FEDL9836-04

OKI Semiconductor

This version: Nov. 2001
Previous version: Nov. 2000

MSM9836-xxx

Voice Synthesis IC with Built-in Mask ROM

GENERAL DESCRIPTION

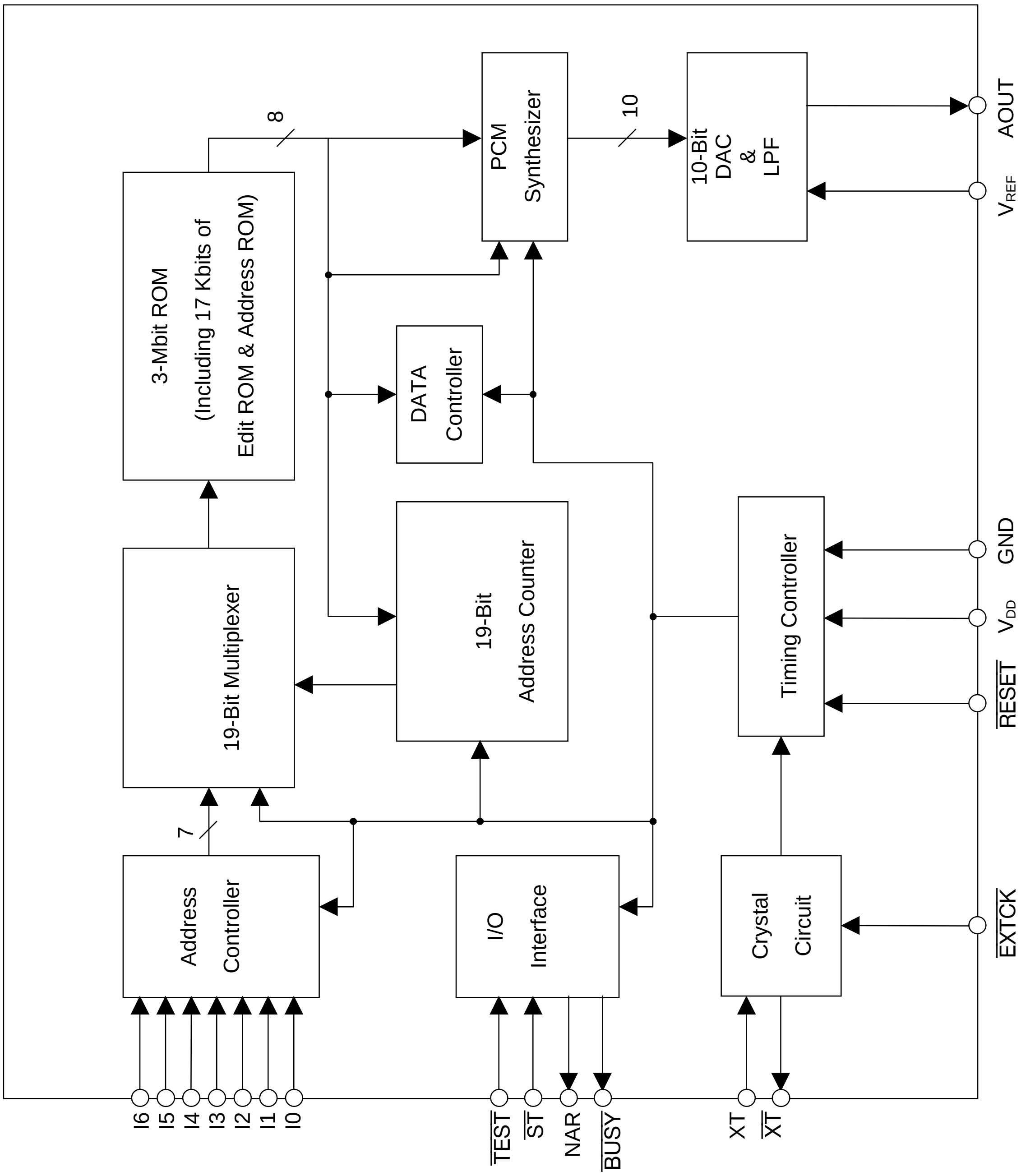
The MSM9836 is a PCM voice synthesis IC with built-in 3-Mbit mask ROM, D/A converter, and low-pass filter (LPF).
The MSM9836 is specifically designed for applications that use a microcontroller.
For this reason, functional support for standalone mode and RC oscillation has been omitted from the MSM9805, and the ROM capacity and the number of phrases have been increased.
By using Oki's Sound Analysis and Editing Tool, ROM data such as Phrase Control Table can be easily set, created, edited, and evaluated.
The following table lists the functional differences between the MSM9836 and the MSM9805.

	MSM9836	MSM9805
ROM Capacity	3 Mbits	2 Mbits
Interface	Microcontroller	Microcontroller/Standalone
Oscillation	Ceramic	Ceramic/RC
Maximum Number of Phrases	127	63
Status Signal	NAR/$\overline{\text{BUSY}}$ simultaneous output	Only NAR output when operating in microcontroller interface mode
Power Supply Voltage Range	4.5 to 5.5 V	2.0 to 5.5 V

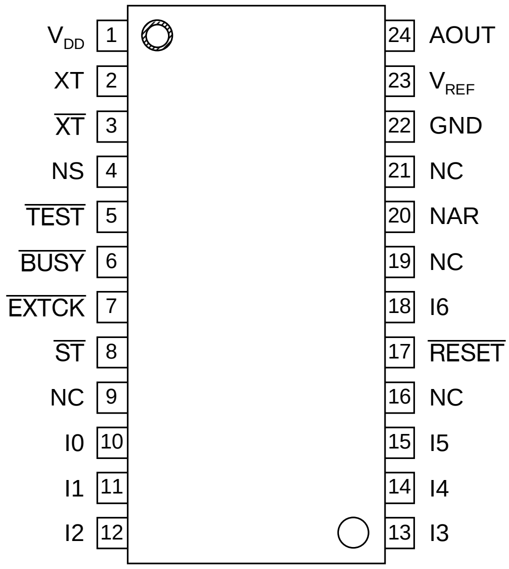
FEATURES

- 8-bit OKI nonlinear PCM method/8-bit Straight PCM method
- Sampling frequency : 4.0 kHz/5.3 kHz/6.4 kHz/8.0 kHz/10.6 kHz/12.8 kHz/16.0 kHz
  (Can be set for each phrase)
- ROM capacity : 3 Mbits
- Maximum playback time : 97.7 sec (f_{SAM} = 4.0 kHz)
  73.7 sec (f_{SAM} = 5.3 kHz)
  61.0 sec (f_{SAM} = 6.4 kHz)
  48.8 sec (f_{SAM} = 8.0 kHz)
- Master clock frequency : 4.096 MHz
  (Ceramic oscillation/external clock input)
- Edit ROM function
- Maximum number of phrases : 127
- Built-in current mode 10-bit D/A converter
- Built-in low-pass filter
- Power supply voltage : +4.5 to +5.5 V
- Package :
  24-pin plastic SOP (SOP24-P-430-1.27-K) (Product name: MSM9836-xxxGS-K)
  xxx indicates code number.
  Chip

