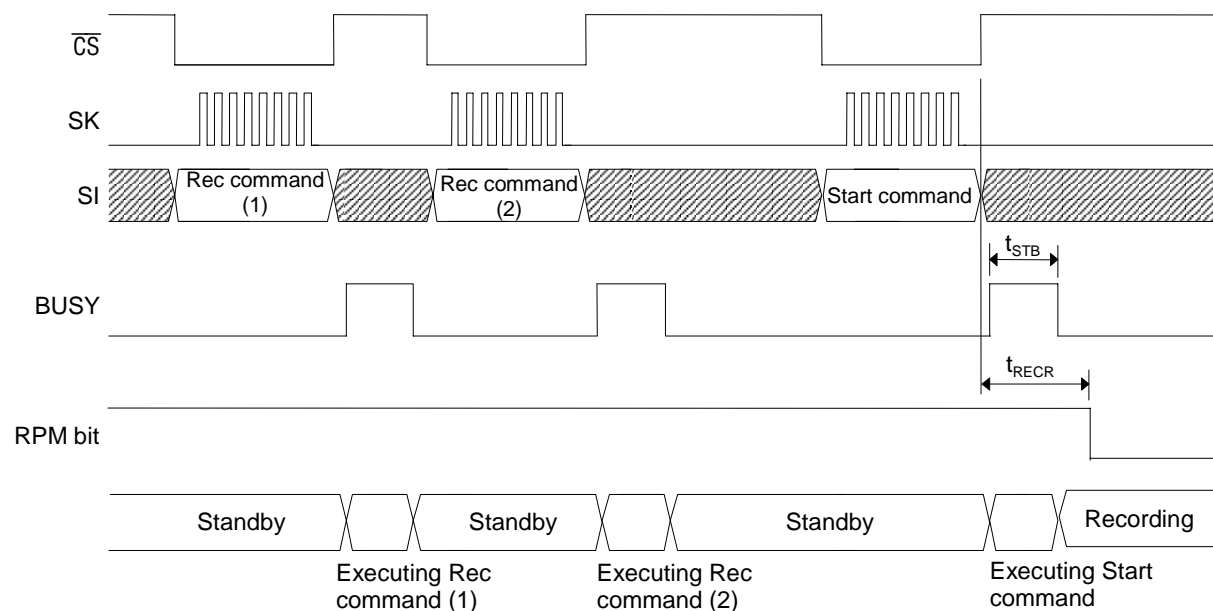
- \overline{CS} : Active-low chip select signal. It pulses low during each command execution.
- SK: Serial clock signal. It provides a series of pulses for each command.
- SI: Serial data input. It carries the 'Play command (1)' and 'Play command (2)' during the active periods of \overline{CS} .
- BUSY: Output signal indicating command execution. It goes high when a command is received and remains high until the command is executed.

The diagram illustrates two cycles of command execution, each followed by a standby period.

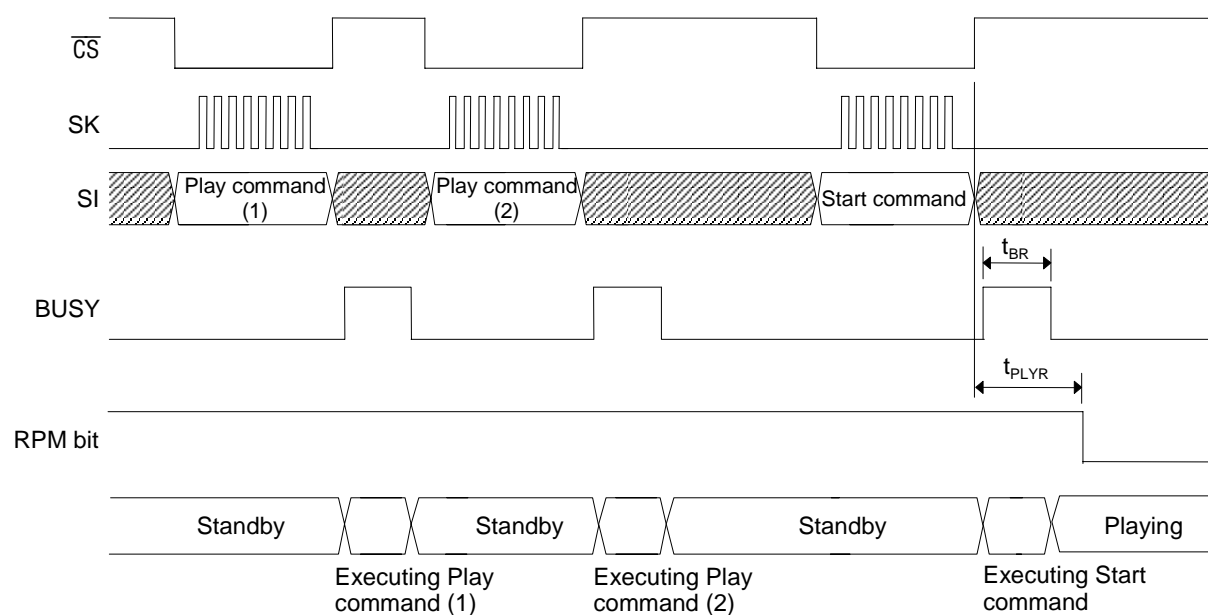
- First Cycle:** \overline{CS} pulses low, SK provides clock pulses, and SI carries 'Play command (1)'. BUSY goes high. The time from the start of \overline{CS} to the start of BUSY is t_{BR} . The time from the end of \overline{CS} to the end of BUSY is t_{PLYB} .
- Second Cycle:** \overline{CS} pulses low, SK provides clock pulses, and SI carries 'Play command (2)'. BUSY goes high. The time from the start of \overline{CS} to the start of BUSY is t_{BR} . The time from the end of \overline{CS} to the end of BUSY is t_{PLYB} .

The states of the system are labeled: Standby, Executing Play command (1), Standby, Executing Play command (2), and Standby.

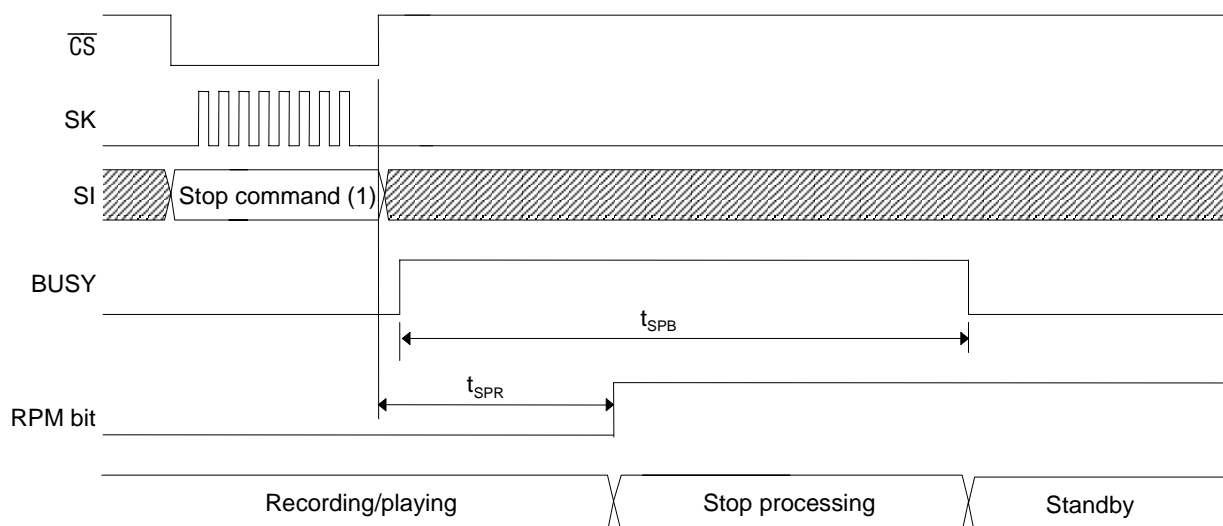
Starting recording with Start command



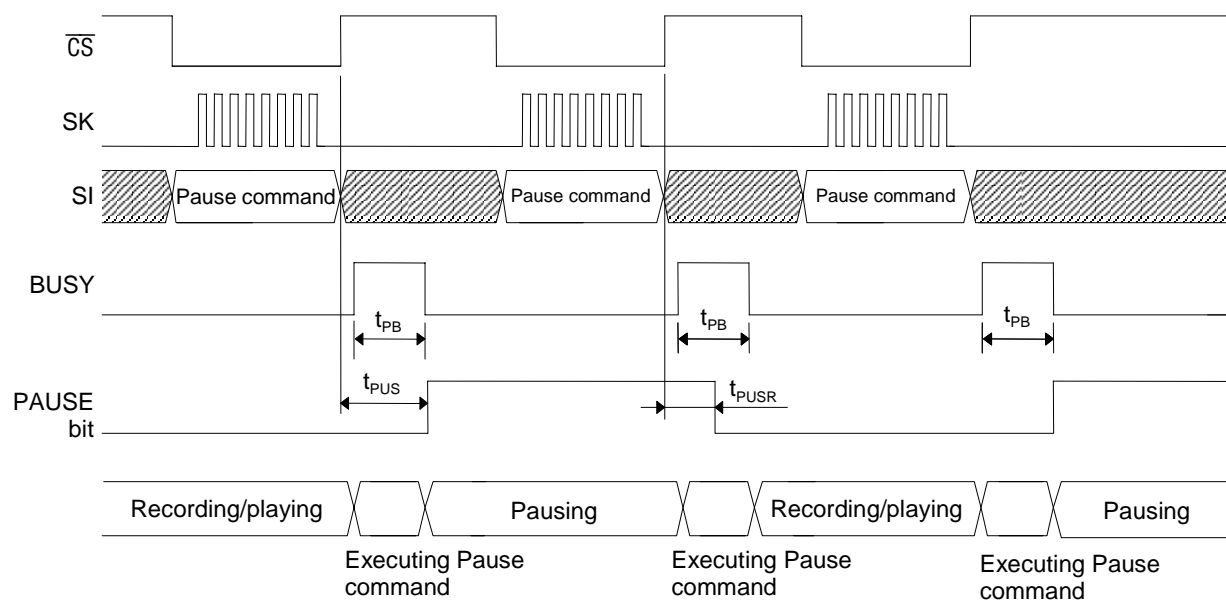
Starting playback with Start command



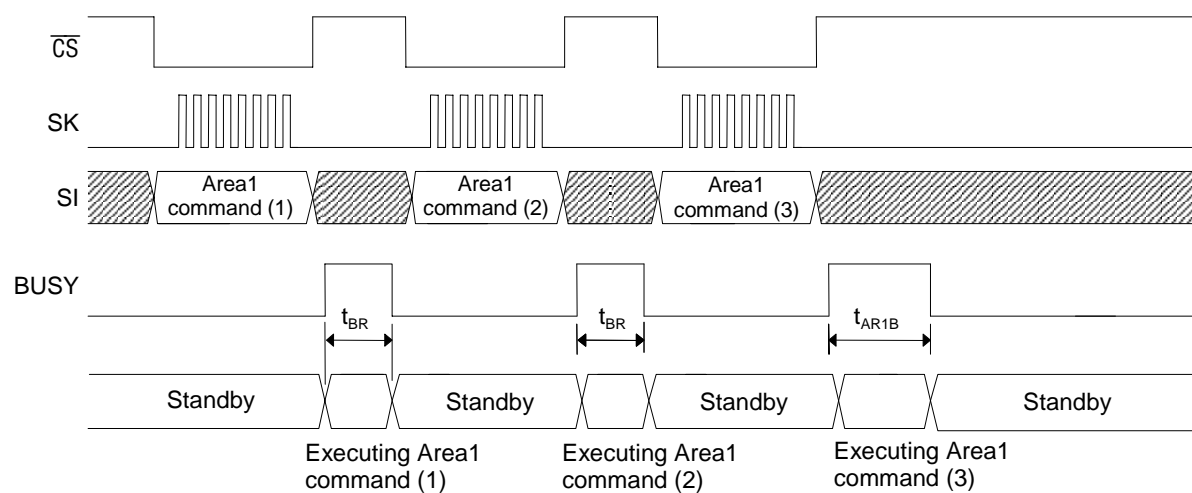
Ending recording/playback with Stop command



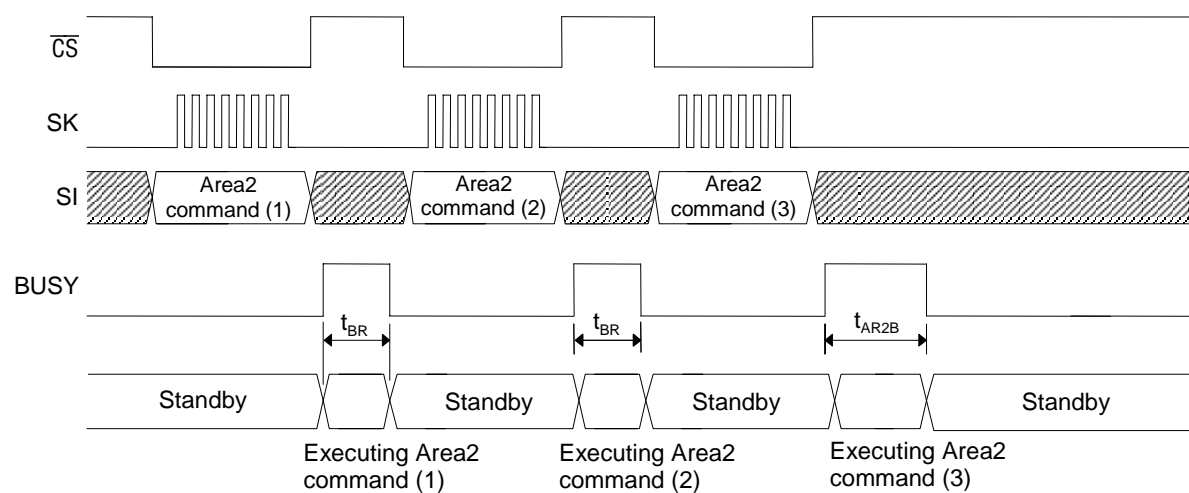
Pause of recording/playback with Pause command

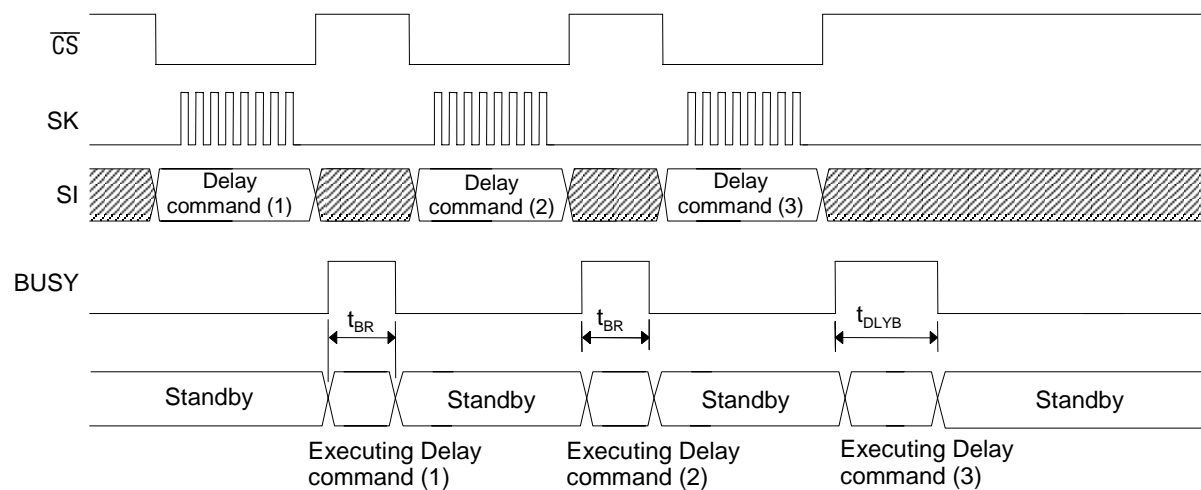
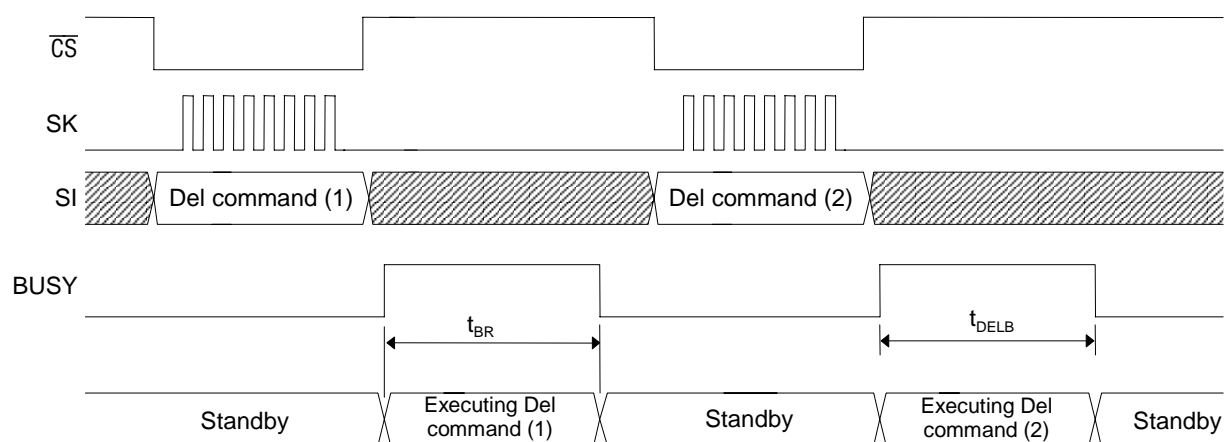


