OVERVIEW

The SM1350AAQM is single-chip high tone quality melody IC, fabricated using NPC's Molybdenum-gate CMOS process. Melodies are selected in serial or binary (parallel) mode, 6 programmable melodies are stored, and the high tone quality melody is output by how to specify the user. It is making this IC ideal for mechanical clocks and similar applications where high tone quality output is demanded.

FEATURES

■ Basic Functions
- 4.0MHz oscillator frequency
- Power-save function
  - Oscillator stopped when no output
  - S0 to S3, MODE, LH pull-up resistors open
- A-class output
- Chattering prevention circuit (STN, STOP, S0 to S3)
- 10-bit D/A converter current-summing

■ Sound Generator Functions
- DWS (dual wave synthesis) sound generators
- 4 simultaneous sounds for 4 tones

■ Melody Functions
- 6 programmable melodies
- Level hold/one-shot melody modes
- Serial/binary (parallel) select modes

■ Control Signal Outputs
- BUSYN signal : LOW during melody output
- CT signal : pulse output synchronizing with selected notes or rests

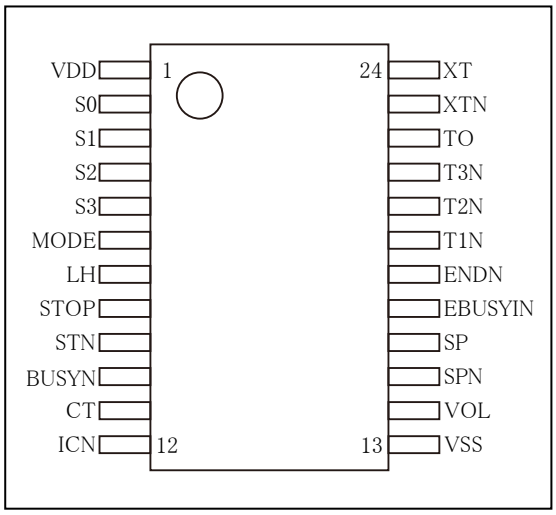
■ 2.4 to 5.5V supply voltage

■ Molybdenum-gate CMOS

■ Package : 24-pin SSOP

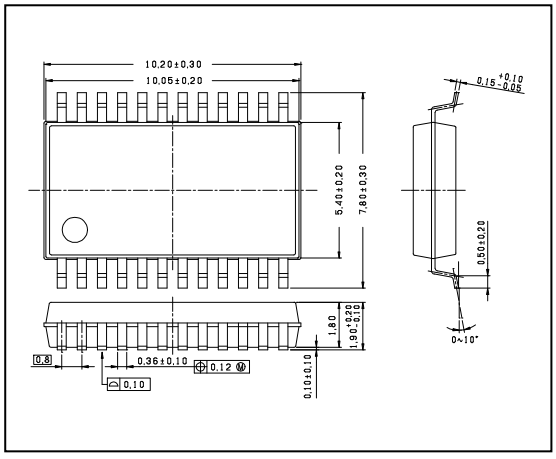
PINOUT

(Top view)