BLOCK DIAGRAM



PIN CONFIGURATION (TOP VIEW)



NC: No connection

24-Pin Plastic SOP

PIN DESCRIPTIONS

Pin	Symbol	Type	Description
17	$\overline{\text{RESET}}$	I	The IC enters the standby state if this pin is set to “L” level. At this time, oscillation stops and AOUT output becomes GND level, then the IC returns to the initial state. Apply a “L” pulse upon power-on. This pin has an internal pull-up resistor.
20	NAR	O	Signal output pin that indicates whether the 7-bit LATCH (see Block Diagram) is idle. NAR at “H” level indicates that the LATCH is empty and $\overline{\text{ST}}$ input is enabled.
7	$\overline{\text{EXTCK}}$	I	Ceramic oscillator input/external clock input switching pin. Set to “H” level if ceramic oscillation is used. Set to “L” level if external clock is used.
23	V_{REF}	I	Volume setting pin. If this pin is set to GND level, the maximum current is forced in, and if set to V_{DD} level, the minimum current is forced in. An approx. 10 kΩ pull-down resistor is internally connected to this pin during operation.
24	AOUT	O	Voice output pin. The voice signals are output as current changes. A “L” level signal is output through this pin in standby state.
22	GND	—	Ground pin.
1	V_{DD}	—	Power supply pin. Insert a bypass capacitor of 0.1 µF or more between this pin and the GND pin.
2	XT	I	Ceramic oscillator connection pin when ceramic oscillation is selected. Input from this pin if external clock is used.
3	$\overline{\text{XT}}$	O	Ceramic oscillator connection pin when ceramic oscillation is selected. Leave this pin open if external clock is used. A “L” level signal is output through this pin in standby state.
5	$\overline{\text{TEST}}$	I	Normally leave this pin open. This pin is used only for testing the internal circuit.
8	$\overline{\text{ST}}$	I	Voice synthesis starts at fall of $\overline{\text{ST}}$, and addresses I0 to I6 are fetched at rise of $\overline{\text{ST}}$. Input $\overline{\text{ST}}$ when NAR, the status signal, is at “H” level. This pin has internal pull-up resistor.
10-15, 18	I0 - I6	I	Phrase input pins corresponding to playback sound.
6	$\overline{\text{BUSY}}$	O	This pin is at “H” level after reset is input. A “L” level signal is output through this pin for the time during which voice is being played.

ABSOLUTE MAXIMUM RATINGS

(GND = 0 V)

Parameter	Symbol	Condition	Rating	Unit
Power Supply Voltage	V_{DD}	Ta = 25°C	–0.3 to +7.0	V
Input Voltage	V_{IN}	Ta = 25°C	–0.3 to V_{DD} +0.3	V
Storage Temperature	T_{STG}	—	–55 to +150	°C

RECOMMENDED OPERATING CONDITIONS

(GND = 0 V)

Parameter	Symbol	Condition	Range			Unit
Power Supply Voltage	V_{DD}	—	4.5 to 5.5			V
Operating Temperature	T_{op}	—	–40 to +85			°C
Original Oscillation Frequency	f_{OSC}	When crystal is selected	Min.	Typ.	Max.	MHz
			3.5	4.096	4.5	

ELECTRICAL CHARACTERISTICS

DC Characteristics

(V_{DD} = 5.0 V, GND = 0 V, Ta = –40 to +85°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
"H" Input Voltage	V_{IH}	—	4.2	—	—	V
"L" Input Voltage	V_{IL}	—	—	—	0.8	V
"H" Output Voltage	V_{OH}	I_{OH} = –1 mA	4.6	—	—	V
"L" Output Voltage	V_{OL}	I_{OL} = 2 mA	—	—	0.4	V
"H" Input Current 1	I_{IH1}	$V_{IH} = V_{DD}$	—	—	10	µA
"H" Input Current 2	I_{IH2}	Applies to XT pin only. $V_{IH} = V_{DD}$	—	—	15	µA
"L" Input Current 1	I_{IL1}	V_{IL} = GND	–10	—	—	µA
"L" Input Current 2 (*1)	I_{IL2}	Internal pull-up resistor	–200	–90	–30	µA
Dynamic Supply Current 1 (*2)	I_{DD1}	$V_{REF} = V_{DD}$, AOUT voltage = 0 V	—	0.4	1	mA
Dynamic Supply Current 2 (*3)	I_{DD2}	At maximum output current V_{REF} = GND, AOUT voltage = 0 V	—	—	16	mA
Standby Current	I_{DS}	Ta = –40 to +70°C	—	—	10	µA
	I_{DS}	Ta = –40 to +85°C	—	—	50	µA
AOUT Output Current	I_{AOUT}	At maximum output current $V_{REF} = V_{DD}$, AOUT voltage = 0 V	6	9.5	15	mA
V_{REF} Pin Pull-Down Resistance	R_{VREF}	—	7	10	13	kΩ

*1 Applicable to $\overline{\mathrm{RESET}}$, $\overline{\mathrm{ST}}$
*2 Dynamic supply current excluding DAC output current
*3 Dynamic supply current at maximum output current