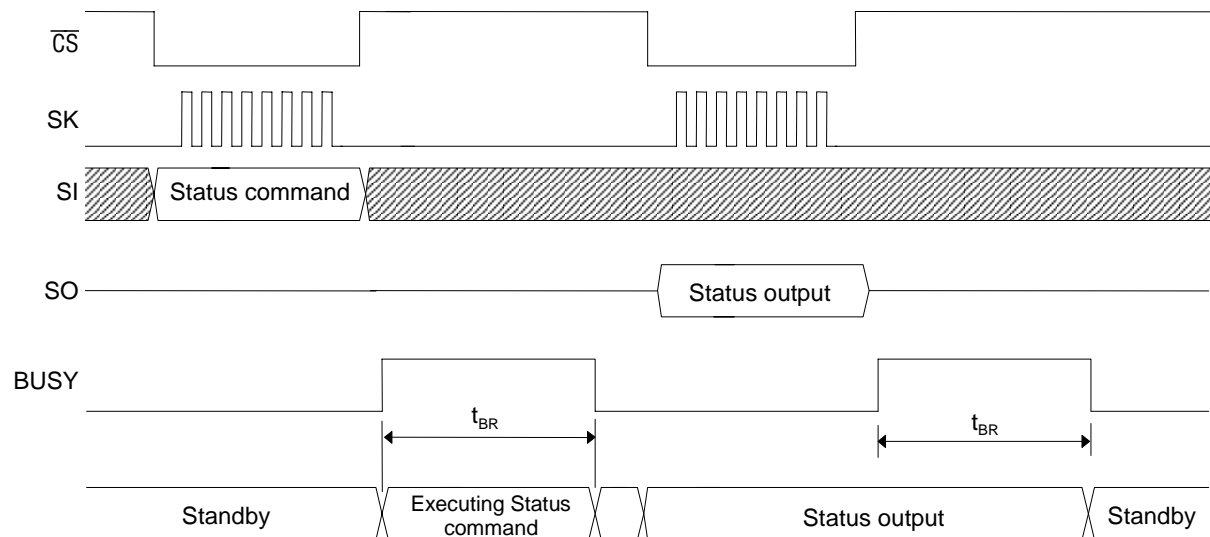
Setting voice area block with Area1 command



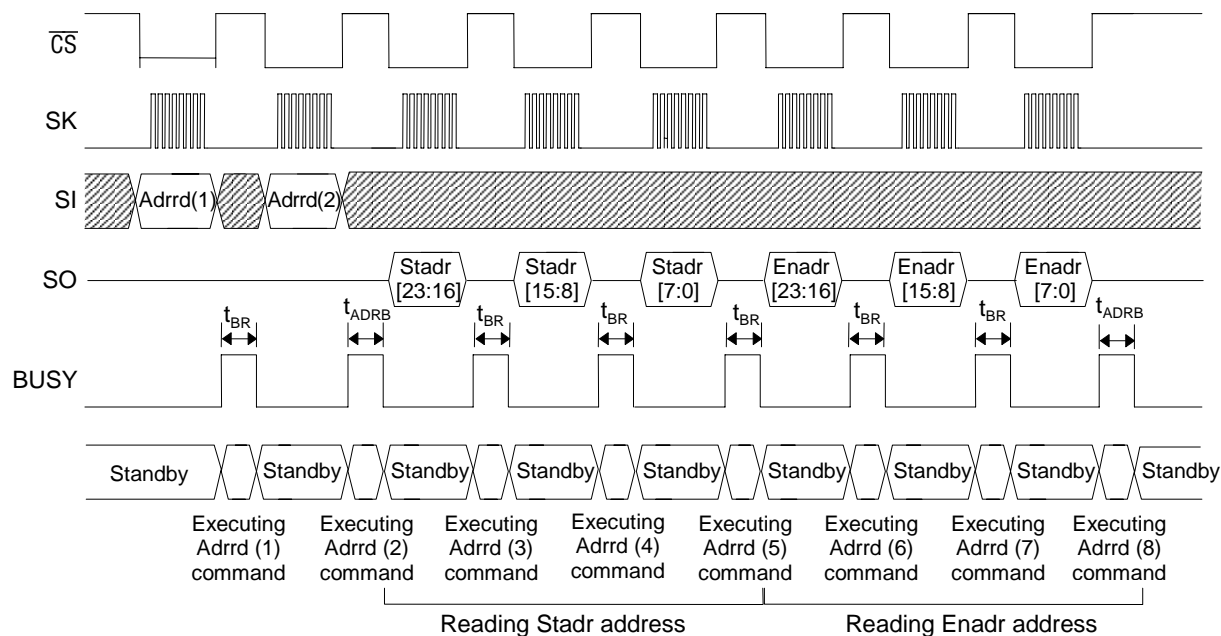
Setting voice area with Area2 command



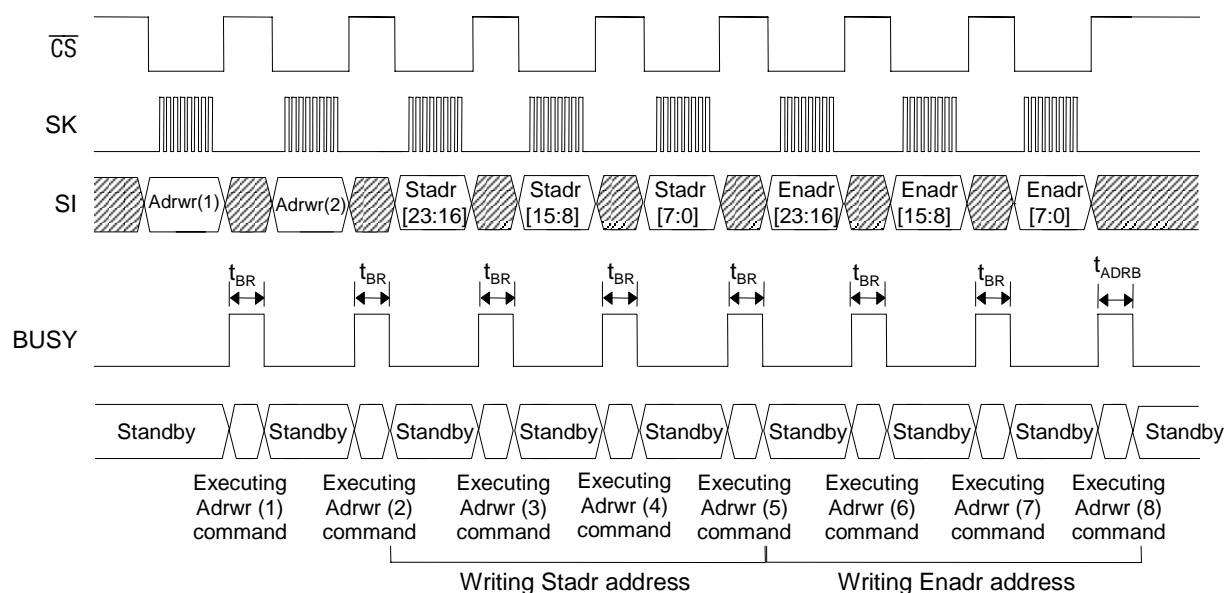
Setting Delay value with Delay command**Deleting phrase with Del command**

Outputting STATUS with Status command

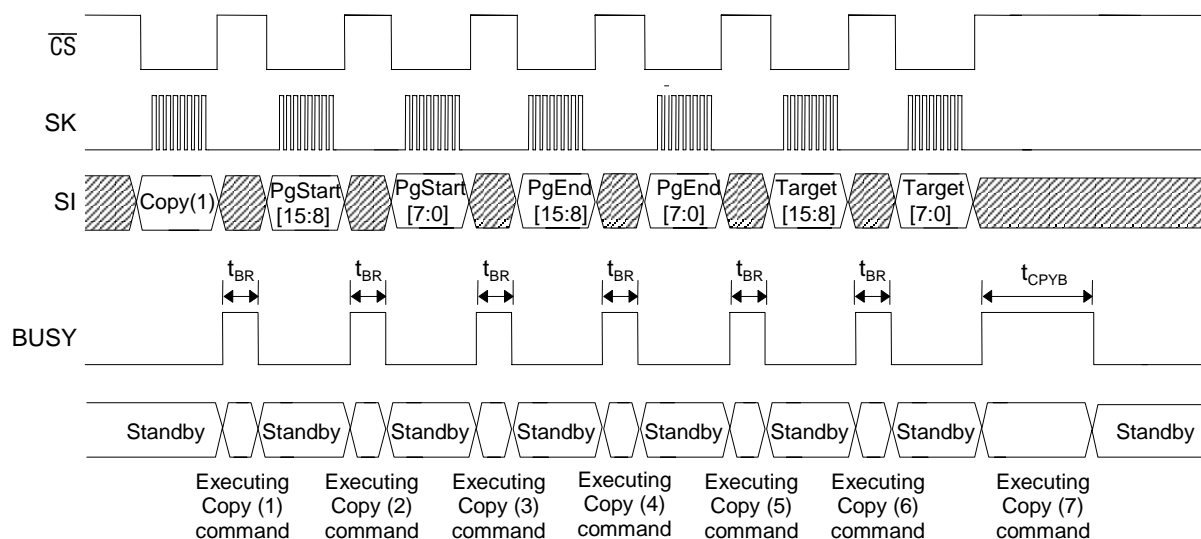
Reading recording/playback start address with Adrrd command



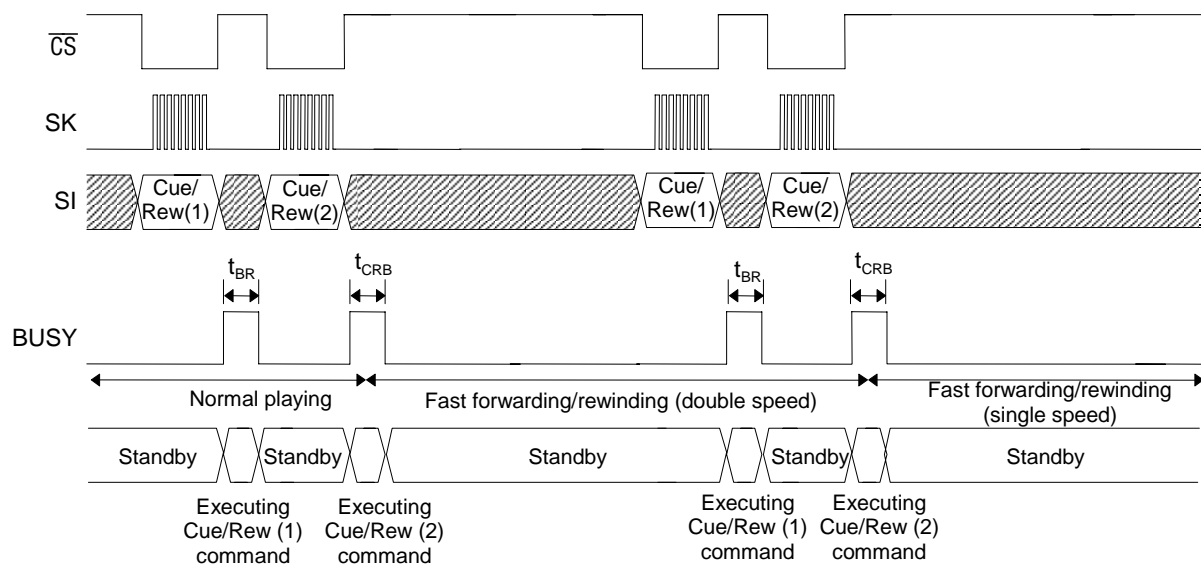
Writing recording/playback start address with Adrwr command



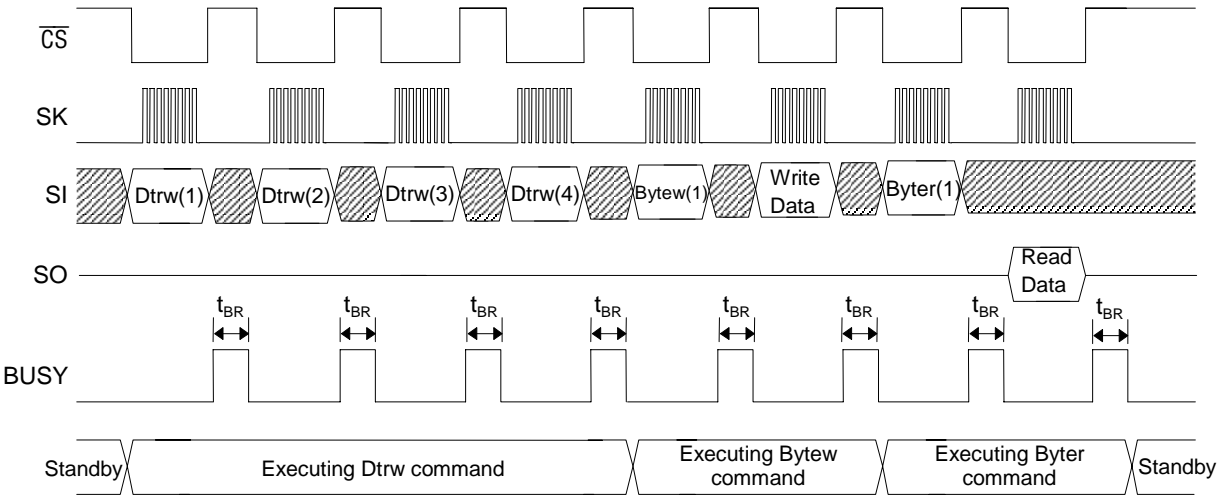
Copying page data with Copy command



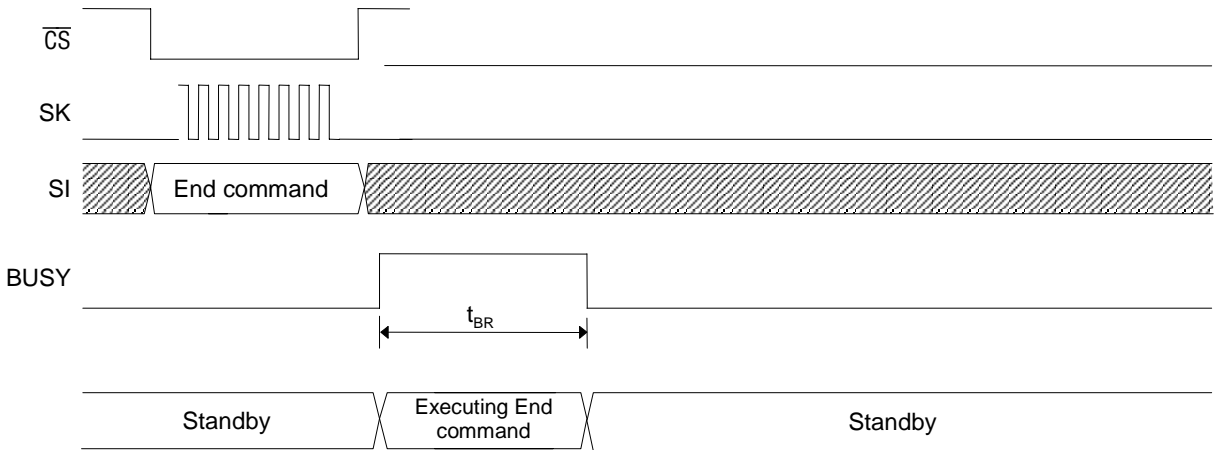
Fast forward/rewind with Cue/Rew command