PACKAGE DIMENSIONS

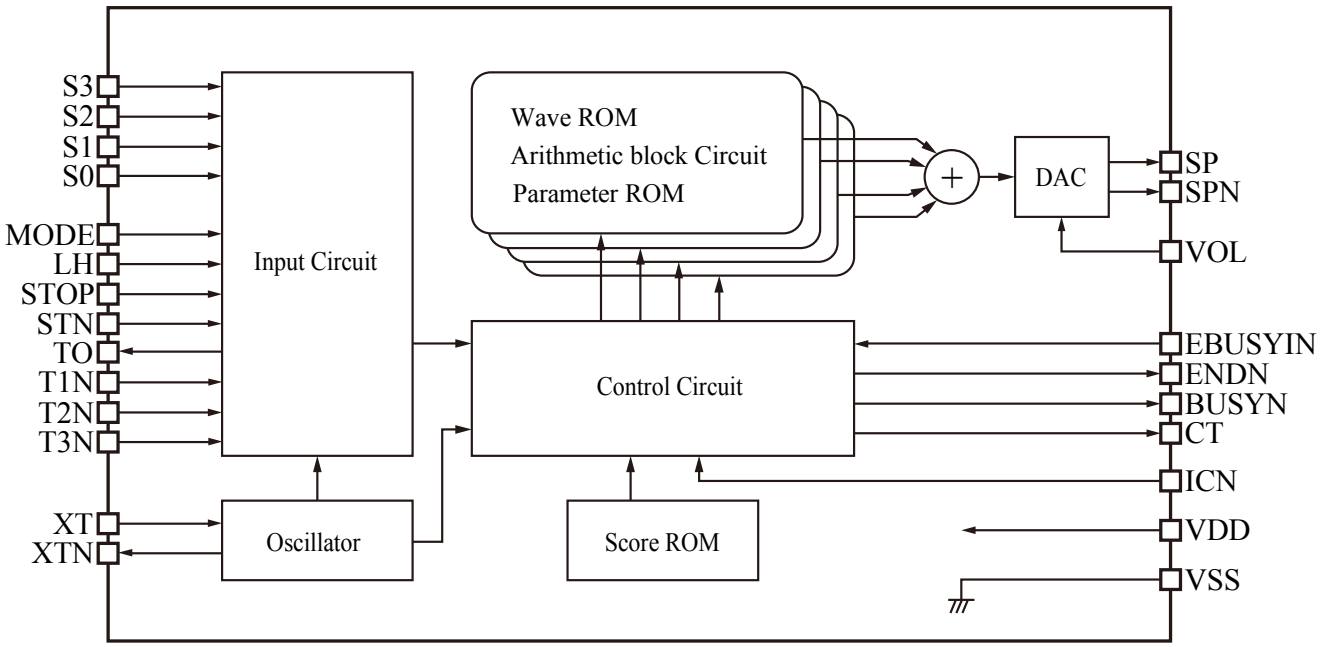
(Unit : mm)



ORDERING INFOMATION

Device	Package
SM1350AAQM	24 pin SSOP

BLOCK DIAGRAM



PIN DESCRIPTION

No.	Pin Name	I/O	State[*1]	Description
1	VDD	-	-	Supply pin
2	S0	I	SU	Binary select mode : Phrase select pins. Serial select mode : S0 and S1 control melody output.
3	S1			
4	S2			
5	S3			
6	MODE	I	SU	Melody select mode control. Binary mode when LOW, and serial mode when HIGH.
7	LH	I	SU	Melody output mode control. One-shot when LOW, and level hold when HIGH.
8	STOP	I	U	One-shot melody mode : Melody output stop control. Level hold melody mode : invalid input.
9	STN	I	U	Melody start control
10	BUSYN	O	C	Busy output signal. LOW when a melody is output.
11	CT	O	C	External control pulse output
12	ICN	I	U	Initialization clear input
13	VSS	-	-	Ground pin
14	VOL	I	-	Volume adjusts control. Volume adjusted using an external resistor.
15	SPN	O	P	VOL current output
16	SP	O	P	10-bit D/A converter output
17	EBUSYIN	I	U	It is not necessary to use it usually. It should connect VDD or OPEN. When this terminal is made LOW, BUSYN compulsorily becomes LOW. A pop sound might be emitted.
18	ENDN	O	C	Pulse signal when melody output ends
19	T1N	I	U	Test signal inputs This terminal cannot be used. It should connect VDD or OPEN.
20	T2N	I	U	
21	T3N	I	U	
22	TO	O	C	Test signal output. 62.5kHz output when not in test mode.
23	XTN	O	-	Oscillator output
24	XT	I	-	Oscillator input

*1. U : pull-up resistor connection
SU : pull-up resistor connection only when melody output starts
(Function for current consumption decrease when driving with battery. Only when the terminal is read, the pull-up resistor is connected.)
P : p-channel open drain
C : complementary output