AC Characteristics

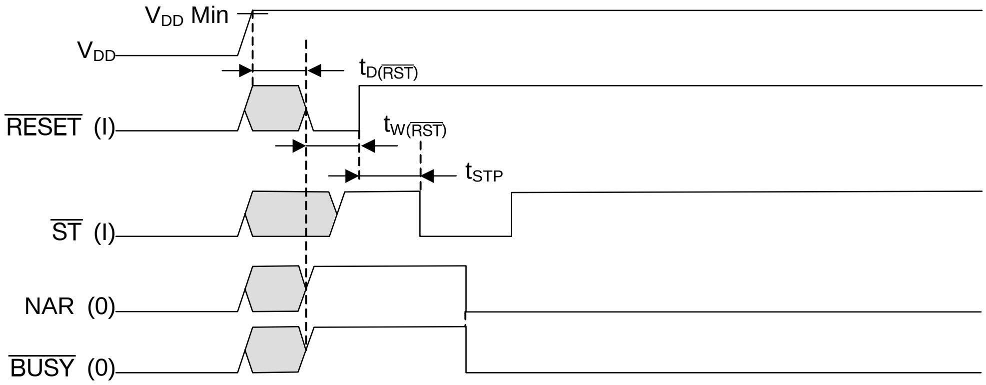
(V_{DD} = 5.0 V, GND = 0 V, f_{OSC} = 4.096 MHz, Ta = –40 to +85°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Master Clock Duty Cycle	f_{duty}	—	40	50	60	%
$\overline{\text{RESET}}$ Input Pulse Width	$t_{w(\overline{RST})}$	—	10	—	—	µs
$\overline{\text{RESET}}$ Input Time After Power-on	$t_{D(\overline{RST})}$	—	0	—	—	µs
$\overline{\text{ST}}$ Signal Setup Time	t_{STP}	At power-on	1	—	—	µs
$\overline{\text{ST}}$ Input Pulse Width	$t_{(\overline{ST})}$	—	0.35	—	2000	µs
The $\overline{\text{ST}}$-$\overline{\text{ST}}$ Pulse Interval	t_{SS}	Upon entering the stop code (*4)	40	—	—	µs
Data Setup Time	t_{DW}	—	1	—	—	µs
Data Hold Time	t_{WD}	—	1	—	—	µs
NAR Output Time 1	t_{SNS}	f_{SAM} = 8 kHz	—	—	10	µs
NAR Output Time 2	t_{NAA}	f_{SAM} = 8 kHz (*4)	350	375	400	µs
NAR Output Time 3	t_{NAB}	f_{SAM} = 8 kHz (*4)	315	440	500	µs
NAR Output Time 4	t_{NAC}	f_{SAM} = 8 kHz (*4)	350	375	500	µs
BUSY Output Time 1	t_{SBS}	f_{SAM} = 8 kHz	—	—	10	µs
BUSY Output Time 2	t_{BSYA}	f_{SAM} = 8 kHz (*4)	350	375	400	µs
D/A Converter Change Time	t_{DAR}, t_{DAF}	—	60	64	68	ms
Standby Transition Time (at end of voice output)	t_{STB}	—	200	250	300	ms
Silence Time Between Phrases	t_{BLN}	f_{SAM} = 8 kHz (*4)	350	375	500	µs

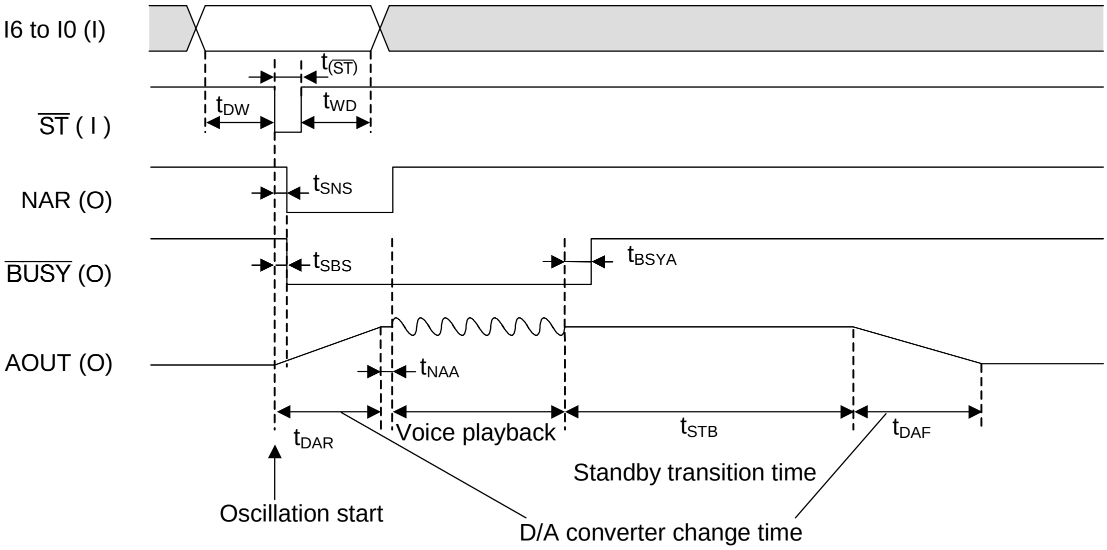
*4 Proportional to master the periods of oscillation frequency f_{OSC1} and f_{OSC2}.
The rated values show values when the standard master oscillation frequency is used.