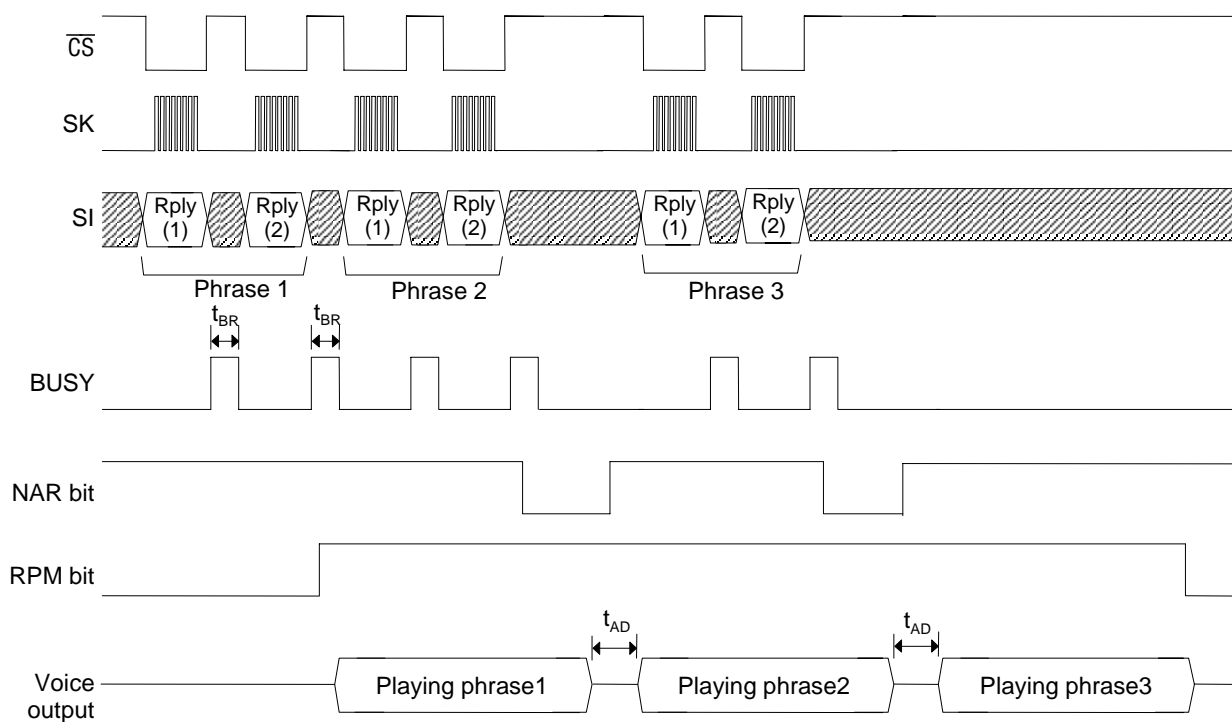
Data transfer with Dtrw command



Ending Dtrw mode with End command

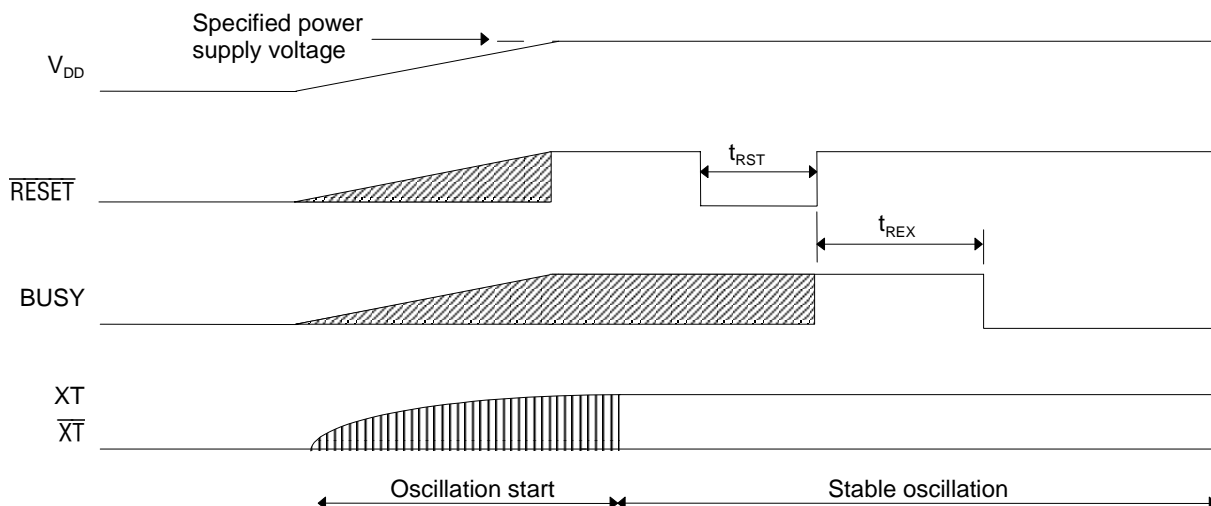


Continuous ROM playback with Rply command

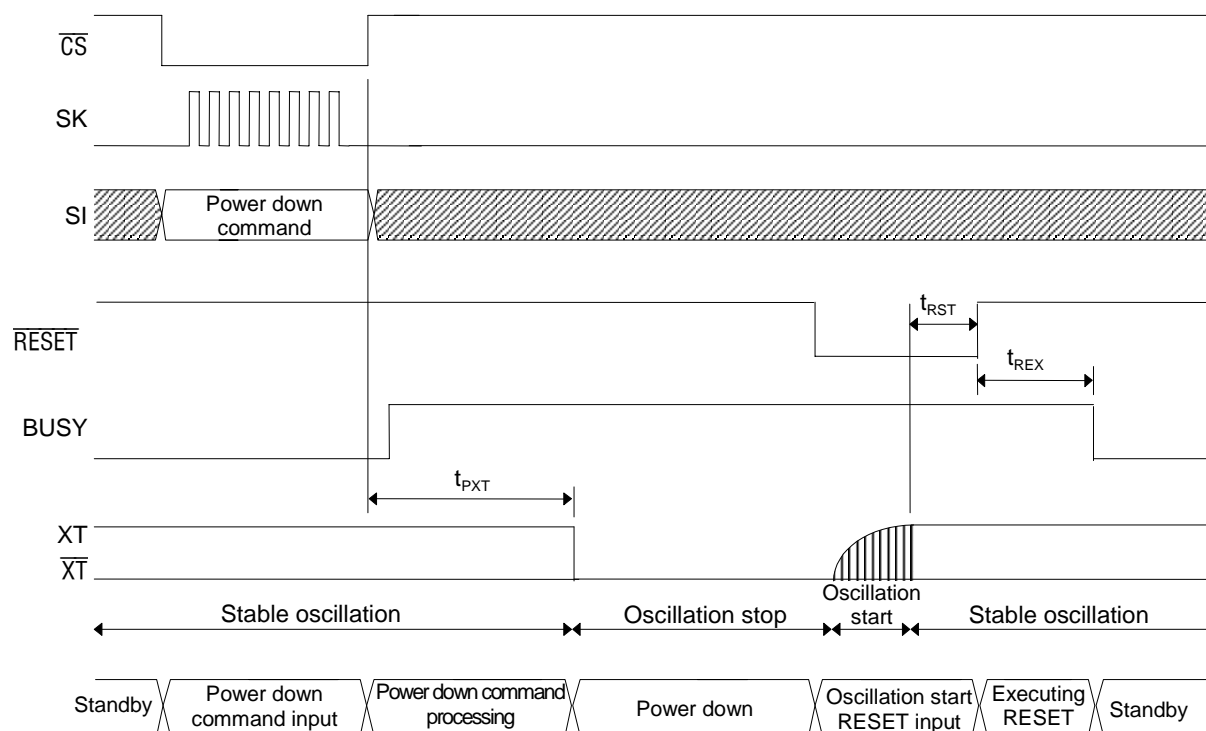


(Note)

When ROM is being continuously played, other commands than Rply command, Stop command, Vol command and Status command cannot be acceptable.

Reset function**[Reset after powering on]**

When powering on, be sure to initialize the internal circuit by inputting an "L" level pulse to the \overline{RESET} pin for a specified time after the power supply voltage level reaches the specified level and oscillation becomes stable.

Power down function

THE COMMANDS LIST

Delayed Play Mode

| Command | Code | | Description | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------|--------------------|-------------|--|--------|-----------|----|-------|----|--------|--------|------------|------|--------------------|----|--------------------|----|--------------------|----|-------------------|----|-------------------|----|-------------------|----|-------------------|----|--------------------|--------|
| Mode | 1st Byte | 01h | Sets the operating mode to Delayed Play Mode. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Area2 | 1st Byte | 39h | Selects a sound data area. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Start2[7:0] | Start Block Address; address range: 00h to FFh, by default set to: 00h | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3rd Byte | End2[7:0] | End Block Address; address range: 00h to FFh, by default set to: FFh | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | The memory area starting from the block specified with the Start2 up to that specified with the End2 is selected. Up to 256 blocks can be selected. Each value set with this command remains valid until you enter Reset or the Mode command to change the operating mode. You may not set the Start2 address value that is lower than the End2 address. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Delay | 1st Byte | 38h | Defines the Delay time (i.e. a time lag between recording and its playback). | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Dly[15:8] | The value for the Dly | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3rd Byte | Dly[7:0] | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | The Delay time can be obtained with the following formula: (Dly × 250 ÷ Sampling Frequency) For more details on setting the Dly value, see “Delay Time in Delayed Play Mode and Retroactive Play Mode” later in this document. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rec | 1st Byte | 10h | Sets the LSI to record-ready state and selects the Method and Samp values. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Method[7:4] | The value for the Method. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Samp[3:0] | The value for the Samp. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | Entering the Start command following the Rec command input initiates recording, which keeps going on until the Stop command is entered. While recording, playback will not start until the Play command is entered. If you enter the Rec command while recording and playing, the LSI stops playing and outputs SG level from the AOUT pin. In this case, recording still goes on even after playback stops. <div><div>Voice Synthesis Algorithm</div><table><tr><th>Method</th><th>Algorithm</th></tr><tr><td>0h</td><td>ADPCM</td></tr><tr><td>1h</td><td>ADPCM2</td></tr><tr><td>Others</td><td>Prohibited</td></tr></table></div> <div><div>Sampling Frequency</div><table><tr><th>Samp</th><th>Sampling Frequency</th></tr><tr><td>3h</td><td>4.0kHz (fosc/1024)</td></tr><tr><td>4h</td><td>4.0kHz (fosc/1024)</td></tr><tr><td>5h</td><td>5.3kHz (fosc/768)</td></tr><tr><td>6h</td><td>6.4kHz (fosc/640)</td></tr><tr><td>7h</td><td>8.0kHz (fosc/512)</td></tr><tr><td>8h</td><td>8.0kHz (fosc/512)</td></tr><tr><td>9h</td><td>10.6kHz (fosc/384)</td></tr><tr><td>Others</td><td>Prohibited</td></tr></table><div>fosc = 4.096 MHz</div></div> | Method | Algorithm | 0h | ADPCM | 1h | ADPCM2 | Others | Prohibited | Samp | Sampling Frequency | 3h | 4.0kHz (fosc/1024) | 4h | 4.0kHz (fosc/1024) | 5h | 5.3kHz (fosc/768) | 6h | 6.4kHz (fosc/640) | 7h | 8.0kHz (fosc/512) | 8h | 8.0kHz (fosc/512) | 9h | 10.6kHz (fosc/384) | Others |
| Method | Algorithm | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0h | ADPCM | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1h | ADPCM2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Others | Prohibited | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Samp | Sampling Frequency | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3h | 4.0kHz (fosc/1024) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4h | 4.0kHz (fosc/1024) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5h | 5.3kHz (fosc/768) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6h | 6.4kHz (fosc/640) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7h | 8.0kHz (fosc/512) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8h | 8.0kHz (fosc/512) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9h | 10.6kHz (fosc/384) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Others | Prohibited | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Play | 1st Byte | 20h | Sets the LSI to play-ready state and selects the Method and Samp values. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Method[7:4] | The value for the Method. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Samp[3:0] | The value for the Samp. | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | Entering the Play command while recording causes the LSI to start playing what has been recorded the Delay time ago, with recording still going on. For more details on the Method and Samp, see description on the Rec command earlier in this document. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Start | 1st Byte | 30h | Starts recording/playing. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Stop | 1st Byte | 40h | Stops recording/playing. | | | | | | | | | | | | | | | | | | | | | | | | | |

Retroactive Play Mode (1/2)

| Command | Code | | Description |
|---------|----------|-------------|---|
| Mode | 1st Byte | 02h | Sets the operating mode to Retroactive Play Mode. (Cue/Rewind function available) |
| Area2 | 1st Byte | 39h | Selects a sound data area. |
| | 2nd Byte | Start2[7:0] | Start Block Address; address range: 00h to FFh, by default set to: 00h |
| | 3rd Byte | End2[7:0] | End Block Address; address range: 00h to FFh, by default set to: FFh |
| | | | The memory area starting from the block specified with the Start2 up to that specified with the End2 is selected. Up to 256 blocks can be selected. Each value set with this command remains valid until you enter Reset or the Mode command to change the operating mode. You may not set the Start2 address value that is lower than the End2 address. |
| Delay | 1st Byte | 38h | Defines the Delay time (i.e. a time to go back to the past). |
| | 2nd Byte | Dly[15:8] | The value for the Dly |
| | 3rd Byte | Dly[7:0] | |
| | | | Use this command to set the Delay time, that is the time length going back to the past from the time when the Play or Play2 command is entered. The Delay time can be obtained with the following formula: (Dly × 250 ÷ Sampling Frequency) For more details on setting the Dly value, see "Delay Time in Delayed Play Mode and Retroactive Play Mode" later in this document. |
| Rec | 1st Byte | 01h | Sets the LSI to record-ready state and selects the Method and Samp values. |
| | 2nd Byte | Method[7:4] | The value for the Method. |
| | | Samp[3:0] | The value for the Samp. |
| | | | For more details on the Method and Samp, see description on the Rec command in Delayed Play Mode earlier in this document. |
| Play | 1st Byte | 20h | Sets the LSI to play-ready state and selects the Method and Samp values. |
| | 2nd Byte | Method[7:4] | The value for the Method. |
| | | Samp[3:0] | The value for the Samp. |
| | | | Entering the Play command while recording causes the LSI to play once from what was recorded the Delay time ago up to the time when the Play command is entered. In this case, recording stops. For more details on setting the Dly value, see "Delay Time in Delayed Play Mode and Retroactive Play Mode" later in this document. |
| Play2 | 1st Byte | 21h | Sets the LSI to repeat-play-ready state and selects the Method and Samp values. |
| | 2nd Byte | Method[7:4] | The value for the Method. |
| | | Samp[3:0] | The value for the Samp. |
| | | | Entering the Play2 command while recording causes the LSI to repeat playing from what was recorded the Delay time ago up to the time when the command is entered. In this case, recording stops. For more details on setting the Dly value, see "Delay Time in Delayed Play Mode and Retroactive Play Mode" later in this document. |

Retroactive Play Mode (2/2)

| Command | Code | | Description |
|---------|----------|-----------------|---|
| Adrrd | 1st Byte | 51h | Use this command to read the Start and End address values of the recorded data. |
| | 2nd Byte | 00h | Set this to "00h". |
| | 3rd Byte | Stadr[23:16](O) | Outputs the start-record address (in serial from the SO pin). |
| | 4th Byte | Stadr[15:8](O) | |
| | 5th Byte | Stadr[7:0](O) | |
| | 6th Byte | Enadr[23:16](O) | Outputs the end-record address (in serial from the SO pin). |
| | 7th Byte | Enadr[15:8](O) | |
| | 8th Byte | Enadr[7:0](O) | |
| | | | You need to know the exact address where sound data is stored to play the data again in Retroactive Play Mode after record/play operation in the mode is complete. This command allows you to read the start-record and end-record addresses. |
| Adrwr | 1st Byte | 50h | Use this command to write the Start and End address values of the playback data. |
| | 2nd Byte | 00h | Set this to "00h". |
| | 3rd Byte | Stadr[23:16] | The value for the start-play address. You need to set the lower 7 bits to "0". |
| | 4th Byte | Stadr[15:8] | |
| | 5th Byte | Stadr[7:0] | |
| | 6th Byte | Enadr[23:16] | The value for the end-play address. You need to set the lower 7 bits to "1". |
| | 7th Byte | Enadr[15:8] | |
| | 8th Byte | Enadr[7:0] | |
| | | | You need to specify the address where sound data is stored to play the data again in Retroactive Play Mode after record/play operation in the mode is complete. This command enables you to write the start-play and end-play addresses. Normally you specify the addresses that you read by using the Adrrd command. |
| Pause | 1st Byte | 41h | Pauses recording or playing. |
| | | | Re-entering the command resets pause state and resumes the earlier operation. |
| Start | 1st Byte | 30h | Starts recording or playing in Retroactive Play Mode. |
| | | | Entering the Start command following the Rec command causes the LSI to start recording in Retroactive Play mode. Meanwhile, entering the Start command following the Play1 or Play2 command causes the LSI to start playing, looking up address information on the internal Stadr/Enadr register that contains the record-start and record-end addresses. |
| Stop | 1st Byte | 40h | Stops recording or playing in Retroactive Play Mode. |

Normal Mode (1/2)

| Command | Code | | Description |
|---------|----------|-------------|--|
| Mode | 1st Byte | 03h | Sets the operating mode to Normal Play Mode. (Cue/Rew function available) |
| Area1 | 1st Byte | 36h | Selects an area for address control and sound data. |
| | 2nd Byte | Start1[7:0] | Start Block Address; address range: 00h to FFh, by default set to: 00h |
| | 3rd Byte | End1[7:0] | End Block Address; address range: 00h to FFh, by default set to: FFh |
| | | | The memory area ranging from the block specified with the Start1 up to that specified with the End1 is selected for storing both address control and sound data. Up to 256 blocks can be selected. Each value set with this command remains valid until you enter Reset. The Area1 command is valid in Normal Play Mode only. You may not set the Start1 address value that is lower than the End1 address. |
| Area2 | 1st Byte | 39h | Selects a sound data area. |
| | 2nd Byte | Start2[7:0] | Start Block Address; address range: 00h to FFh, by default set to: 00h |
| | 3rd Byte | End2[7:0] | End Block Address; address range: 00h to FFh, by default set to: FFh |
| | | | This command is used to select a sound data area within the memory area defined by using the Area1 command. The area ranging from the block specified with the Start2 up to that specified with the End2 is selected. Each value set with this command remains valid until you enter Reset or the Mode command to change the operating mode. The first 2 blocks (02h; 16 pages) of the memory area selected by the Area1 command are automatically assigned to the Address Control Data Area. Therefore, blocks you can actually select as Sound Data Area are the third block and thereafter (the value for the Start1 + 02h). The values defined by the Start1, Start2 and End1, End2 must satisfy the following formula: $\text{Start2} \geq \text{Start1} + 02\text{h}; \text{End2} \leq \text{End1}$ For more details, see “Controlling addresses in Normal Play Mode” later in this document. Note: You may not set the Start2 address value that is lower than the End2 address. |
| Rec | 1st Byte | 10h | Sets the LSI to record-ready state and selects the Method and Samp values. |
| | 2nd Byte | Method[7:4] | The value for the Method. |
| | | Samp[3:0] | The value for the Samp. |
| | | | For more details on the Method and Samp, see description on the Rec command in Delayed Play Mode earlier in this document. |
| Play | 1st Byte | 20h | Sets the LSI to one-time-play-ready state and selects a phrase to be played. |
| | 2nd Byte | Phrase[7:0] | The value for the Phrase. Range: 01h to FFh |
| | | | For playback the LSI uses the Method and Samp values set with the Rec command. |
| Play2 | 1st Byte | 21h | Sets the LSI to repeat-play-ready state and selects a phrase to be played. |
| | 2nd Byte | Phrase[7:0] | The value for the Phrase. Range: (01h to FFh) |
| | | | For playback the LSI uses the Method and Samp values set with the Rec command. |