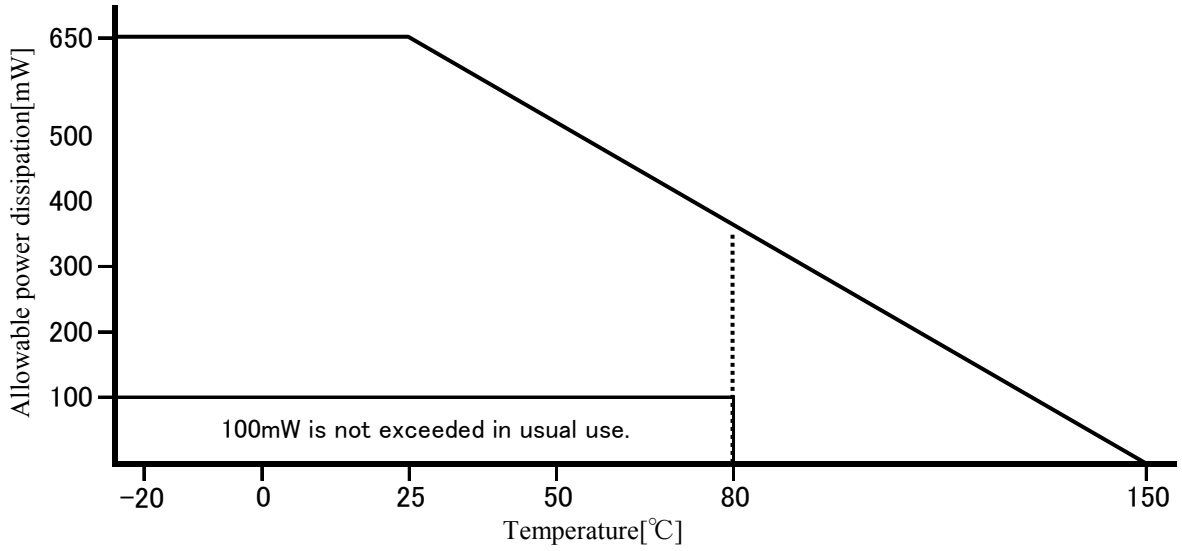
SPECIFICATIONS

Absolute Maximum Ratings

V_{SS}=0V

Parameter	Symbol	Rating	Unit
Supply voltage	V_{DD}	-0.3 to 7.0	V
Input voltage*1	V_{IN}	-0.3 to V_{DD}+0.3	V
Output voltage*1	V_{OUT}	-0.3 to V_{DD}+0.3	V
Operating temperature	T_{OPR}	-20 to 80	°C
Storage temperature	T_{STG}	-40 to 125	°C
Allowable power dissipation	P_W	650	mW

*1. They are range of the voltage where IC destroys and the characteristics degradation and the reliability decrease are not caused.



Recommended Operating Conditions

V_{SS}=0V

Parameter	Symbol	Rating			Unit
		MIN	TYP	MAX	
Supply voltage	V_{DD}	2.4		5.5	V
Operating temperature	T_a	-20		80	°C

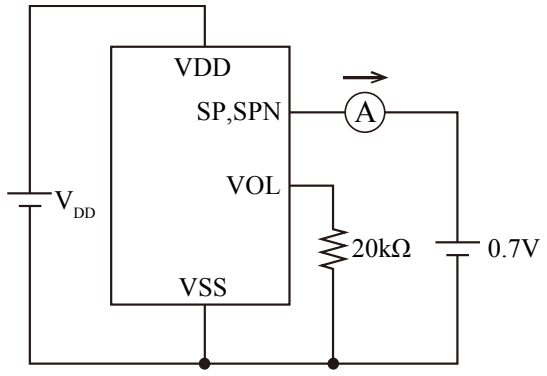
DC Characteristics

T_a=25°C,V_{DD}=3.0V or 5.0V,V_{SS}=0V,f_O=4.0MHz unless otherwise noted.

Parameter	Pin Name	Symbol	Condition		Rating			Unit
					MIN	TYP	MAX	
Minimum operating supply voltage*1	VDD,VSS	V_{MIN}					2.4	V
Maximum operating supply voltage*1	VDD,VSS	V_{MAX}			5.5			V
Standby current consumption	VDD	I_{STBY}	No melody output				1.0	µA
Operating current consumption	VDD	I_{DD}	BUSYN,CT,TO, SP,SPN,ENDN, open	V_{DD}=3.0V			3.5	mA
				V_{DD}=5.0V			9.5	
HIGH-level input voltage	S0～S3,MODE, LH,STOP,STN, ICN,EBUSYIN	V_{IH}			V_{DD}-0.3		V_{DD}	V
LOW-level input voltage		V_{IL}			V_{SS}		V_{SS}+0.3	V
HIGH-level input current	S0～S3,MODE, LH,STOP,STN, ICN,EBUSYIN	I_{IH}	V_{IH}=V_{DD}	V_{DD}=3.0V			1	µA
				V_{DD}=5.0V			1	
LOW-level input current		I_{IL}	V_{IL}=V_{SS}	V_{DD}=3.0V		10	20	µA
				V_{DD}=5.0V		30	50	
HIGH-level output current1	BUSYN,CT,TO	I_{OH1}	V_{OH1}=V_{DD}-0.7		2.0			mA
LOW-level output current1		I_{OL1}	V_{OL1}=V_{SS}+0.7		2.0			mA
HIGH-level output current2	ENDN	I_{OH2}	V_{OH2}=V_{DD}-0.7		3.0			mA
LOW-level output current2		I_{OL2}	V_{OL2}=V_{SS}+0.7		3.0			mA
Output current3*2	SP,SPN	I_{OH3}	V_{OH3}=V_{SS}+0.7	V_{DD}=3.0V			4.0	mA
				V_{DD}=5.0V			7.7	

*1. Supply voltage ratings shown are with oscillator running and all functions operating normally.