TIMING DIAGRAMS

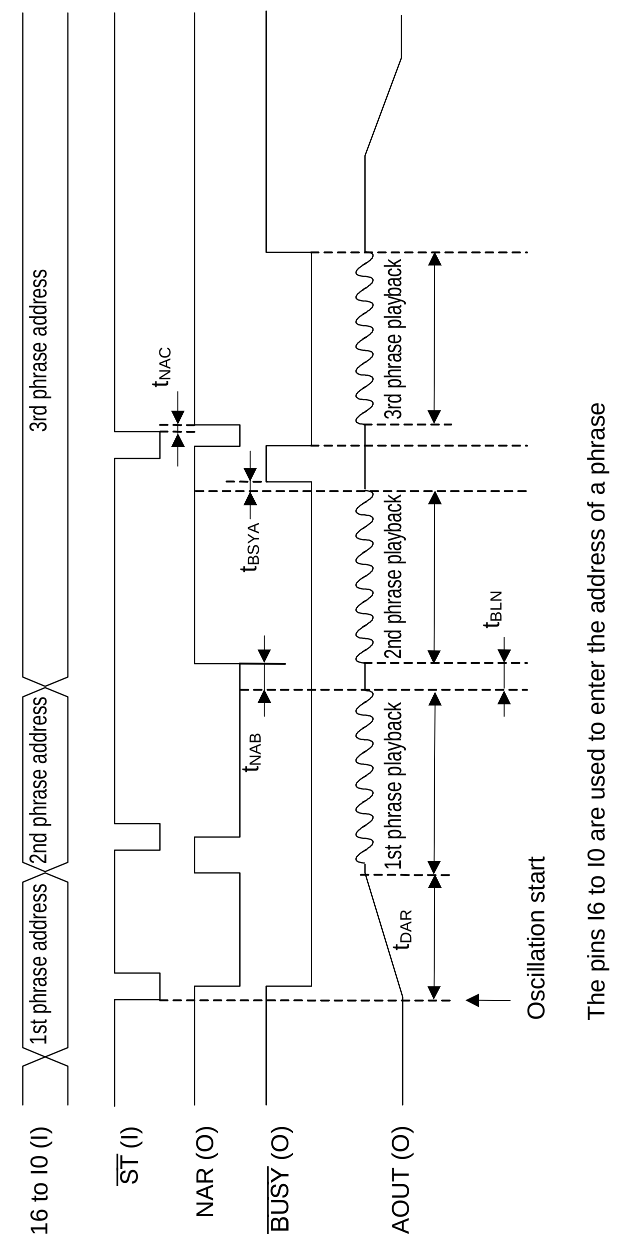
AC Characteristics at Power-On



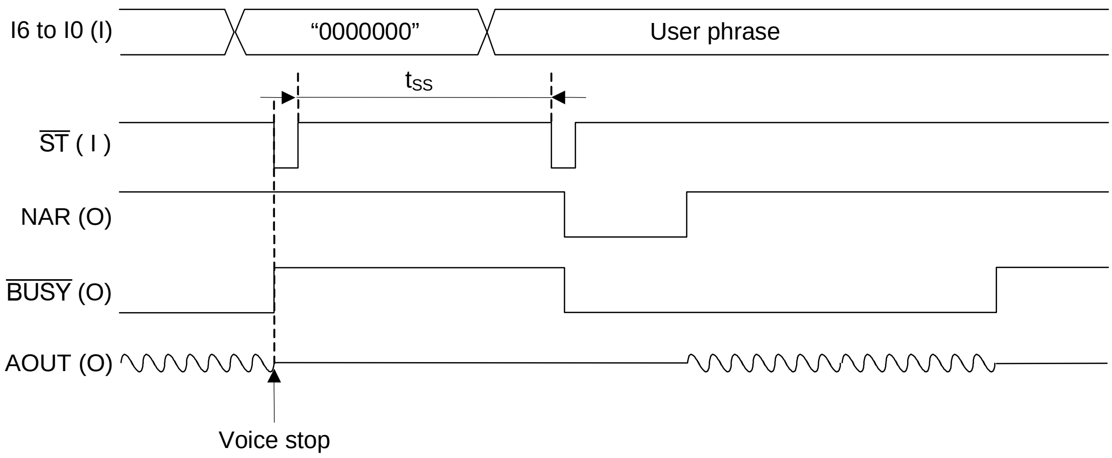
AC Characteristics in Standby Status and when the IC is Activated



Playback Timing



Stop Code Input Timing



When I6-I0 are set to "0000000" during voice playback (during the output of "L" level at the $\overline{\text{BUSY}}$ pin), and a $\overline{\text{ST}}$ signal is input, playback stops regardless of whether NAR is at "H" or "L" level and AOUT becomes 1/2 I_{AOUT}. Stop code becomes valid at the falling edge of $\overline{\text{ST}}$.
<u>The stop code does not initialize internal units but only stops playback. To initialize an internal register, use the $\overline{\text{RESET}}$ pin.</u>

Sampling Frequency

As shown in Table 1, 7 sampling frequencies are available.
A sampling frequency can be selected and assigned to each phrase in ROM data.

Table 1 Sampling Frequency

Sampling Frequency (At standard oscillation frequency)	Frequency dividing ratio
4.0 kHz	$f_{OSC1}/1024$
5.3 kHz	$f_{OSC1}/768$
6.4 kHz	$f_{OSC1}/640$
8.0 kHz	$f_{OSC1}/512$
10.6 kHz	$f_{OSC1}/384$
12.8 kHz	$f_{OSC1}/320$
16.0 kHz	$f_{OSC1}/256$

Recording/Playback Time

Figure 1 below shows memory allocation of the on-chip Mask ROM. About 17 Kbits of data area is allocated for the Phrase Control Table, Phrase Data Control and Test Data.
Therefore, actual data area for storing sound data equals the total Mask ROM capacity minus 17 Kbits.

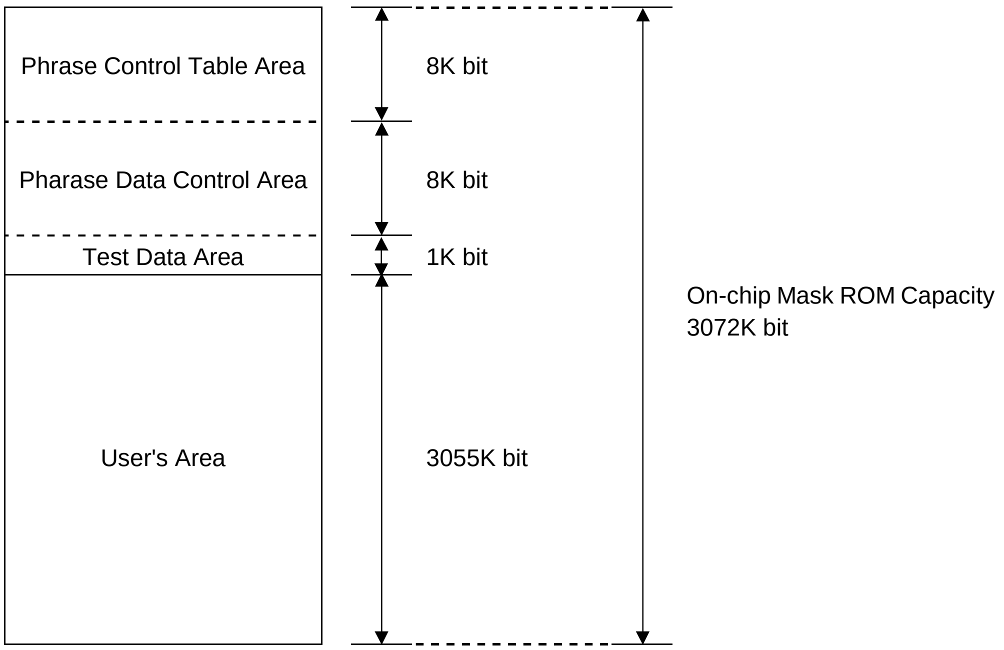


Figure 1 Memory Allocation of On-chip Mask ROM

The playback time is obtained by dividing the memory capacity by the bit rate.
The playback time for 8-bit PCM algorithm is obtained by using the following equation.