Normal Mode (2/2)

| Command | Code | | Description |
|---------|---|-----------------|---|
| Adrrd | 1st Byte | 51h | Use this command to read the Start and End address values of the specified phrase. |
| | 2nd Byte | Phrase[7:0] | The value for the Phrase. Range: 01h to FFh |
| | 3rd Byte | Stadr[23:16](O) | Outputs the Start Address (in serial from the SO pin). |
| | 4th Byte | Stadr[15:8] (O) | |
| | 5th Byte | Stadr[7:0] (O) | |
| | 6th Byte | Enadr[23:16](O) | Outputs the End Address (in serial from the SO pin). |
| | 7th Byte | Enadr[15:8](O) | |
| | 8th Byte | Enadr[7:0](O) | |
| | | | This command allows you to read the Start Address and End Address of the phrase specified. |
| Adrwr | 1st Byte | 50h | Use this command to write the Start and End address values of the specified phrase. |
| | 2nd Byte | Phrase[7:0] | The value for the Phrase. Range: 01h to FFh |
| | 3rd Byte | Stadr[23:16] | The value for the Start Address. You need to set the lower 7 bits to "0". |
| | 4th Byte | Stadr[15:8] | |
| | 5th Byte | Stadr[7:0] | |
| | 6th Byte | Enadr[23:16] | The value for the End Address. You need to set the lower 7 bits to "1". |
| | 7th Byte | Enadr[15:8] | |
| | 8th Byte | Enadr[7:0] | |
| | | | With this command you can define a phrase and the Start and End addresses of the phrase. Addressing is in Pages. You should specify the page's top address (the lower 7 bits = 0) for the Start Address, while the page's end address (the lower 7 bits = 1) for the End Address. If you specify Stadr = Enadr, the LSI performs endless (loop) recording. Note: You may not specify the Start address value that is larger than the End address. |
| Del | 1st Byte | 70h | Deletes the specified phrase(s). |
| | 2nd Byte | Phrase[7:0] | The value for the Phrase. Range: 01h to FFh |
| | If you specify "00h" for the Phrase, all phrase data will be erased. | | |
| Pause | 1st Byte | 41h | Pauses recording or playing. |
| | Re-entering the command resets pause state and resumes the earlier operation. | | |
| Start | 2nd Byte | Phrase[7:0] | Starts recording or playing. |
| Stop | 1st Byte | 40h | Stops recording or playing. |

Other Commands Common in All Modes (1/2)

| Command | Code | | Description | | | | | | | | | | | | | | | | | | | | |
|---------|-------------|-------------|---|-----|-------------|-----|-------------|----|------|----|--------|----|-------|----|--------|----|-------|----|--------|----|-------|----|--------|
| Nop | 1st Byte | 00h | Represents "No Operation". The command is ignored. | | | | | | | | | | | | | | | | | | | | |
| Dtrw | 1st Byte | 60h | Use this command to make an access to the on-chip DRAM or Mask ROM. | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Adr[23:16] | Specify the head address at which you want to start reading or writing. | | | | | | | | | | | | | | | | | | | | |
| | 3rd Byte | Adr[15:8] | | | | | | | | | | | | | | | | | | | | | |
| | 4th Byte | Adr[7:0] | | | | | | | | | | | | | | | | | | | | | |
| | | | You can't access to DRAM and Mask ROM simultaneously. If you want to access to the other memory address, you need to enter the End command to end Dtrw mode once, and then set up the new address by using the Dtrw command again. | | | | | | | | | | | | | | | | | | | | |
| Bytew | 1st Byte | 61h | Use this command to write data to the on-chip DRAM. | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Data[7:0] | Writing data. | | | | | | | | | | | | | | | | | | | | |
| | | | After writing data is complete, the address pointer for writing is incremented by one. When the last address of the DRAM is reached, the next address automatically returns to the top address of the DRAM. | | | | | | | | | | | | | | | | | | | | |
| Byter | 1st Byte | 62h | Use this command to read data from the on-die DRAM or Mask ROM. | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Data[7:0] | Reading data (in serial from the SO pin). | | | | | | | | | | | | | | | | | | | | |
| | | | After reading data is complete, the address pointer for reading is incremented by one. When the last address of the DRAM or Mask ROM is reached, the next address automatically returns to the top address of each memory. | | | | | | | | | | | | | | | | | | | | |
| End | 1st Byte | 63h | Use this command to end Dtrw mode. | | | | | | | | | | | | | | | | | | | | |
| Pdwn1 | 1st Byte | 80h | Use this command to let the LSI enter power-down state. The on-chip DRAM enters self-refresh mode to preserve all the stored data. | | | | | | | | | | | | | | | | | | | | |
| Pdwn2 | 1st Byte | 88h | Use this command to let the LSI enter power-down state. Data on the DRAM will be lost. | | | | | | | | | | | | | | | | | | | | |
| Test | 1st Byte | F0h | The LSI test command. Do not enter the command. | | | | | | | | | | | | | | | | | | | | |
| Rply | 1st Byte | 24h | Use this command to play Mask ROM data. | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Phrase[7:0] | Sets ROM phrase value. | | | | | | | | | | | | | | | | | | | | |
| | | | The Mask ROM Phrase values are independently controlled, separately from the Phrase values for DRAM recording. | | | | | | | | | | | | | | | | | | | | |
| Vol | 1st Byte | 28h | Use this command to set up a volume level. | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Vol[7:0] | The default value for the Vol is "0h". | | | | | | | | | | | | | | | | | | | | |
| | | | Vol values and Attenuation | | | | | | | | | | | | | | | | | | | | |
| | | | <table border="1"> <thead> <tr> <th>Vol</th><th>Attenuation</th><th>Vol</th><th>Attenuation</th></tr> </thead> <tbody> <tr> <td>0h</td><td>0 dB</td><td>4h</td><td>-12 dB</td></tr> <tr> <td>1h</td><td>-3 dB</td><td>5h</td><td>-15 dB</td></tr> <tr> <td>2h</td><td>-6 dB</td><td>6h</td><td>-18 dB</td></tr> <tr> <td>3h</td><td>-9 dB</td><td>7h</td><td>-21 dB</td></tr> </tbody> </table> | Vol | Attenuation | Vol | Attenuation | 0h | 0 dB | 4h | -12 dB | 1h | -3 dB | 5h | -15 dB | 2h | -6 dB | 6h | -18 dB | 3h | -9 dB | 7h | -21 dB |
| Vol | Attenuation | Vol | Attenuation | | | | | | | | | | | | | | | | | | | | |
| 0h | 0 dB | 4h | -12 dB | | | | | | | | | | | | | | | | | | | | |
| 1h | -3 dB | 5h | -15 dB | | | | | | | | | | | | | | | | | | | | |
| 2h | -6 dB | 6h | -18 dB | | | | | | | | | | | | | | | | | | | | |
| 3h | -9 dB | 7h | -21 dB | | | | | | | | | | | | | | | | | | | | |

Other Commands Common in All Modes (2/2)

| Command | Code | | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------|----------|--|--|---------------------|--|--|-----|------|-------------|---|-------|-----------------------------|---|-----|-----------------------------|---|-----|-------------------------------|---|-----|--|---|-----|---|---|---|--------------|---|---|--------------|---|---|--------------|
| Copy | 1st Byte | 68h | Use this command to move data in Pages. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | PgStart[15:8] | Enter the top address of the page where the data you want to move is stored. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3rd Byte | PgStart[7:0] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4th Byte | PgEnd[15:8] | Enter the last address of the page where the data you want to move is stored. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5th Byte | PgEnd[7:0] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6th Byte | Target [15:8] | Enter the top address of the starting page to which you want to move the data. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7th Byte | Target [7:0] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | The data from the page specified with the PgStart to the page specified with the PgEnd is moved to the pages starting from the page specified with the Target. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Status | 1st Byte | FFh | Reads LSI's status. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2nd Byte | Status[7:0](O) | Outputs the LSI's status signals. (in serial from the SO pin) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | <table><tr><th colspan="3">Status Bit Function</th></tr><tr><th>Bit</th><th>Name</th><th>Description</th></tr><tr><td>7</td><td>PAUSE</td><td>Outputs "H" during pausing.</td></tr><tr><td>6</td><td>PLY</td><td>Outputs "H" during playing.</td></tr><tr><td>5</td><td>REC</td><td>Outputs "H" during recording.</td></tr><tr><td>4</td><td>RPM</td><td>Outputs "L" while processing recording or playing data. Outputs "H" while the ADPCM unit is ready.</td></tr><tr><td>3</td><td>NAR</td><td>Outputs "H" when the LSI gets ready to accept the next phrase data while playing Mask ROM data.</td></tr><tr><td>2</td><td>—</td><td>No function.</td></tr><tr><td>1</td><td>—</td><td>No function.</td></tr><tr><td>0</td><td>—</td><td>No function.</td></tr></table> | Status Bit Function | | | Bit | Name | Description | 7 | PAUSE | Outputs "H" during pausing. | 6 | PLY | Outputs "H" during playing. | 5 | REC | Outputs "H" during recording. | 4 | RPM | Outputs "L" while processing recording or playing data. Outputs "H" while the ADPCM unit is ready. | 3 | NAR | Outputs "H" when the LSI gets ready to accept the next phrase data while playing Mask ROM data. | 2 | — | No function. | 1 | — | No function. | 0 | — | No function. |
| Status Bit Function | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bit | Name | Description | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | PAUSE | Outputs "H" during pausing. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | PLY | Outputs "H" during playing. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | REC | Outputs "H" during recording. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | RPM | Outputs "L" while processing recording or playing data. Outputs "H" while the ADPCM unit is ready. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | NAR | Outputs "H" when the LSI gets ready to accept the next phrase data while playing Mask ROM data. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | — | No function. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | — | No function. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | — | No function. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Fast Forward/Rewind Playback (Valid only in Retroactive Play mode and Normal Mode)

| Command | Code | | Description |
|---------|----------|------------|--|
| Cue/Rew | 1st Byte | 23h | Start fast forward or rewinding playback |
| | 2nd Byte | Unit[7:4] | Sets Unit value |
| | | Speed[3:0] | Sets Speed value |

Use this command, while playing, to start Fast Forward or Rewinding playback from the point that is currently played. When you want to get the speed back to normal X1 play, execute the Cue/Rew command again with the Speed value of "0". The Unit value is ignored in this operation.

Unit Function

| Unit | Description |
|------|------------------------|
| 0 | By unit of 1,024 bits |
| 1 | By unit of 2,0484 bits |
| 2 | By unit of 4,0964 bits |
| 3 | By unit of 8,192 bits |
| 4 | By unit of 16,384 bits |

Speed Function

| Speed | Description | Speed | Description |
|-------|-------------------|-------|-----------------------|
| 0 | FF at X1 speed | 8 | Rewind at X1 speed |
| 1 | FF at X1.25 speed | 9 | Rewind at X1.25 speed |
| 2 | FF at X1.5 speed | A | Rewind at X1.5 speed |
| 3 | FF at X2 speed | B | Rewind at X2 speed |
| 4 | FF at X3 speed | C | Rewind at X3 speed |
| 5 | FF at X4 speed | D | Rewind at X4 speed |

Combinations of Units and Speeds

| Speed | | Unit | | | | | |
|-------|-------|------|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| 0 | X1 | — | — | — | — | — | — |
| 1 | X1.25 | — | — | ○ | ○ | ○ | ○ |
| 2 | X1.5 | — | ○ | ○ | ○ | ○ | ○ |
| 3 | X2 | ○ | ○ | ○ | ○ | ○ | ○ |
| 4 | X3 | ○ | ○ | ○ | ○ | ○ | ○ |
| 5 | X4 | ○ | ○ | ○ | ○ | ○ | ○ |
| 8 | X1 | — | — | — | — | — | — |
| 9 | X1.25 | — | — | ○ | ○ | ○ | ○ |
| A | X1.5 | — | ○ | ○ | ○ | ○ | ○ |
| B | X2 | ○ | ○ | ○ | ○ | ○ | ○ |
| C | X3 | ○ | ○ | ○ | ○ | ○ | ○ |
| D | X4 | ○ | ○ | ○ | ○ | ○ | ○ |

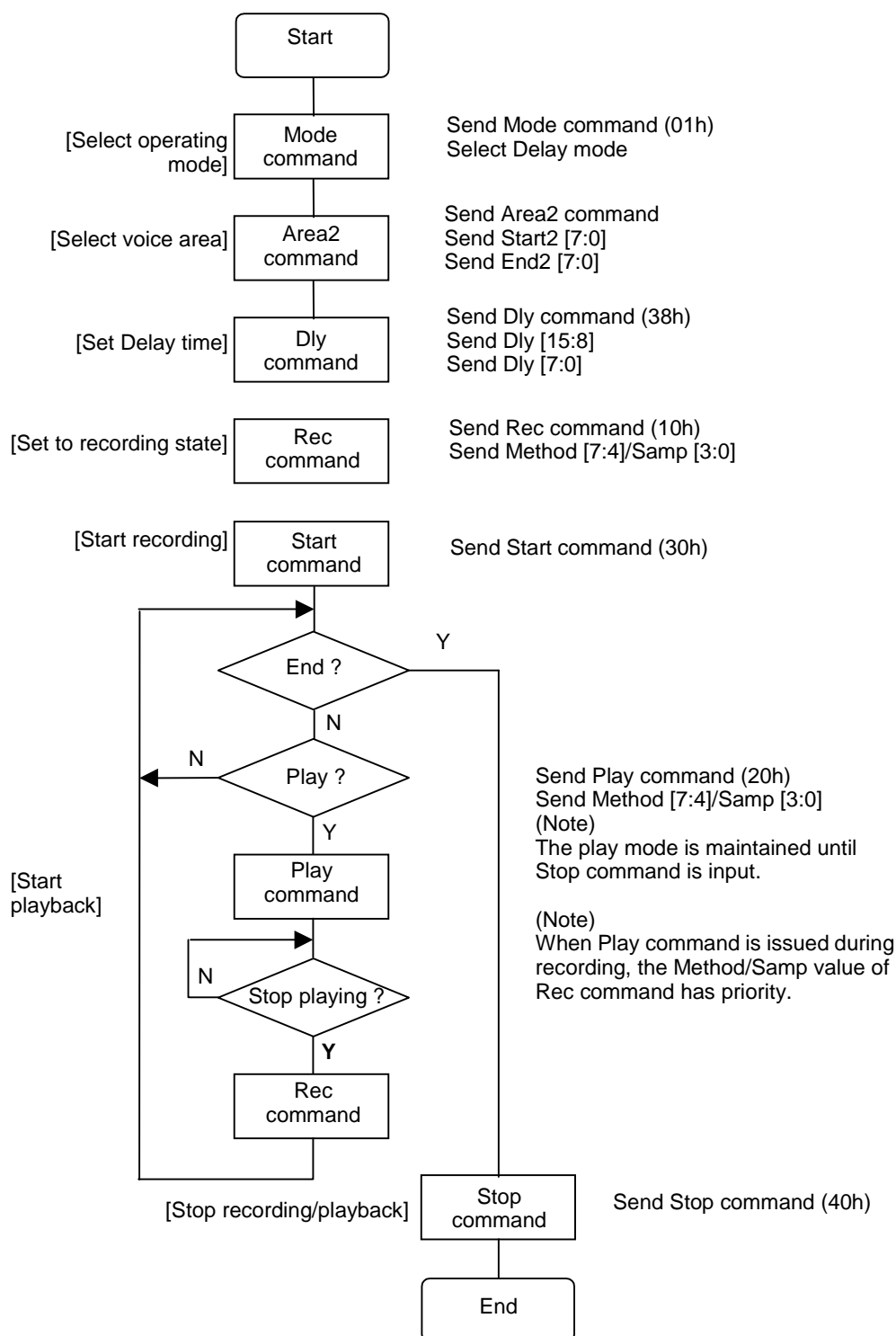
The combination of the Unit value and the Speed value affects playback sound. Therefore, choose a proper combination of the two values depending on the type of sound to be played. The Fast Forward/Rewind Play function is available only in Retroactive Play Mode and Normal mode. If you use this function, you should not use the Block address FFh.

Note: The following restrictions apply to this function:

- The size of the sound data area must be 128 pages (i.e. 16 blocks) or more.
- You may not use the block address FFh.
- The Cue/Rew command is unavailable for playback after an endless recording session or repeat play by using the Play2 command.