*2. Output current when 20kΩ volume control resistor is connected to VOL, and all D/A converter bits ON, measured using the following circuit.



AC Characteristics

T_a=25°C,V_{DD}=3.0V or 5.0V,V_{SS}=0V unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
			MIN	TYP	MAX	
Initialization clear time	t_{ICW}		1.0			µsec
ICN-STN time to spare	t_{SS}				10	µsec
STN pulse width	t_{STW}		81921			µsec
Clock frequency*1	f_{XTI}		3.8	4.0	4.2	MHz
Clock duty cycle*1	R_{XTI}		40	50	60	%
Oscillator stop time	t_{XEN}		180224		196608	µsec
D/A converter rise delay time	t_{DAST}		40000	81921	163842	µsec
D/A converter fall delay time	t_{DAEN}		180224		196608	µsec
Standby chattering prevention time	t_{CH1}	STN,STOP Time after oscillator start	40000	81921	163842	µsec
Oscillator chattering prevention time	t_{CH2}	STN,STOP	65537		81921	µsec
Melody select chattering prevention time	t_{CH3}	S0～S3 Applied level hold melody mode	65536		131072	µsec
MODE、LH read timing	t_{MR}		10000	15875	31750	µsec
S0 to S3 read timing	t_{SR}		10000	31875	63750	µsec
BUSYN fall delay time	t_{BYST}		4096	8192	16384	µsec
BUSYN rise delay time*2	t_{BYEN}				8192	µsec
Melody start delay time	t_{PYST}		8192	16384	32768	µsec
STOP pulse width	t_{STPW}		81921			µsec
ENDN delay time	t_{EDST}				8192	µsec
ENDN pulse width	t_{EDW}		8	16	32	µsec

*1. These are ratings when clock signals are input from the outside to XT pin.
*2. The time taken for fast damping to reduce the envelope to 0 level.

Note. Input signal should be risen or fallen to the following time or less.

FUNCTIONAL DESCRIPTION

Chattering Prevention

STN, STOP chattering prevention function

(a) Oscillator stopping（Standby Mode）

The oscillator starts when STN goes from HIGH to LOW in standby mode. Input data is received and melody data output starts 81.9ms after the oscillator start if STN is LOW. SM1350 dose not operate even if the signal is input to STOP in standby mode.

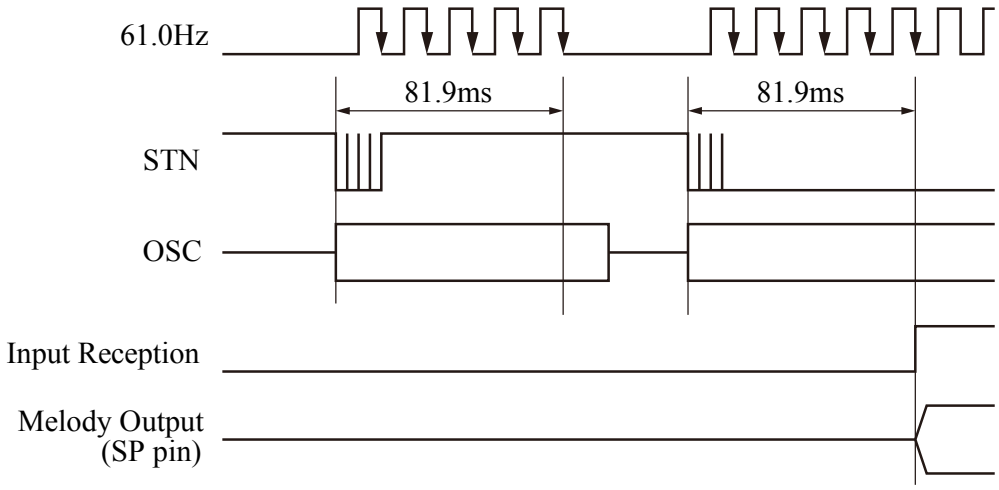


Figure 1. STN,STOP chattering prevention timing (oscillator stopping）

(b) Oscillator running

Input data is considered valid 81.9ms after STN and STOP have last changed state. Input data is considered invalid for intervals less than 65.5ms.