$$\text{Playback time [sec]} = \frac{\text{Memory capacity [bit]}}{\text{Bit rate [bps]}} = \frac{\text{Memory capacity [bit]}}{\text{Sampling frequency [Hz]} \times 8 \text{ [bit]}}$$

For example, if all phrases are stored in the MSM9836 at 8 kHz sampling frequency, the maximum playback time is as follows.

$$\text{Playback time} = \frac{(3072-17) \times 1024 \text{ [bit]}}{8000 \text{ [Hz]} \times 8 \text{ [bit]}} \cong 48.8 \text{ [sec]}$$

Table 2 Maximum Playback Time

Model	ROM capacity	User's area	Maximum playback time (sec)			
			f_{SAM} = 4.0 kHz	f_{SAM} = 6.4 kHz	f_{SAM} = 8.0 kHz	f_{SAM} = 16.0 kHz
MSM9836	3M bit	3055K bit	97.7	61.0	48.8	24.4

Playback Method

This IC provides two kinds of playback methods, non-linear PCM algorithm and straight PCM algorithm. When the 8-bit non-linear PCM algorithm is selected, sound quality can be improved because a resolution equivalent to 10-bit straight PCM is available around the waveform center. You can select either non-linear PCM algorithm or straight PCM algorithm for each phrase. Table 3 shows the relationship between playback methods and applicable sounds. It is recommended to evaluate the sound quality before actual use.

Table 3 Relationship between Playback Methods and Applicable Sounds

Playback method	Applicable sound
8-bit non-linear PCM algorithm	Human voice
8-bit straight PCM algorithm	BEEP tone, sound effects

Phrase Control Table

Because the LSI contains the Phrase Control Table, it is possible to play back multiple phrases in succession by a single easy control operation like controlling a single regular phrase playback. Up to 8 combined phrases including a silence can be registered in a single address in the Phrase Control Table.
Further, you can use the maximum memory space for data storage because it is not required to have the same phrase data.
To show an example, let's assume that your application needs to speak two similar sentences, “It is fine today” and “It is rainy today.” The two sentences have the common words “it”, “is” and “today”. What you have to do is to prepare these common sound data, not in sentences but in words, and to store each combined phrase data in Phrase Control Table as shown in Table 4 and Figure 2.
Multiple phrases can be played continuously merely by specifying a desired phrase using an X address. For an example from Table 4, when address “01” is specified, “It is fine today” is played, and when address“02” is specified, “It is rainy” is played.
Phrase Control Table, a silence can be inserted without using the User's Area.

Minimum time for silence	32 ms
Maximum time for silence	4064 ms
Time unit for setting up silence	32 ms

Table 4 Matrix of the Phrase Control Table

No.	X-Address (HEX)	Y-Address (Up to 8 phrases)								Sound Data
1	01	[10]	[02]	Silence	[01]	[03]				It is (silence) fine today.
2	02	[01]	[02]	Silence	[12]	[03]			I	It is (silence) rainy today.
3	03	[01]	[02]	[10]	[21]	[11]	[22]	[12]	[03]	It is fine becoming cloudy, rainy in some areas today.
⋮	⋮									⋮
126	7E									
127	7F									

Phrase Control Table Area

No.	X-Address
1	01
2	02
3	03
4	04
5	05
6	06
7	07
8	08
9	09
⋮	⋮
127	7F

Phrase Addigned	
1	[01a] it
2	[02] is
3	Silence (64ms)
4	[12] rainy
5	[03] today
6	—
7	—
8	—

Silence time setting ($32ms \times n$)	
0	Silence time
1	32 ms
2	64 ms
⋮	⋮
127	4064 ms

Phrase Data Registration Area

No.	Y-Address	Phrase
1	01	it
2	02	is
3	03	today
⋮	⋮	⋮
16	10	fine
17	11	cloudy
18	12	rainy
19	13	snowy
⋮	⋮	⋮
32	20	occasionally
33	21	becoming
34	22	in some areas
⋮	⋮	⋮
127	7F	—

Figure 2 Phrase Combination Matrix for Phrase Control Table

Oscillation and Clock Input

Ceramic oscillation

Figure 3 shows an external circuit using a ceramic oscillator.

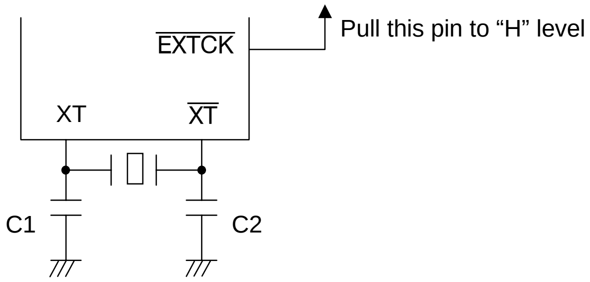


Figure 3 External Circuit Using a Ceramic Oscillator

For example, the following table shows the optimum load capacitances, power supply voltage ranges, and operating temperature ranges when ceramic oscillators made by Murata MFG Co., Ltd. and TDK Co., Ltd. are used.

Ceramic oscillator			Optimal load capacity		Supply voltage range (V)	Operating temperature range (°C)
Maker	Type	Frequency (MHz)	C1 (pF)	C2 (pF)		
Murata MFG.	CSTCR4M09G53-R0	4.096	Built in	Built in	2.2 to 5.5	–40 to +85
	CSTLS4M09G53-B0		Built in	Built in	2.3 to 5.5	–40 to +85
TDK	CCR4.0MC3	4.0	Built in	Built in	2.4 to 5.5	–40 to +85

(Note) When a 4 MHz ceramic oscillator is used, the playback speed of MSM9802/03/05 is slower by 2 percent than that of an analysis tool or a demonstration board.

External clock input

Figure 4 shows a circuit for external clock input.