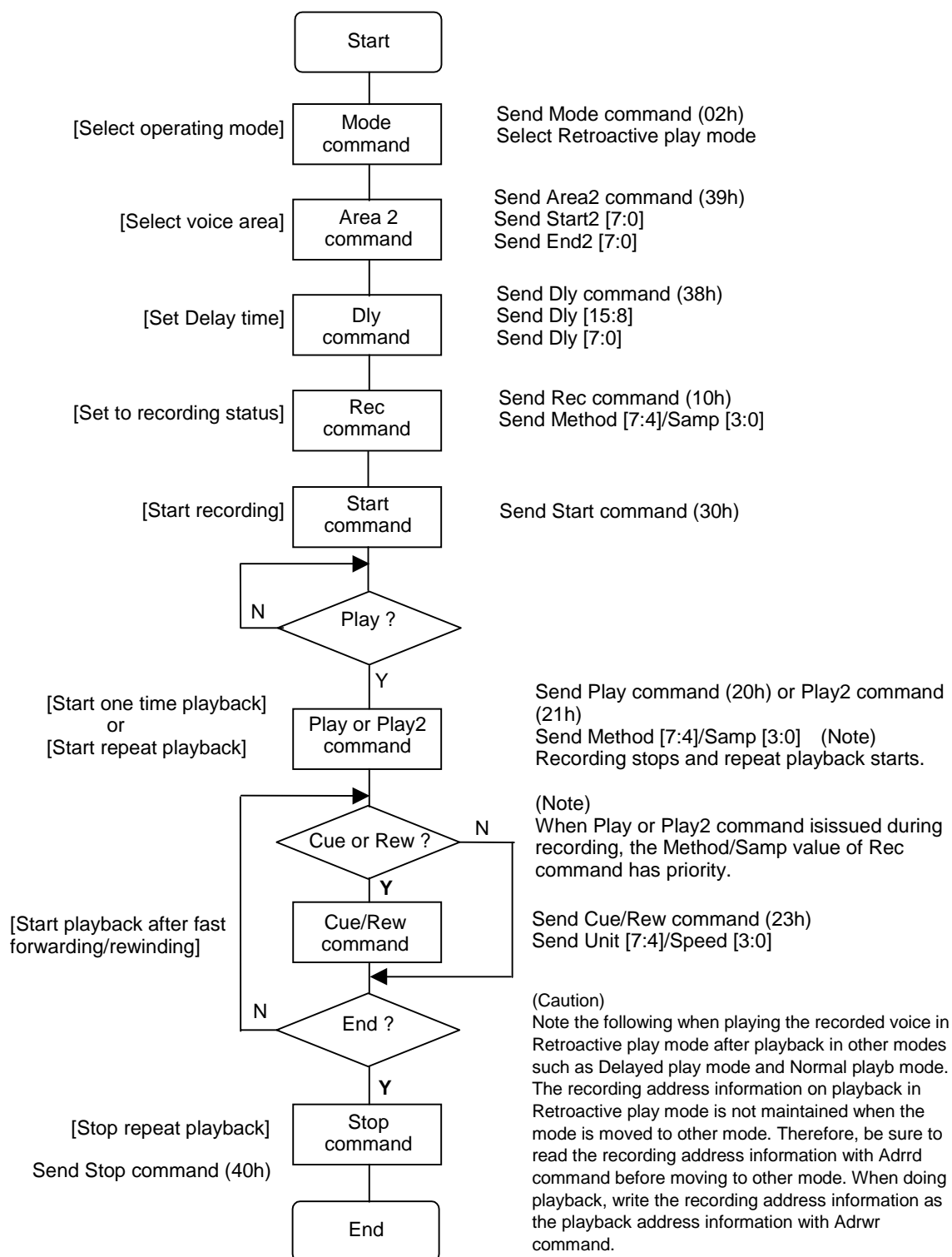
FLOWCHARTS

Delayed Play Mode



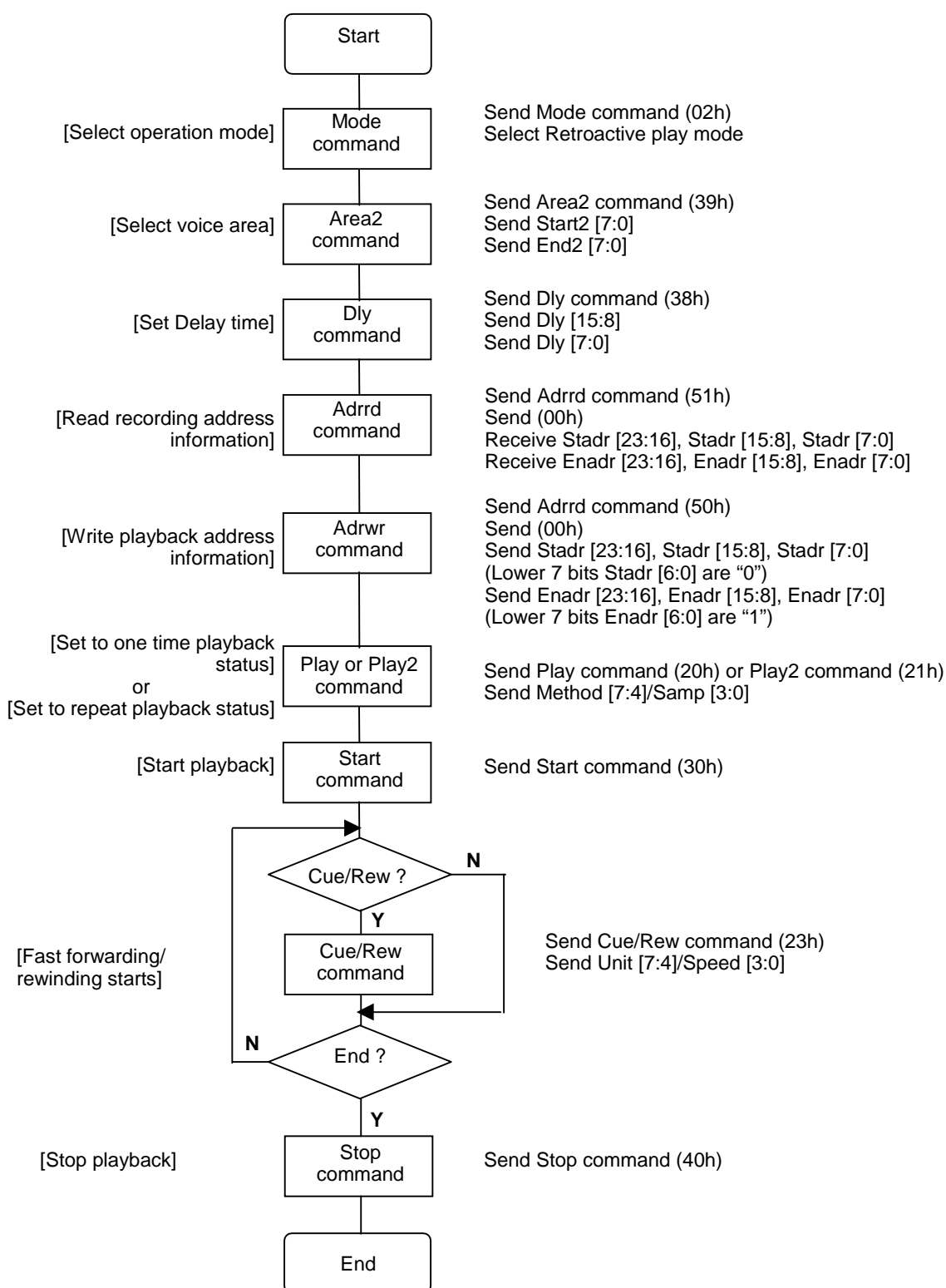
Retroactive Play Mode (1)

Shown below is the flowchart in which playback starts by issuing the Play or Play2 command during recording. When playing the recorded voice, see the flowchart on the next page.

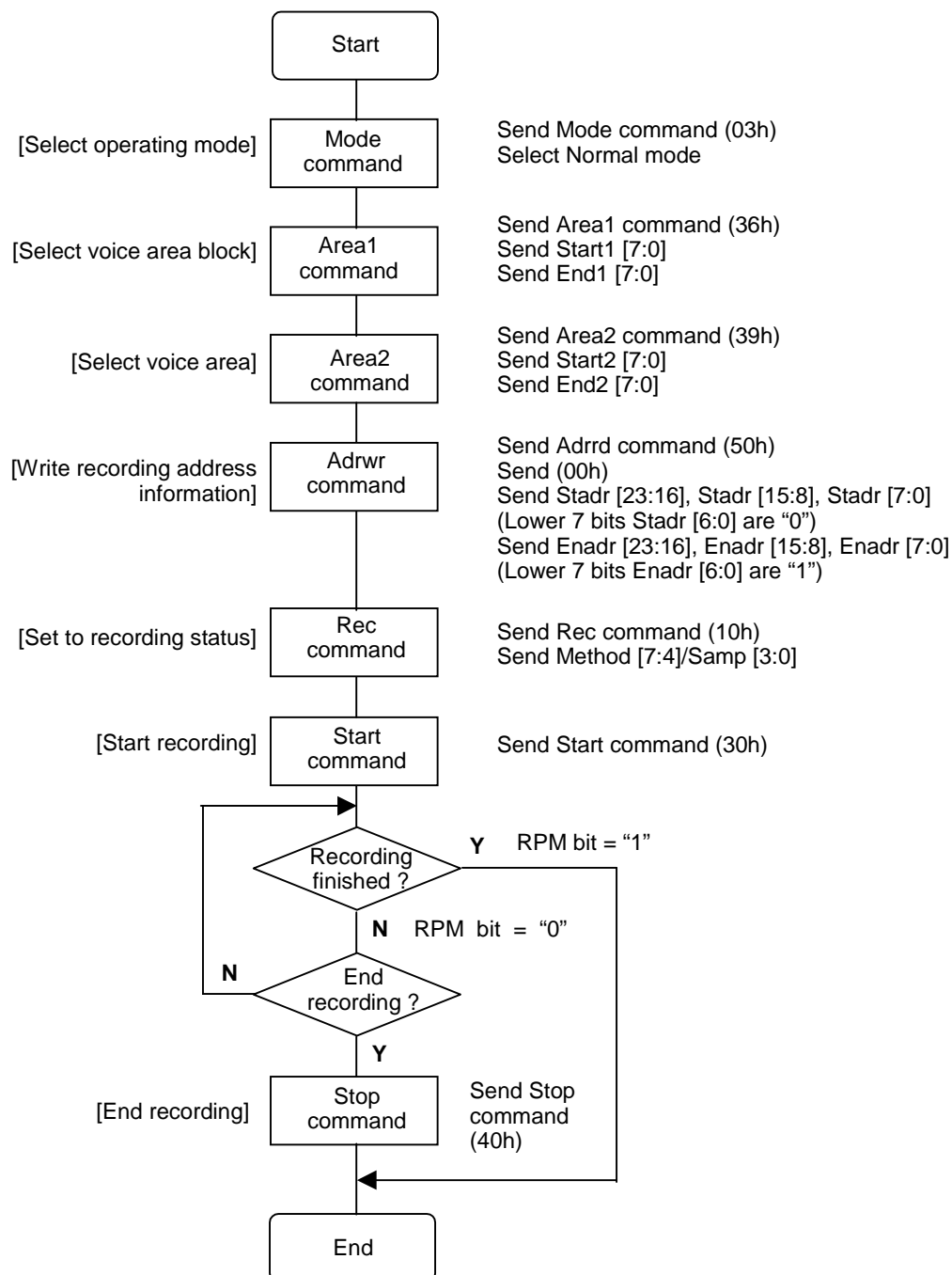


Retroactive Play Mode (2)

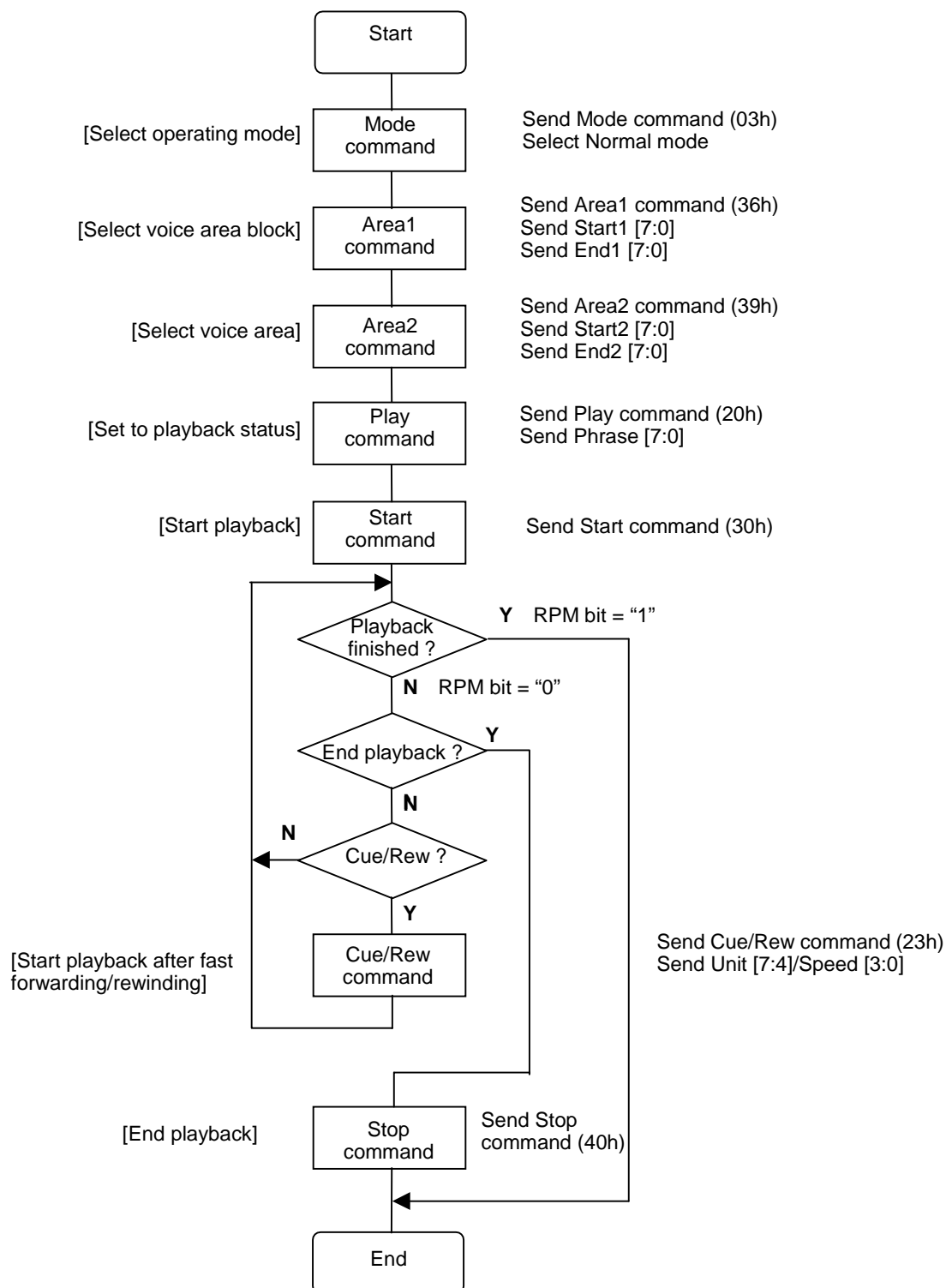
Shown below is the flowchart in which the voice that was recorded in Repeat playback mode is played later.