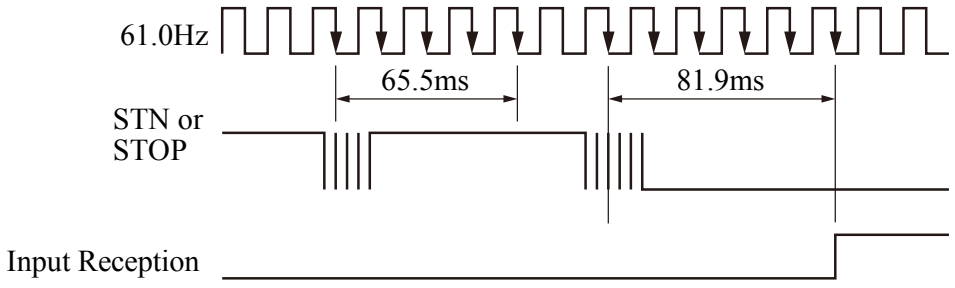


Figure 2. STN,STOP chattering prevention timing (oscillator running）

S0 to S3 chattering prevention function

In binary select mode, S0 to S3 are sampled in sync with the 15.26Hz clock during level-hold melody output. The chatter prevention function compares the data sampled 65.5ms after a data transition on S0 to S3 with the data sampled 65.5ms before the data transition. If the 2 data samples are the same, then the data transition is considered invalid. However, if they are not the same indicating a true transition has occurred, melody output stops and only restarts again after 2 consecutive identical melody select data samples occur. Note that except for binary select mode with level hold output, the S0 to S3 chattering prevention circuit is disabled.

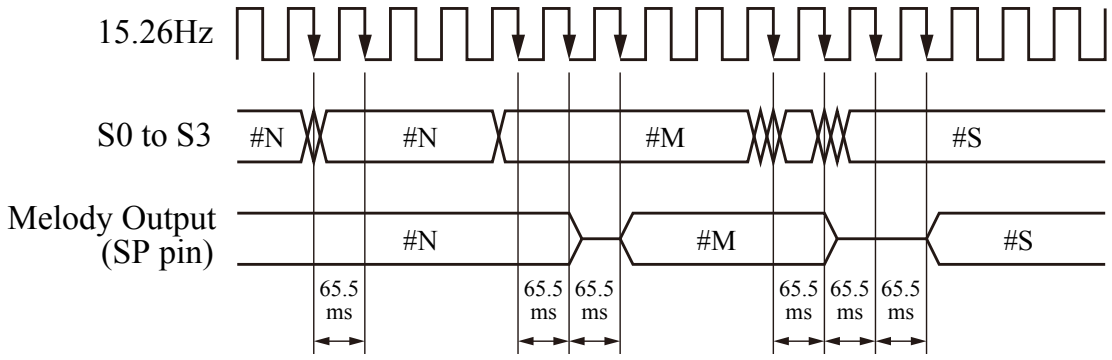


Figure 3. S0～S3 chattering prevention timing

Initialization

When power on and ICN goes LOW, all pins and internal states are initialized to the states shown below. It is recommended to initialize before melody output for steady operation.

■ Output pins

- SP, SPN : Open
- ENDN : V_{DD}
- CT : V_{SS}
- BUSYN : V_{DD}

■ Serial melody counter

Reset to first melody (S0 to S3 all 0)

■ Oscillator circuit

Stopped

Melody Output Circuit

The volume control circuit comprises a P-channel current-summing D/A converter, a built-in constant-current source and an external variable resistor.

Output circuit (A-class)

The A-class output circuit comprises a single 10-bit D/A converter with current output on SP. The D/A converter is set ON immediately after the oscillator starts, and the current output that results is the center point above and below which the converter current output varies in response to the waveform amplitude. The SP output is current-to-voltage converted for connection to audio equipment or amplifiers. The 4 sound generator waveforms are time multiplexed, so an integrating circuit must be connected between SP and the amplifier to recover the signal.