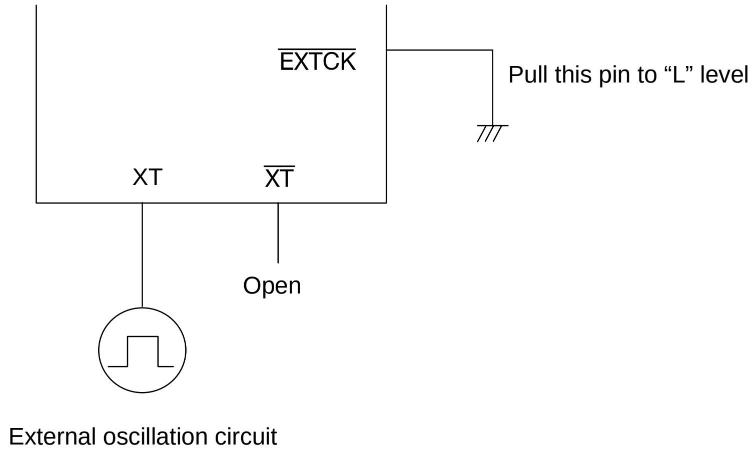


Figure 4 Circuit for External Clock Input

Low-Pass Filter

In this IC, all voice outputs are through the built-in low-pass filter (LPF). Figure 5 and Table 5 show the LPF frequency characteristics and LPF cutoff frequency respectively.
Only the voice output through LPF is enabled in this IC.

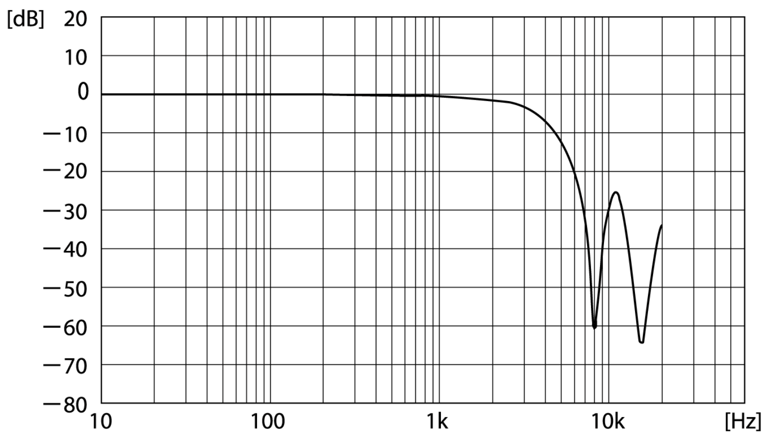


Figure 5 LPF Frequency Characteristics (f_{SAM} = 8 kHz)

Table 5 LPF Cutoff Frequency

Sampling Frequency (kHz) (f_{SAM})	Cutoff Frequency (kHz) (f_{CUT})
4.0	1.2
5.3	1.6
6.4	2.0
8.0	2.5
10.6	3.2
12.8	4.0
16.0	5.0

Standby Transition

When playback of a phrase is finished, if playback of the next phrase does not start up within t_{STB} (0.25 sec. typ.), the IC enters standby status and the entire operation stops.

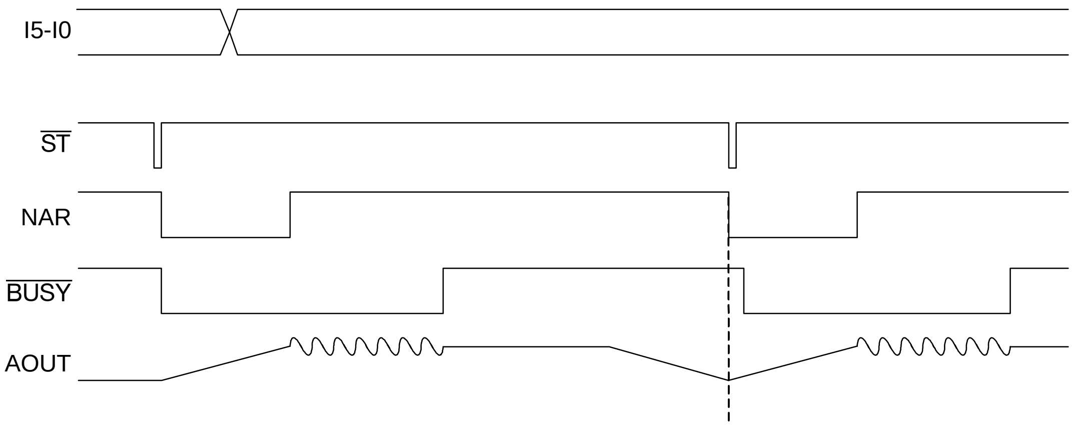
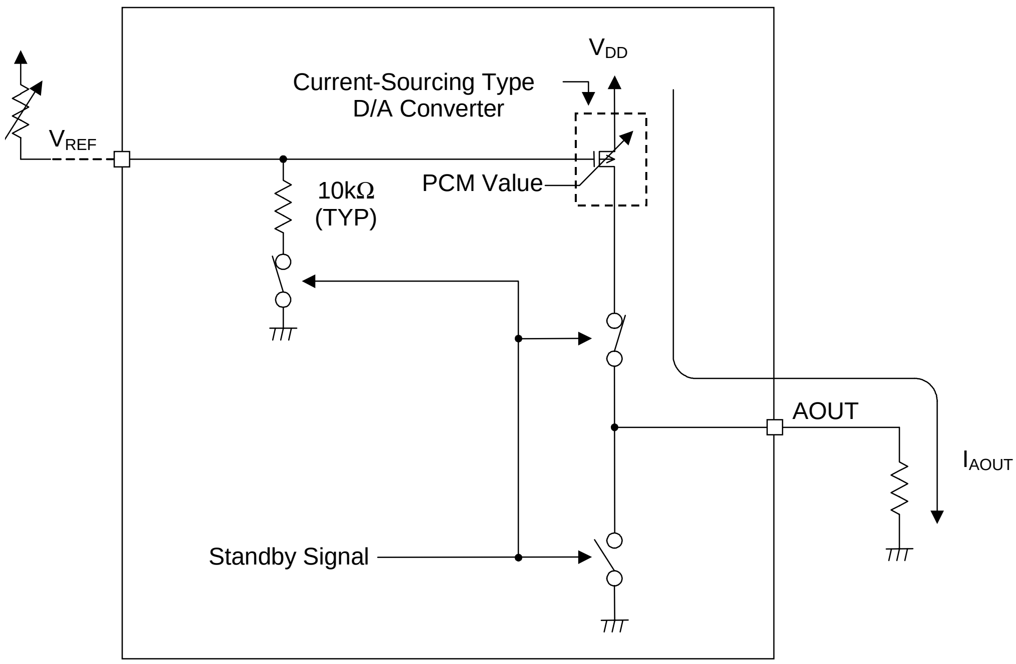


Figure 6 Voice Playback Timing during D/A Converter Change Time

If playback is attempted during D/A converter change time as shown in Figure 6, the IC exits from standby status and the output from the D/A converter begins going to the 1/2 I_{AOUT} level. When the output reaches 1/2 I_{AOUT}, voice playback starts.