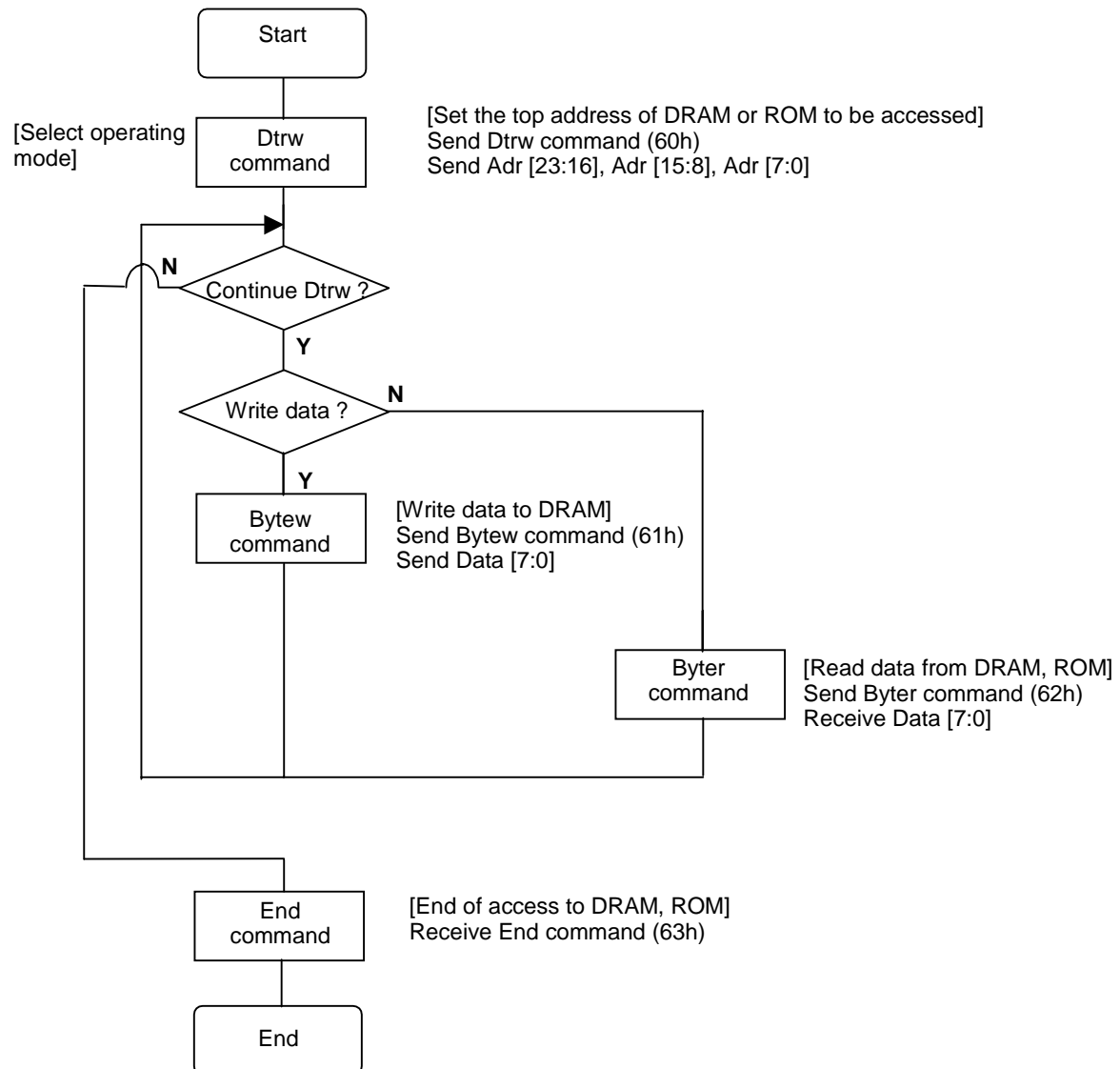


Recording in Normal Mode

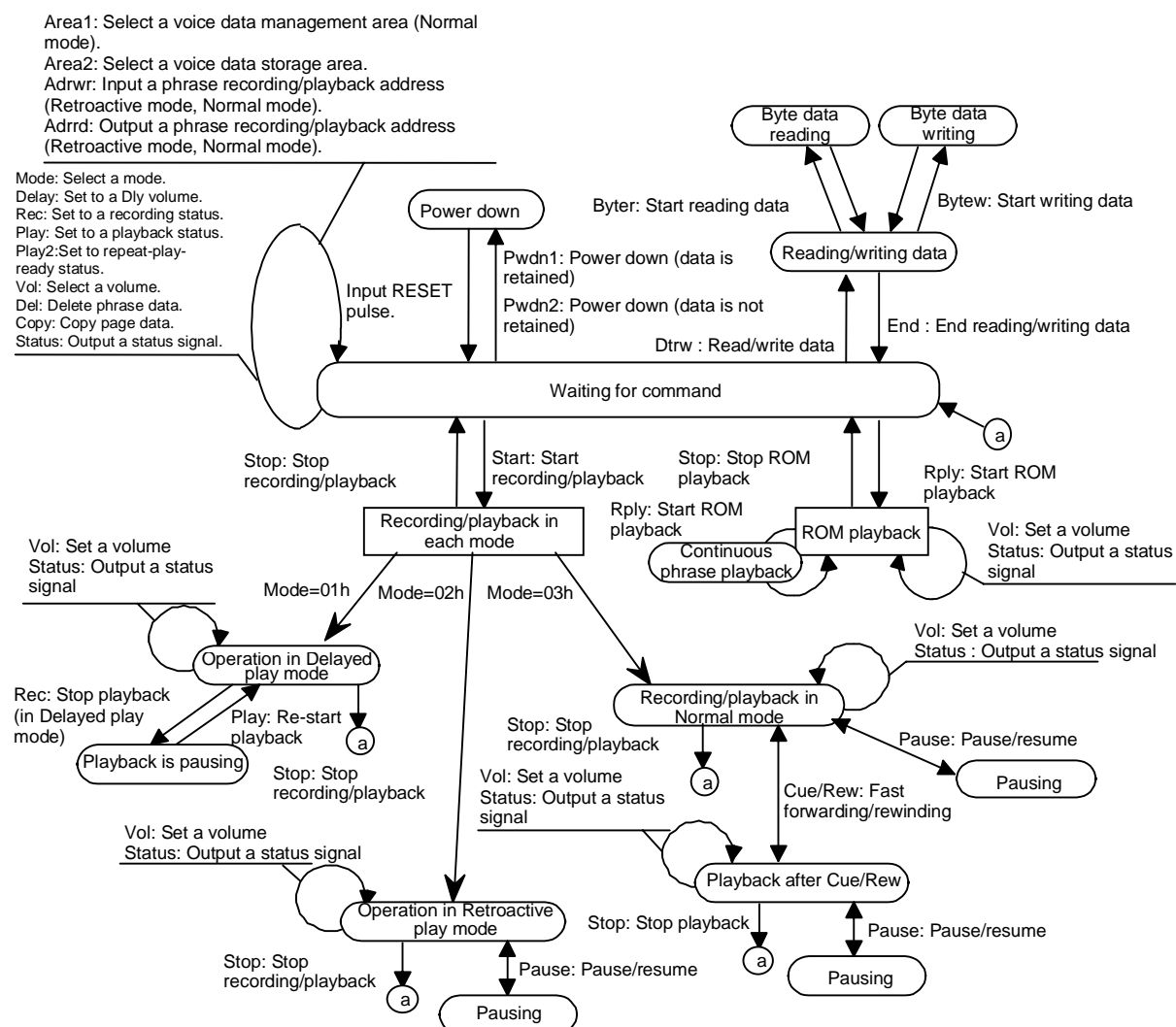


Playback in Normal Mode



Dtrw Command

STATUS TRANSITION DIAGRAM

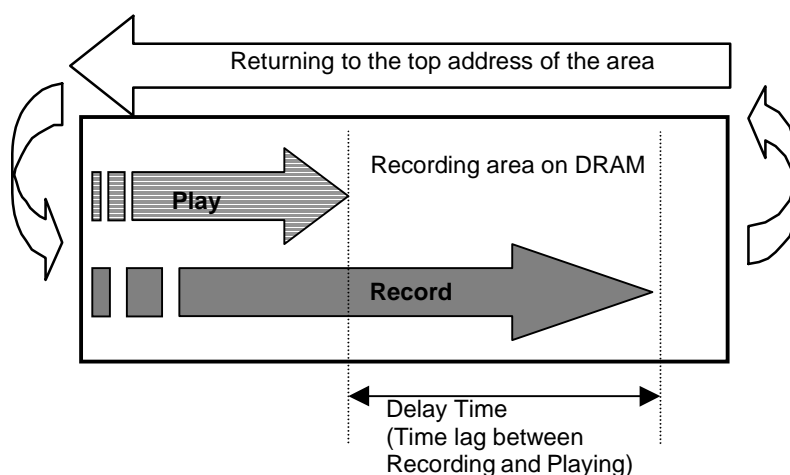


SUMMARY OF OPERATING MODES AND FUNCTIONS

Delayed Play Mode

Delayed Play is a unique operational mode that enables you to hear what has been recorded several seconds ago while the LSI keeps on recording current sound. As shown in the figure below, while the LSI keeps on recording in endless circular motion by returning to the top address of the DRAM's area specified with the Area2 command, it simultaneously plays what has been recorded earlier with a time lag defined with the Delay command.

Adding this function to a conventional recording system like cassette tape recorder enables you to record sound in the past to such other media as a cassette tape.

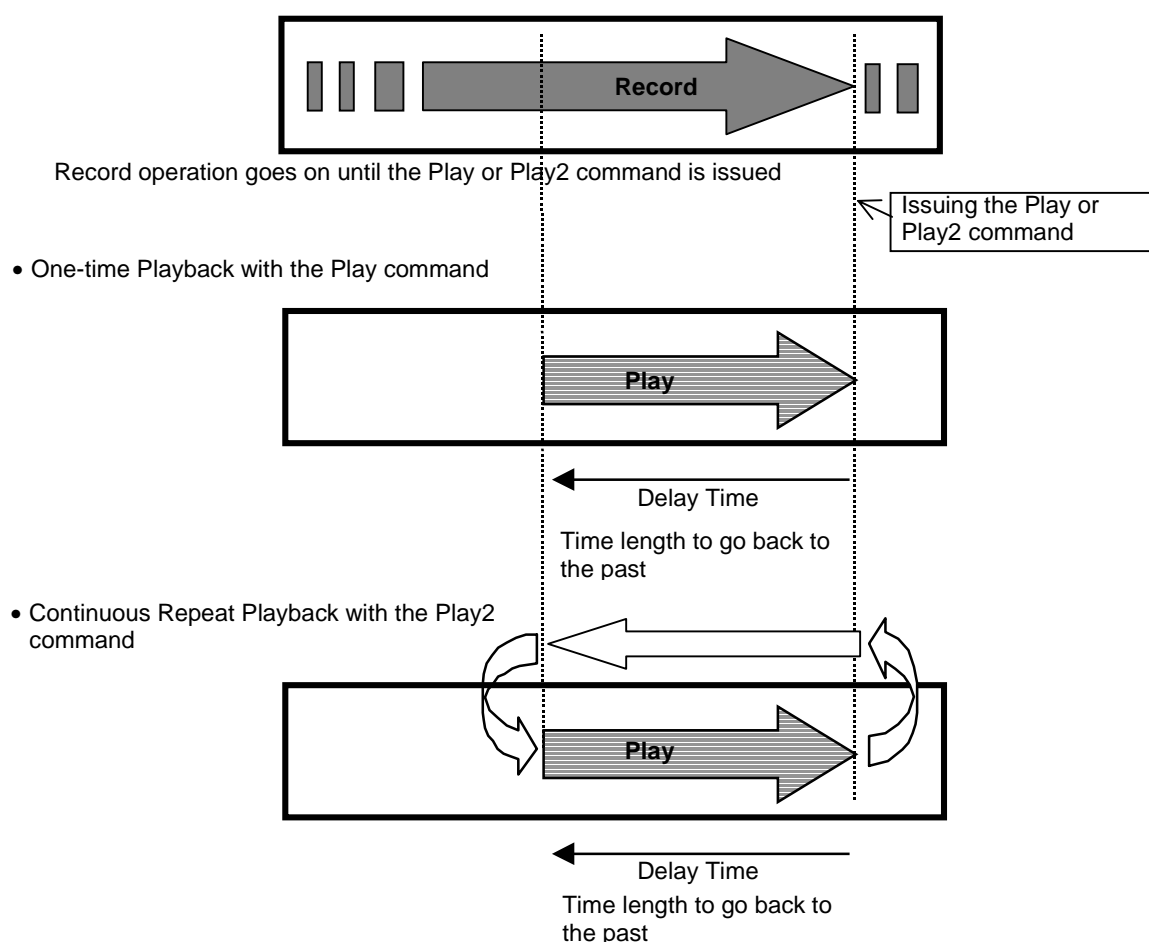


In Retroactive Play Mode or Normal Mode, you cannot play what has been recorded in Delayed Play Mode.

Retroactive Play Mode

Retroactive Play is another unique and handy operational mode that enables you to hear what you have missed a short period ago. While you let the LSI continue recording in endless circular motion to the memory's area specified with the Area2 command, you can issue the Play or Play2 command to hear what you have missed, going back to earlier data that the LSI has stored so far. This enables you to record sound in the past retroactively, which differentiates your application from so called "Voice Reminder" type of applications. The Delay time, that is a time length to go back to the past, can be defined by using the Delay command.

In addition, the LSI supports Cue/Rewind function that has been unavailable with conventional ADPCM record/play chips. This provides you with faster search capability among recorded messages.



Issuing the Play or Play2 command during recording operation causes the LSI to stop recording.

Normal Mode

MS87V1021 also provides Normal Mode where you can record or play to/from the on-chip DRAM as with a conventional solid-state recorder. You can readily build a “Voice Reminder” application around this microchip that enables up to 255-phrase recording and playing. In addition, the LSI supports Cue/Rewind function that has been unavailable with conventional ADPCM record/play chips. This provides you with faster search capability among recorded messages.

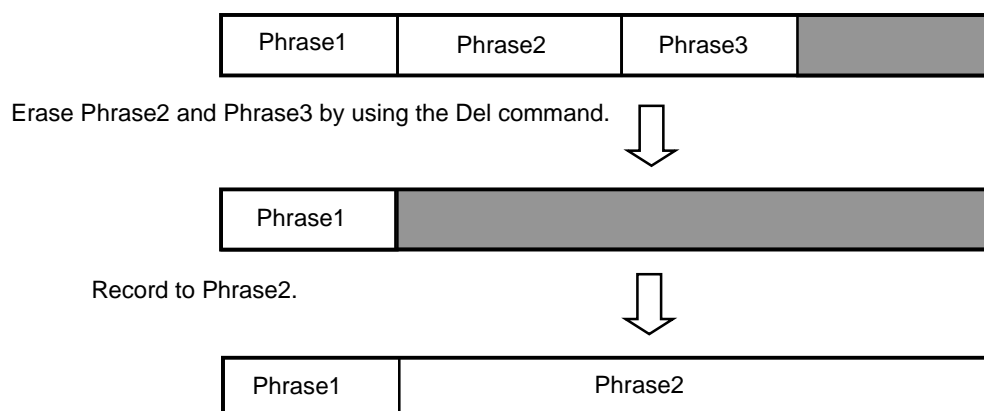
DRAM's Sound Data Storage Area

| | | | | | |
|---------|---------|---------|-------|-----------|-----------|
| 1Phrase | 2Phrase | 3Phrase | | 254Phrase | 255Phrase |
|---------|---------|---------|-------|-----------|-----------|

You can flexibly adjust the size of each phrase area according to your recording time requirement.

Assume that you already have Phrase1 through Phrase3 recorded. Now, you want to erase Phrase2 and Phrase3 so that you can create new Phrase2 with larger memory space.

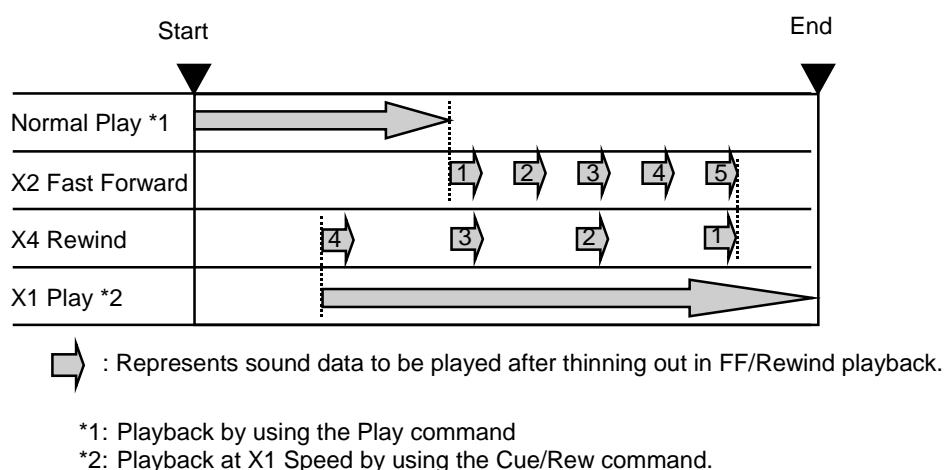
To do so, follow the steps below:



Fast Forward/Rewind Function (Cue/Rew)

Fast Forward/Rewind playback function is a unique new feature that enables you to do speed hearing across multiple phrases. This function is available in Retroactive Play Mode and Normal Mode only. Fast Forward and Rewind playback is performed by culling recorded ADPCM data. You can optimize speedy hearing quality for source sound types by selecting appropriate culling interval and playback speed.

The figure below shows an example operations performing Fast Forward/Rewind playback in the following order;
Normal Play \Rightarrow X2 Fast Forward \Rightarrow X4 Rewind \Rightarrow X1 Play



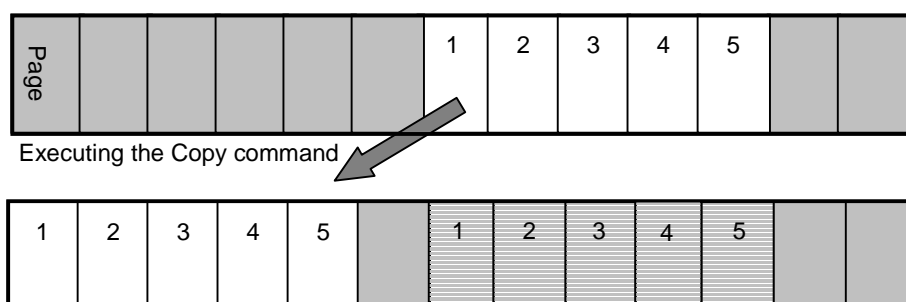
You need to issue the Cue/Rew command, setting the Speed value to “0”, if you want to return to normal X1 speed playback after performing Cue/Rew operation.

[Restrictions on Fast Forward/Rewind Playback Function]

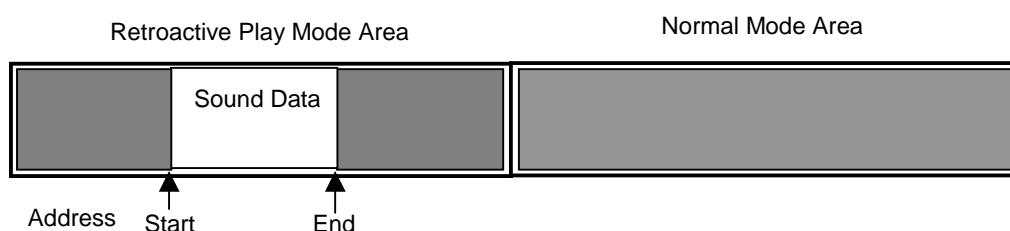
- (1) If you plan to use Cue/Rew function in your application, you should not use block address FFh for storing sound data in Retroactive Play Mode and Normal Mode. If you intend not to use the function, you can use all blocks including FFh.
- (2) You cannot use Cue/Rew function in Normal mode when the Record_start address is equal to the Record_end address. (When voices are played after endless recording)

Copy Command

You can use the Copy command to move recorded data that you want to keep to another location on the memory. Moving specific data to another location enables you to secure contiguous open memory space for longer recording time. Be sure to select a destination area not overlapping with a source data area. The minimum unit for copying data is in pages.

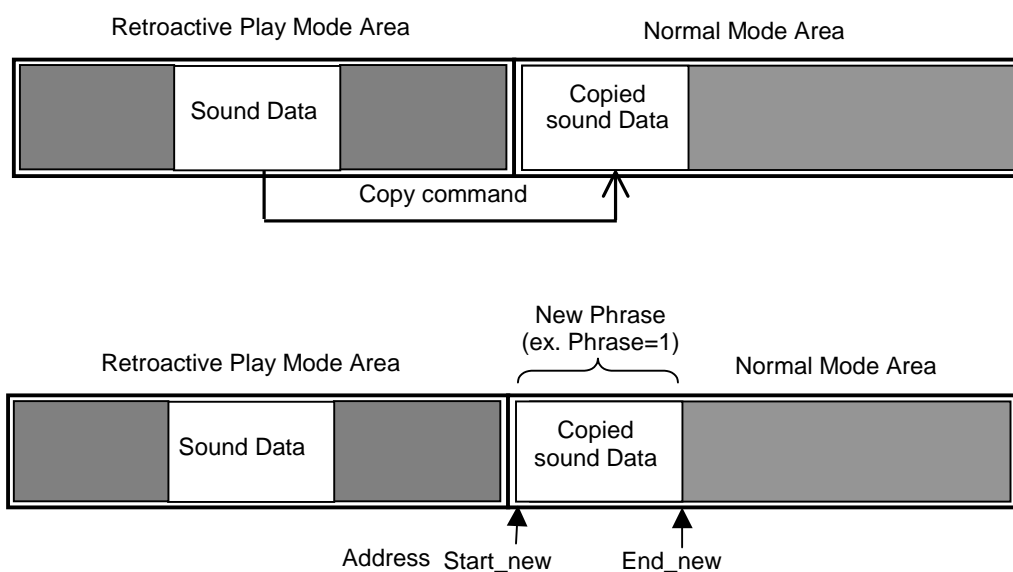


You can also move data in the Retroactive Play Mode area to the Normal Mode area.



Copy sound data with the Copy command.

Set up Start_new and End_new addresses, Method, and Samp information so as to control a new phrase.



[Defining the Method, Samp and address information]

To let the LSI to recognize a copied sound data as a new phrase, you need to define address control information that includes the Method, Samp, Start Address and End Address. Such information should be entered to an address control data area for each phrase. For more details on address control data area, see "Controlling addresses in Normal Play Mode".

To define address control information, follow the steps below:

1. Defining the Method and Samp

Use the Bytew command to write the data.

(Ex.) Where;

Phrase 1, Method = 01h, Samp = 08h and Start Address for Area1 = 00h

- (1) Specifying the Start Address

Enter the DTRW command; 2nd Byte: 00h, 3rd Byte: 00h, 4th Byte: 08h

- (2) Writing the data

Enter the Bytew command; 2nd Byte: 18h • Writing the Method and Samp data

- (3) Ending Write Mode

Enter the End command

2. Defining the Start Address and End Address

Use the Adrwr command to define the data for each phrase.

(Ex.) Where;

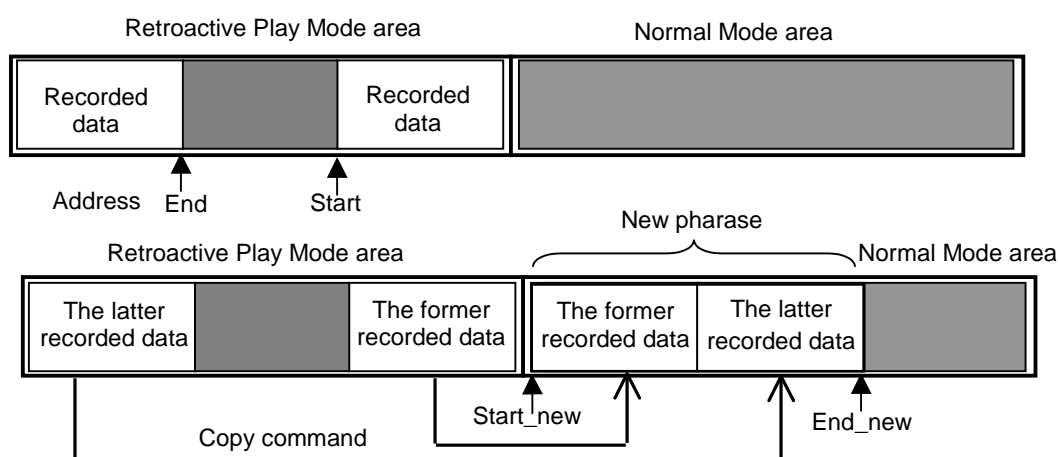
Phrase 1, Stadr = 000800h and Enadr = 010000h

Enter the Adrwr command; 2nd Byte: 01h, 3rd Byte: 00h, 4th Byte: 80h

5th Byte: 00h, 6th Byte: 01h, 7th Byte: 00h, 8th Byte: 00h

[Copying separated data]

To copy two data that were separately recorded in two portions of a Retroactive Play Mode area as shown below, issue the Copy command twice, first for the former data and second for the latter data.

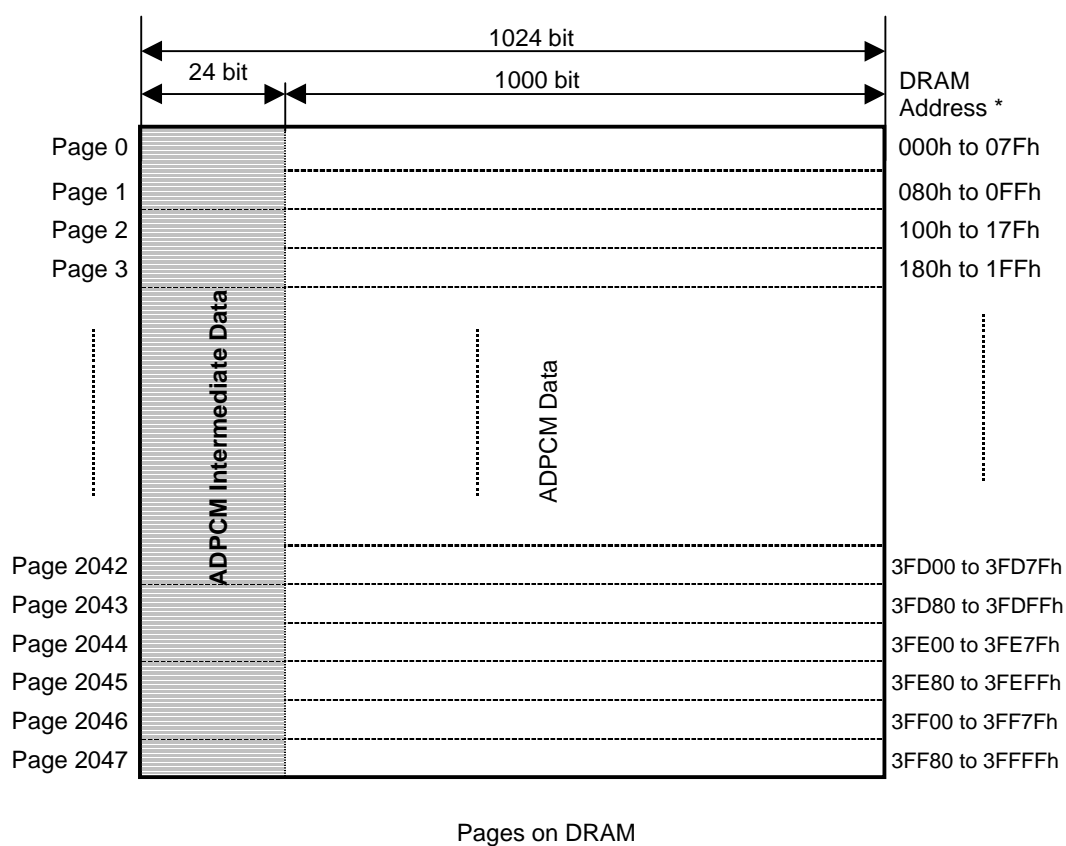


MEMORY ALLOCATION

Storing Sound Data to DRAM (In Pages)

The on-die 2-Mbit DRAM consists of 2048 pages, 1024 bits for each page. The first 24-bit memory space of each page is allocated for storing ADPCM intermediate data and the remaining 1000-bit space for storing ADPCM (sound) data.

For additional information on data structures of pages allocated for address control in Normal Mode, see “Controlling Addresses of Sound Data in Normal Mode” later in this document.

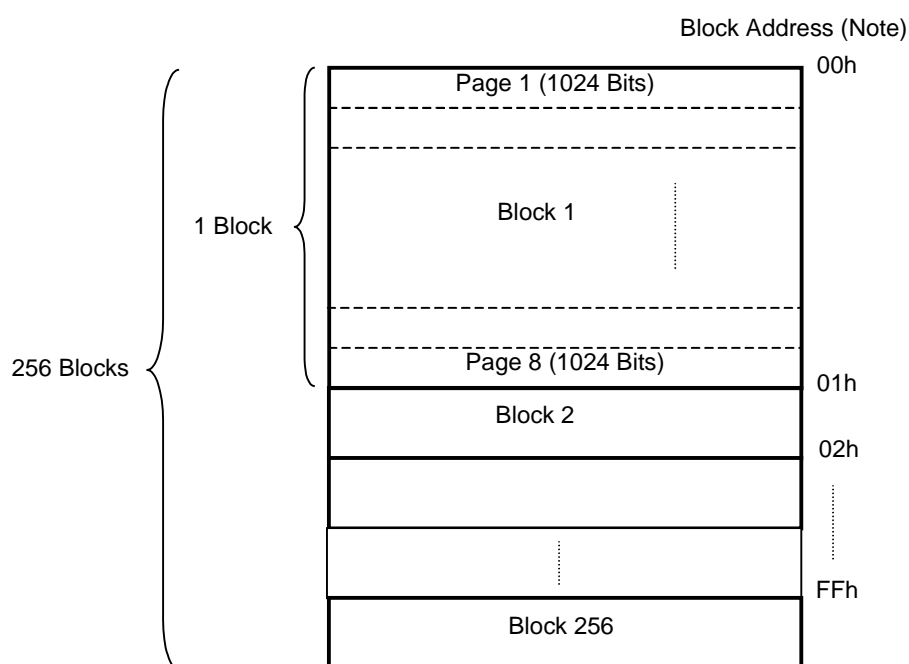


Note: “DRAM Address” means the addresses used with the Adrrd and Adrwr commands, i.e. Stadr[23:0] and Enadr[23:0].

Storing Sound Data to DRAM (In Blocks)

A block is a memory space unit that is equivalent to 1/256 of the entire DRAM capacity. The memory space for a block can be obtained by the following formula:

$$1 \text{ Block} = 2,097,152 \text{ Bits} / 256 = 8,192 \text{ Bits (Equals to 8 Pages)}$$



Note: Block address is a value for the Start1/ Start2 and End1/End2 when you specify a memory area using the Area1 or Area2 command.

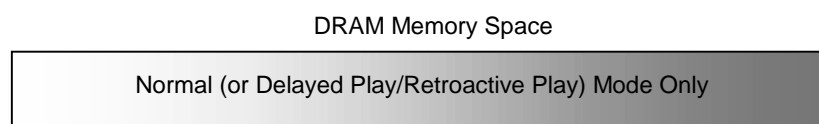
Each block is assigned to a specific memory address. The following table shows block addresses and its corresponding memory addresses at the top of each block. For blocks not appearing in the table below, you can get the top address value of a given block by incrementing 400h for each single block.

DRAM Memory Address at the top of Blocks

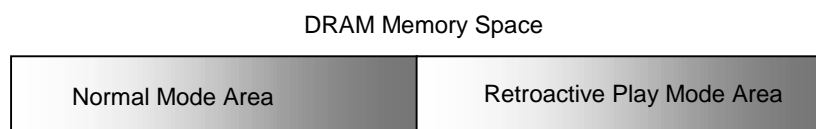
| Block Address | DRAM Memory Address |
|---------------|---------------------|
| 00h | 000000h |
| 01h | 000400h |
| 02h | 000800h |
| 04h | 001000h |
| 08h | 002000h |
| 10h | 004000h |
| 20h | 008000h |
| 40h | 010000h |
| 80h | 020000h |
| FFh | 03FC00h |

You need to assign a separate memory space area for each playback mode. Delayed Play Mode, Retroactive Play Mode and Normal Mode must have their own memory space, when used in a single application. Each mode cannot share any memory space with other modes. Therefore, you need to define a proper memory area for each mode if you are required to use more than one mode in a single application.

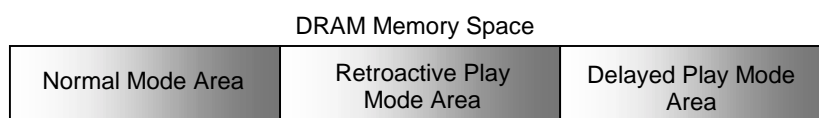
- (1) When the entire DRAM memory space is used for a single play mode



- (2) When the DRAM memory space is divided into two areas (For Normal and Retroactive Play Mode in this example)



- (3) When the DRAM memory space is divided into three areas

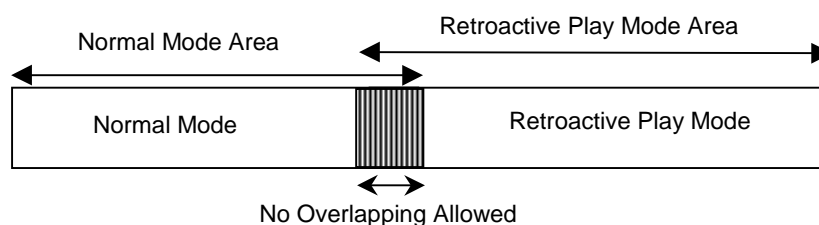


You can move, in pages, sound data recorded in Retroactive Play Mode to the Normal Mode area by using the Copy command. This enables you to control phrases recorded in Retroactive Play Mode in Normal Mode. Sound data recorded in Delayed Play Mode cannot be moved to the Retroactive Play Mode area or Normal Mode area. Data in the Normal Mode area neither can be moved to the Retroactive Play Mode area.

[Note 1 on Selecting Blocks for more than one mode]

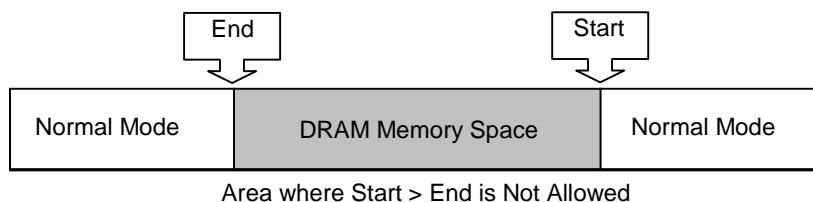
Be sure to select blocks not overlapping with the area specified for other modes, when you select blocks for multiple modes.

When you define an area for each mode, you can define only one area for a specific mode. So, as shown in the above three figure, you can define up to three areas for three modes.

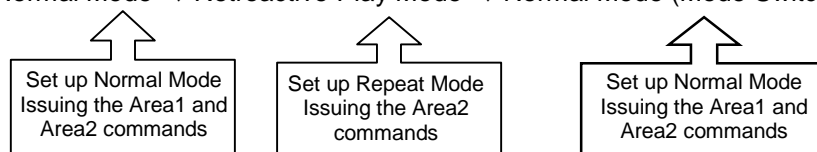
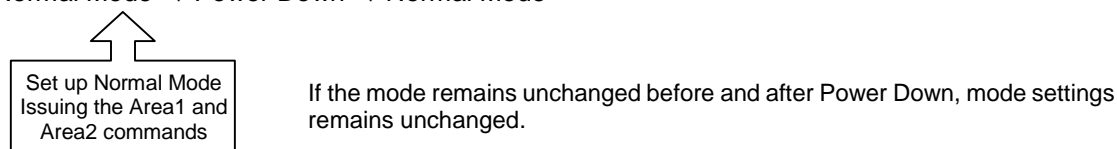


[Note 2 on Selecting Blocks for more than one mode]

As shown in the following example, you cannot select blocks across the end address of the DRAM when you define an area with the Area1 or Area2 command. Therefore, the Start1, 2 and End1, 2 values must always satisfy $\text{Start1, 2} < \text{End1, 2}$.

**[Re-defining an Area after Mode Switch]**

When you switch an operation mode from one to another, you should redefine the area by using the Area2 command.

(1) Normal Mode \Rightarrow Retroactive Play Mode \Rightarrow Normal Mode (Mode Switched)**(2) Normal Mode \Rightarrow Power Down \Rightarrow Normal Mode**

The values set with the Area1 command in Normal Mode remain unchanged until Reset signal is entered.

Controlling Addresses in Retroactive Play Mode

In Retroactive Play Mode, four registers are defined within the internal Record/Play register. Those are the record/play_start address (Stadr), the record/play_end address (Enadr), the sampling frequency (Samp) and the method (Method).

Use the Adrrd command to read the Stadr/Enadr value, and the Adrwr command to write the Stadr/Enadr value. In addition, you need to set up a sampling frequency and an ADPCM algorithm (Method) by using the Rec or Play command.

The Internal Record/Play Registers

| | |
|-----------------|-----------------|
| Stadr (24 bits) | |
| Enadr (24 bits) | |
| | Samp (4 bits) |
| | Method (4 bits) |

[Note on Issuing the Adrrd or Adrwr command]

In Retroactive Play Mode, multiple phrasing is not allowed by its design. However, the recorded data is processed as “Phrase = 0” internally. Therefore, be sure to set the second byte to “00h” as you issue the Adrrd or Adrwr command.

[Note on Issuing the Stadr and Enadr commands]

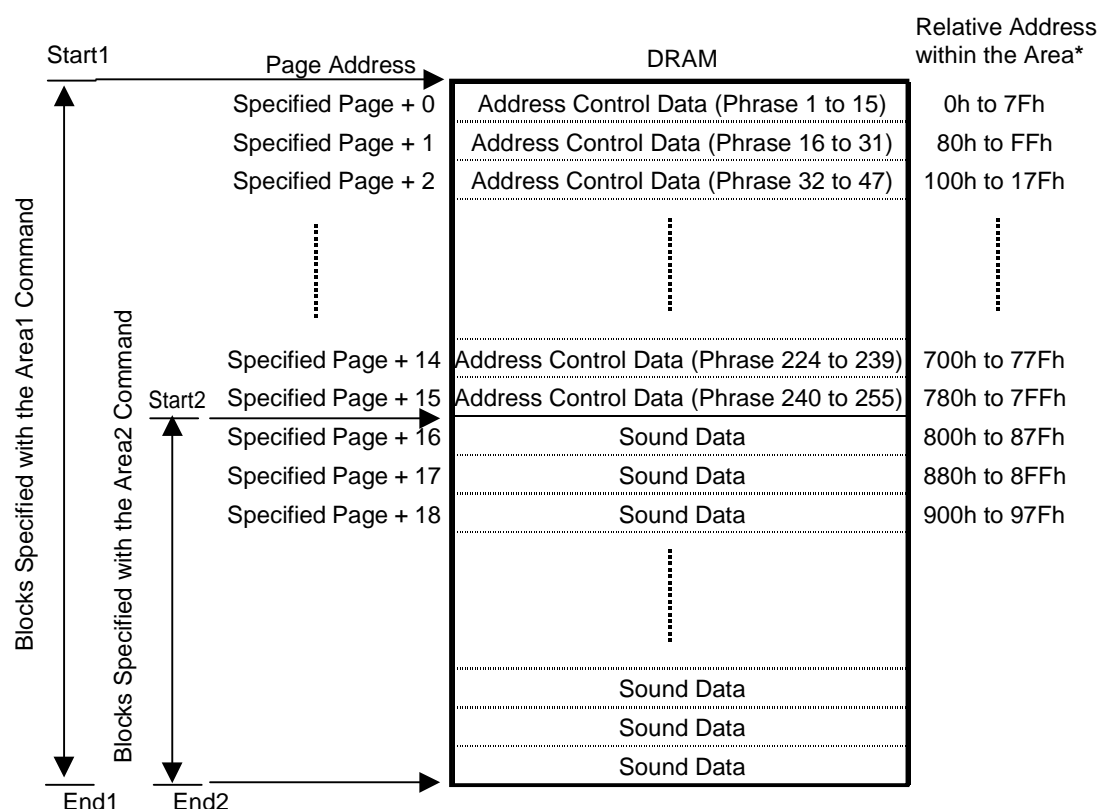
Sound data has ADPCM intermediate data in each page. By the nature of ADPCM, playback must start from the top address of a page, otherwise playback cannot be performed properly. Therefore, when you define the Stadr value with the Adrwr command, be sure to set the lower 7-bit to “0” (i.e. specifying a page’s top address). Similarly, set the lower 7-bit to “1” when you define the Enadr. (A single page on the DRAM is 1024 bits.)