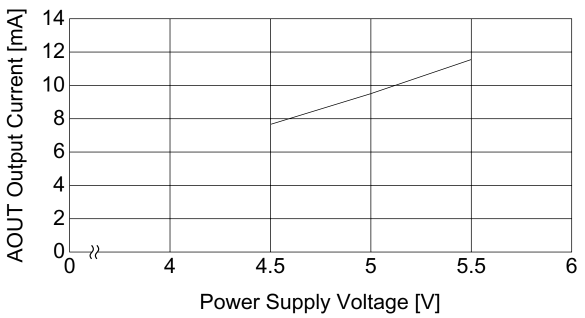
Voice Output Unit Equivalent Circuit (AOUT, F_{REF} Pins)



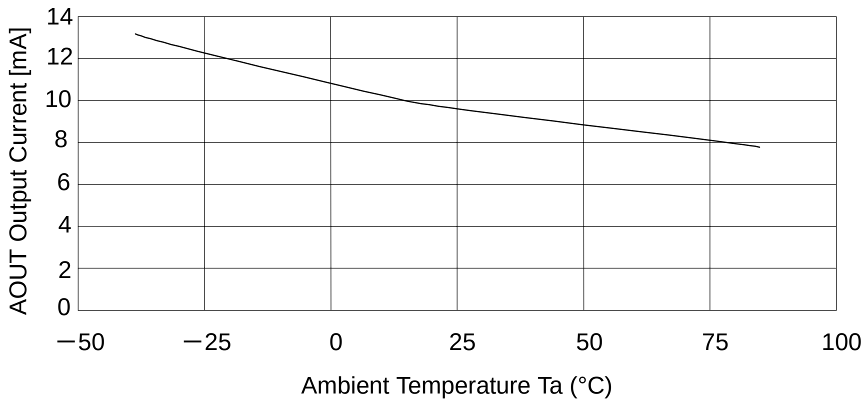
(The above switch positions show those when the circuit is active.)

Figure 7 Voice Output Unit Equivalent Circuit

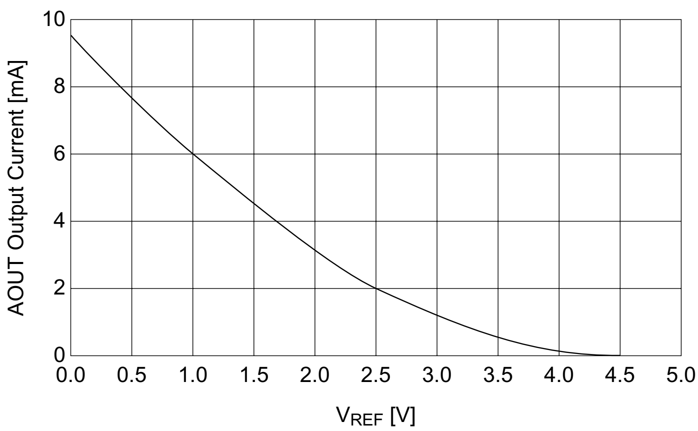
D/A CONVERTER OUTPUT CURRENT CHARACTERISTICS



Power Supply Voltage vs. Output Current Characteristics (Ta = 25°C, V_{AOUT} = 0 V)