For the details, see “Storing Sound Data to DRAM (In Blocks)” and “Addressing with the Adrrd and Adrwr Commands” sections.

Controlling Addresses in Normal Mode

In Normal Mode, the address control data area and the sound data area are allocated within the blocks selected by using the Area1 and Area2 commands. The address control data area is for storing address control data for up to 255 phrases, while the sound data area is for storing ADPCM intermediate data and ADPCM data, as described in “Storing Sound Data to DRAM”, earlier in this document.

1 to 255 phrase value is available. Phrase = 0 is unavailable in Normal Mode because it is used only in Retroactive Play Mode. For further details on address control data for each phrase, see “Address Control Data for Each Phrase”, later in this document.



Note: Relative address means relative address value from the top address of the area defined by the Area1 command.

[Notes on Issuing the Area Command]

As shown in the above figure, the first 2 blocks (16 pages) are assigned for storing address control data when you define an area with the Area1 command. So, with Area2 command, you need to select blocks not overlapping with such address control data area (with the Area commands, selecting an area in Blocks, i.e. 8-page). Therefore, the value for the Start2 of the Area2 command must be larger than the Start1 value + 16 pages. In other words, the Start1, 2 and the End1, 2 must satisfy the following:

$\text{Start2} \geq \text{Start1} + 02\text{h}$, $\text{End2} \leq \text{End1}$ (All values within 00h to FFh range)

Address Control Data for Each Phrase

Address Control data for each phrase consists of 8 bytes (64 bits), as shown in the following table.

| | Address | Bit | | | | | | | |
|--------|---------------------------|----------------------|---|---|---|------|---|---|---|
| Phrase | Address ^(Note) | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00h | 00_0000 | Reserved Area | | | | | | | |
| | 00_0001 | | | | | | | | |
| | 00_0002 | | | | | | | | |
| | 00_0003 | | | | | | | | |
| | 00_0004 | | | | | | | | |
| | 00_0005 | | | | | | | | |
| | 00_0006 | | | | | | | | |
| | 00_0007 | | | | | | | | |
| 01h | 00_0008 | Method | | | | Samp | | | |
| | 00_0009 | Upper Start Address | | | | | | | |
| | 00_000A | Middle Start Address | | | | | | | |
| | 00_000B | Lower Start Address | | | | | | | |
| | 00_000C | Upper End Address | | | | | | | |
| | 00_000D | Middle End Address | | | | | | | |
| | 00_000E | Lower End Address | | | | | | | |
| | 00_000F | Reserved Area | | | | | | | |
| ⋮ | ⋮ | ⋮ | | | | | | | |
| 0FFh | 00_07F8 | Method | | | | Samp | | | |
| | 00_07F9 | Upper Start Address | | | | | | | |
| | 00_07FA | Middle Start Address | | | | | | | |
| | 00_07FB | Lower Start Address | | | | | | | |
| | 00_07FC | Upper End Address | | | | | | | |
| | 00_07FD | Middle End Address | | | | | | | |
| | 00_07FE | Lower End Address | | | | | | | |
| | 00_07FF | Reserved Area | | | | | | | |

(Note) Each address means a relative address starting from the top address of Area 1.

Addressing with the Adrrd and Adrwr Commands

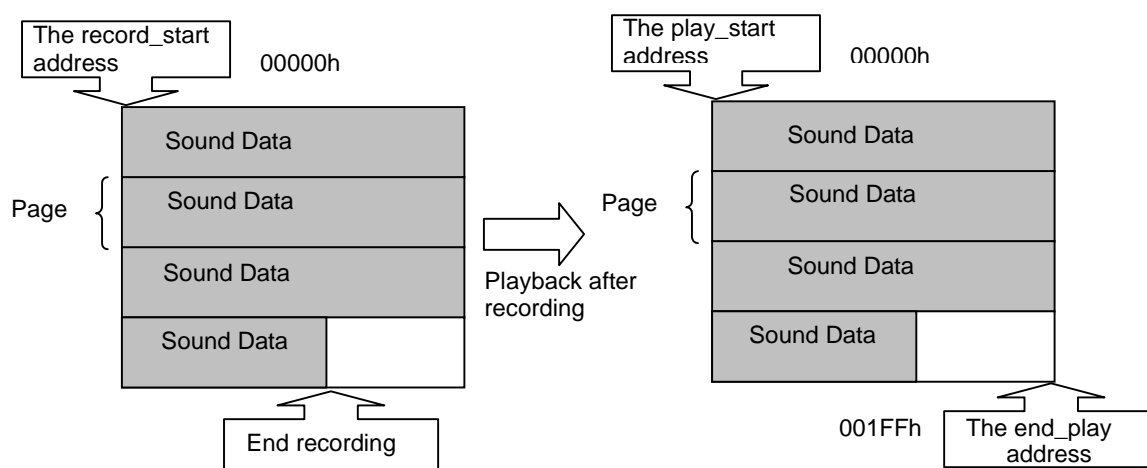
In Retroactive Play Mode and Normal Mode, you can control addresses for recording and playing by using the Adrrd and Adrwr commands.

[The Adrrd Command]

In Retroactive Play Mode and Normal Mode, the Adrrd command enables you to read the DRAM's record_start address and the record_end address. These addresses represent specific address locations on the on-die DRAM, as described in "Storing sound Data to DRAM" section earlier in this document. You can determine the address to be played based on those address information.

[The Adrwr Command]

In Retroactive Play Mode and Normal Mode, the Adrwr command enables you to specify the DRAM address at which the LSI starts to play. You can determine the starting and ending addresses according to address information obtained by using the Adrrd command. When you define the play_start address, you need to specify the top address of the starting page. By the nature of ADPCM, playback must start from the top address of a page, otherwise playback cannot be performed properly. Similarly, you should specify the last address of the ending page when you define the end_play address.



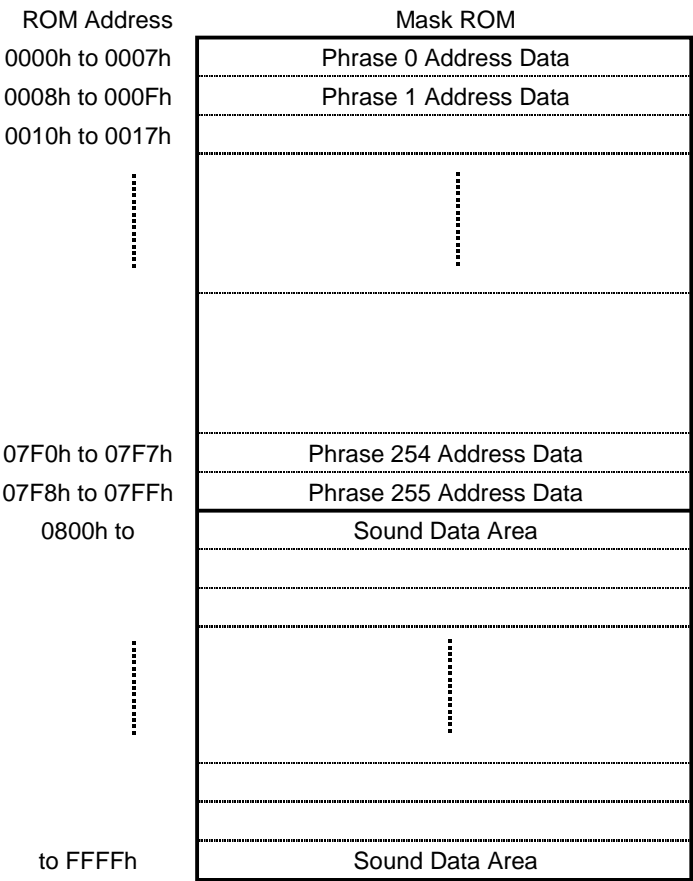
Addressing with the Adrwr command
 Stadr = 00000h Enadr = 001FFh
 (The Enadr must be the last address of the ending page)

[Notes on addressing]

The play_start address cannot be larger than the play_end address. Therefore, the addressing should be $\text{Stadr} \leq \text{Eadr}$.

Memory Allocation of Mask ROM

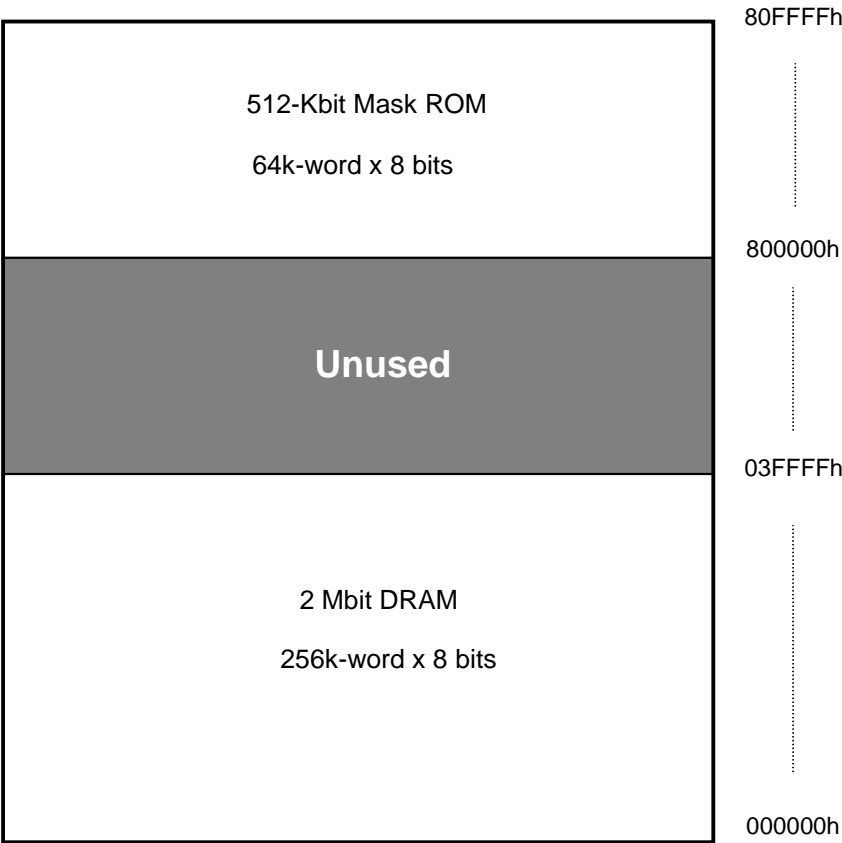
The following figure illustrates the on-chip Mask ROM memory allocation.



The format of address control data for each phrase is identical to the one for the DRAM. ROM Address means the address values specified with the Stadr and Enadr, used for controlling Mask ROM phrases. Remember that these addresses are different from physical memory addresses used with the Dtrw command to make an access to the Mask ROM. (See “Memory Map” section on the following page)

Memory Map

The figure below shows the memory map of DRAM and Mask ROM. Addresses shown in this figure represent physical addresses of each memory, which you can use with the Dtrw command.



Recording Time Length

This section describes recording time length of the blocks selected with the Area1 and Area2 commands. A block is a memory space equal to 1/256 of 2-Mbit on-chip DRAM. The following formula can be used to obtain the memory space per block:

$$\text{Block} = 2,097,152 \text{ Bits} / 256 = 8,192 \text{ Bits (equal to 8 Pages)}$$

A page consists of 1024 bits, out of which a 24-bit space is allocated for storing ADPCM intermediate data. Therefore, actual usable area for storing sound data is as follows:

$$\text{Actual usable area per block} : 8,192 \text{ bits} - 24 \text{ bits} \times 8 \text{ pages} = 8,000 \text{ bits}$$

You can obtain recording time per block with the following formula:

Where; Sampling Frequency $F_{\text{sam}} = 8 \text{ kHz}$

Recording time per Block: $8,000 \text{ bits} / (4 \text{ bits} \times 8 \text{ kHz}) = \text{Approx. } 0.25 \text{ sec}$

Note: "4 bits" represents 4-bit ADPCM.

The following table summarizes recording time length at each sampling frequency.

Sampling Frequency and Recording Time

| Sampling Frequency | Recording Time per Block | Recording Time for Entire 2 Mbit |
|--------------------|--------------------------|----------------------------------|
| 4.0 kHz | Approx. 0.50 sec | Approx. 128 sec |
| 5.3 kHz | Approx. 0.38 sec | Approx. 97 sec |
| 6.4 kHz | Approx. 0.31 sec | Approx. 80 sec |
| 8.0 kHz | Approx. 0.25 sec | Approx. 64 sec |
| 10.6 kHz | Approx. 0.18 sec | Approx. 48 sec |

[Recording Time in Delayed Play Mode and Retroactive Play Mode]

In Delayed Play Mode and Retroactive Play Mode, the maximum recording time depends on the number of blocks selected with the Area2 command as all the blocks selected are allocated for storing sound data.

[Recording Time in Normal Mode]

In Normal Mode, the area selected with the Area2 command is assigned for storing sound data, therefore the maximum recording time depends on the number of blocks included in the area. Note that the first two blocks of the area selected with the Area1 command is automatically allocated to the Address Control data area in Normal Mode. So, the maximum number of blocks usable for storing sound data (i.e. the area that can be selected with the Area2 command) is the number of blocks selected with the Area1 command minus 2 blocks. For example,

Blocks selected with the Area1 command: Start1 = 00h; End1 = 0Fh (16 blocks)

Blocks selectable with the Area2 command: Start2 = 02h; End2 = 0Fh (14 blocks)

(Area for storing sound data)

Where:

Sampling frequency $F_{sam} = 8 \text{ kHz}$;

Maximum recording time: About 3.5 sec

Delay Time in Delayed Play Mode and Retroactive Play Mode

In Delayed Play Mode and Retroactive Play Mode, you should define the Delay Time, that is a time lag between recording and its playback in the former or the time going back to the past in the latter. Use 16-bit unsigned integer value Dly[15:8], Dly [7:0] to set up the Delay time. The following section summarizes the relationship between the Dly value you set and the actual delay time obtained in the operation.

$$\text{Delay Time} = \text{Dly value} \times 250 / \text{Sampling Frequency}$$

For example, with sampling frequency at 8 kHz, if you set the Dly value to 0100h, the actual delay time can be obtained by the following formula:

$$\text{Delay Time} = 0100h \times 250 / 8 \text{ kHz} = 8 \text{ sec}$$

[Restriction on setting the Dly value in Delayed Play Mode and Retroactive Play Mode]

There is a certain limitation on setting the Dly value in Delayed Play Mode and Retroactive Play Mode. You cannot set up the Delay time that is equal or longer than the maximum recording time for the current mode. The LSI may not operate properly when you set up the Delay time as shown below:

Sound data area selected with the Area2 command: 00h to FFh (239 blocks, about 59.75 sec at Fsam = 8 kHz)

Dly value: 0778h Delay Time: about 59.75 sec

Therefore, the Dly value and the number of selected blocks must satisfy the following formula:

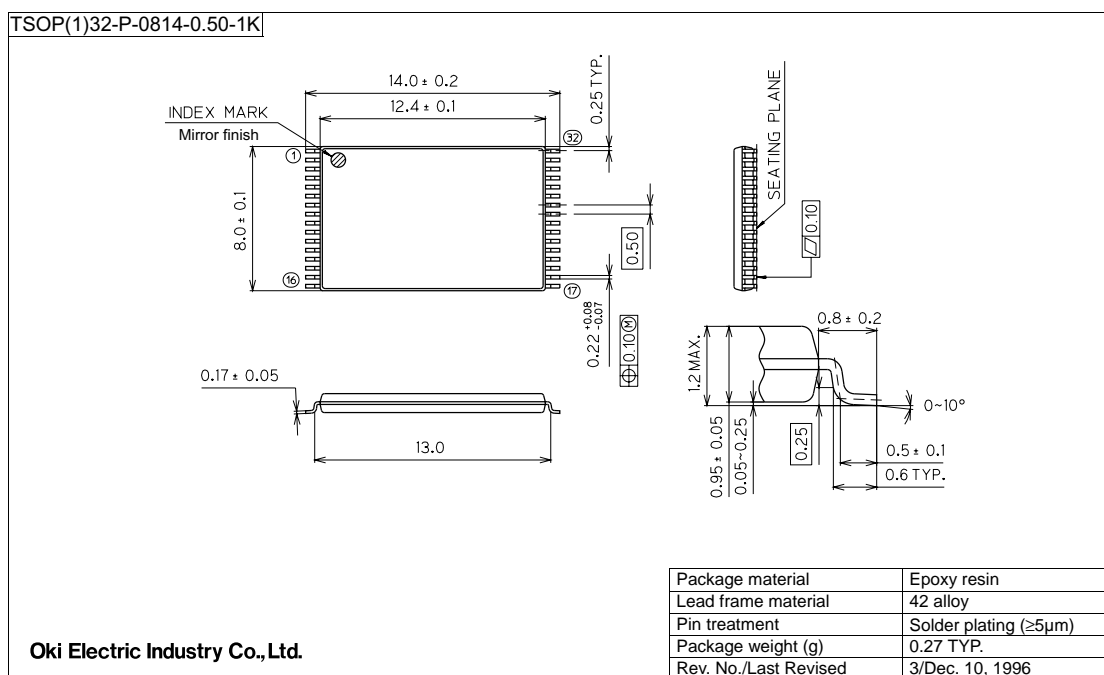
$$\text{Dly value} < 8 \times \text{Number of selected blocks}$$

For the above example, the Maximum Delay time that satisfies the formula is as follows:

$$\text{Dly value: } 0777h < 8 \times 239 \text{ blocks} \quad \text{Delay Time: about 59.71 sec}$$

PACKAGE DIMENSIONS

(Unit: mm)



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 Oki's responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

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