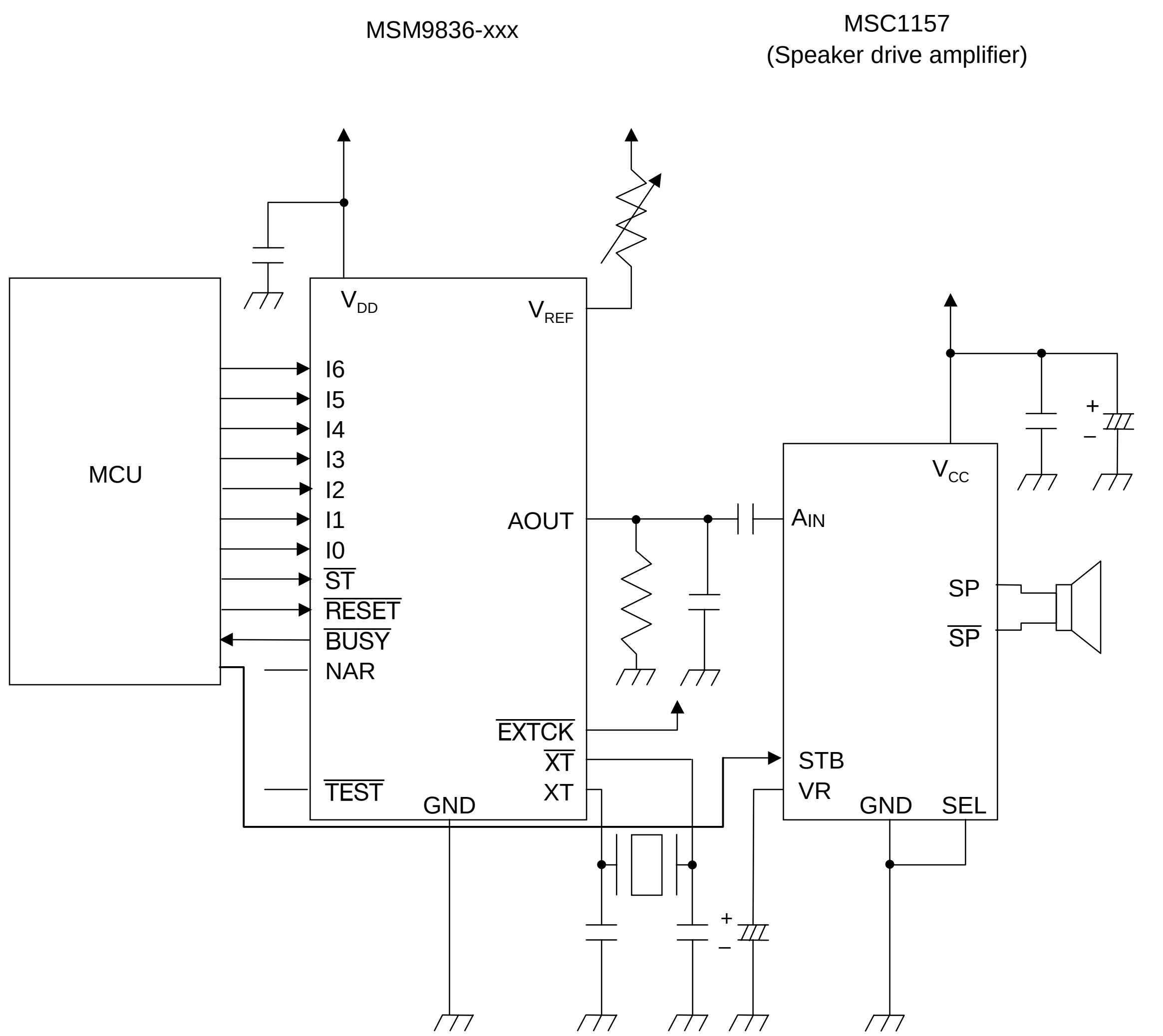


Temperature vs. Output Current Characteristics (V_{DD} = 5 V, V_{AOUT} = 0 V)



V_{REF} Voltage vs. Output Current Characteristics (Ta = 25°C, V_{DD} = 5 V, V_{AOUT} = 0 V)

APPLICATION CIRCUIT

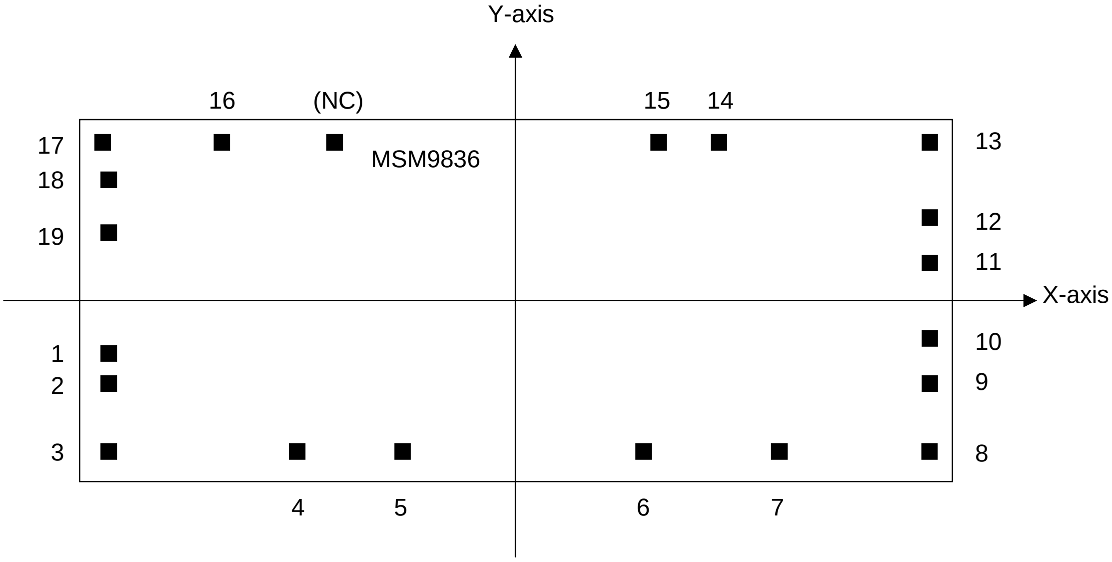


PAD CONFIGURATION

Pad Layout

Chip size	X = 7.65 mm, Y = 3.32 mm
Chip thickness	350 µm ± 30 µm
Pad size	110 µm × 110 µm
Substrate potential	GND

Chip and pad number



Pad Coordinates (Chip center is located at X = 0 and Y = 0)

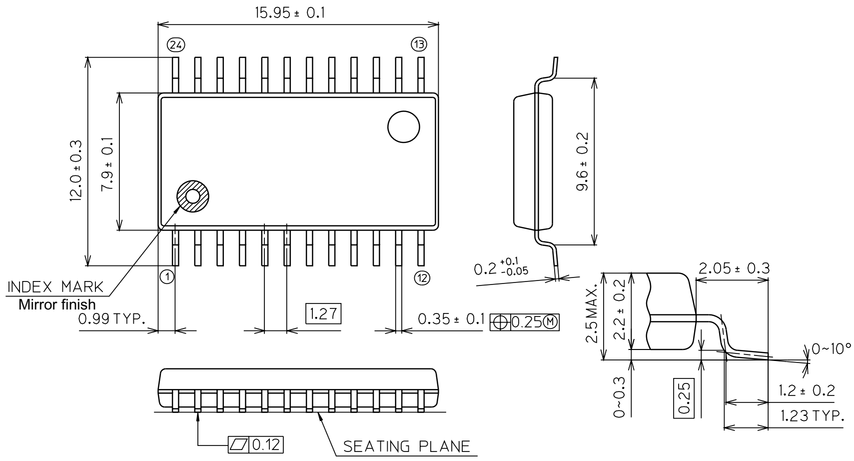
(Unit: µm)

PAD No.	PAD Name	X-axis	Y-axis	PAD No.	PAD Name	X-axis	Y-axis
1	V_{DD}	–3620	–452	11	I3	3673	415
2	XT	–3623	–742	12	I4	3673	816
3	$\overline{XT}$	–3623	–1349	13	I5	3673	1460
4	$\overline{TEST}$	–1932	–1460	14	$\overline{RESET}$	1778	1460
5	$\overline{BUSY}$	–1044	–1455	15	I6	1260	1458
6	$\overline{EXTCK}$	1163	–1453	16	NAR	–2443	1460
7	$\overline{ST}$	2234	–1455	17	GND	–3665	1460
8	I0	3673	–1432	18	V_{REF}	–3623	1136
9	I1	3673	–754	19	AOUT	–3623	585
10	I2	3673	–312				

PACKAGE DIMENSIONS

(Unit: mm)

SOP24-P-430-1.27-K



Oki Electric Industry Co., Ltd.

Package material	Epoxy resin
Lead frame material	42 alloy
Pin treatment	Solder plating (≥5μm)
Package weight (g)	0.58 TYP.
Rev. No./Last Revised	5/Oct. 13, 1998

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).