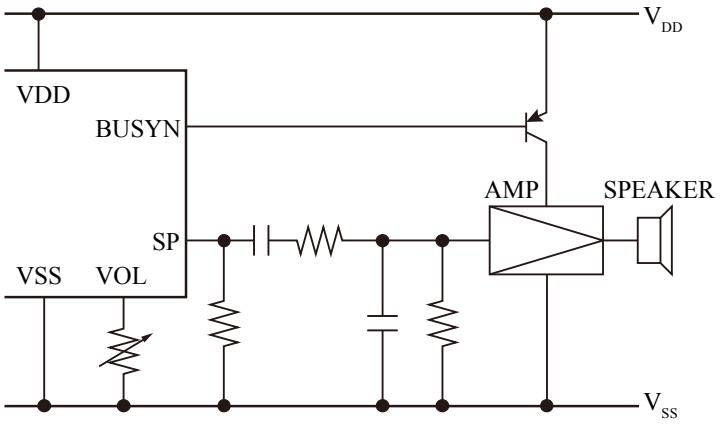


Figure 4. Output circuit (A-class)

Pin Functions

STN pin

Melody start signal. Melody starts when LOW is detected.

One-shot melody output (LH=LOW)

One-shot melody is a melody control that stops melody after it play to the last of the melody when there is a start trigger. When STN goes LOW during melody output, the melody specified with S0 to S3 is played

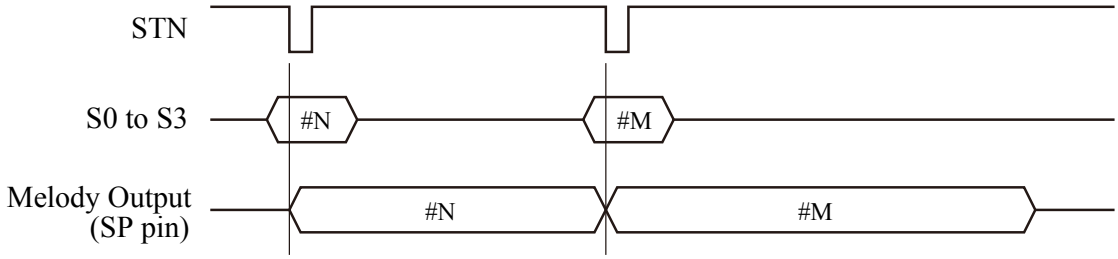


Figure 5. One-shot mode

One-shot mode repeat function

In one-shot melody mode, the output repeats the same melody while STN is LOW. When STN goes HIGH, the output continues until the end of the currently playing melody and then stops.

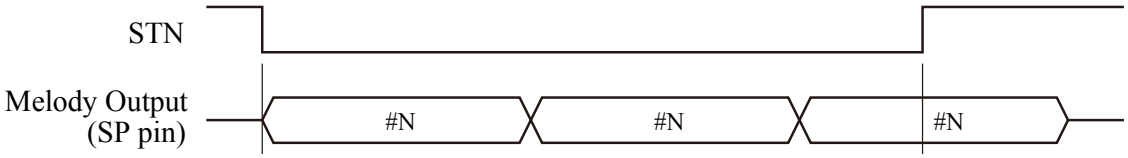


Figure 6. One-shot melody repeat timing

Level hold melody output (LH=HIGH)

Level hold melody output is played when STN is LOW, and it goes HIGH, it is melody control which stops in the middle of melody. When either of S0 to S3 changes during melody output, it restarts from the head of the melody newly selected.

* This function is effective only while the level hold melody output in the binary select mode.

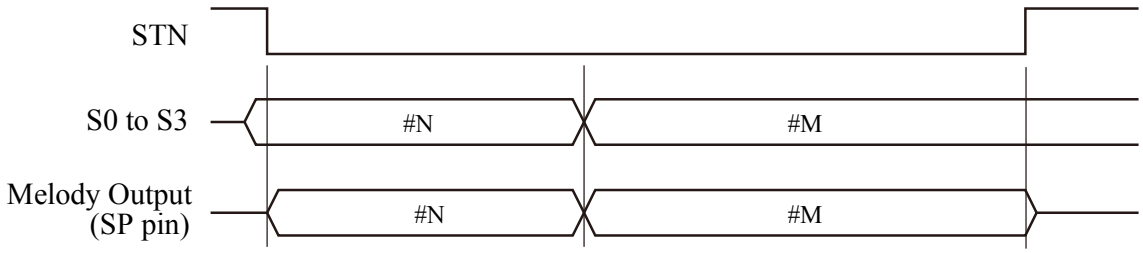


Figure 7. Level hold mode

Binary select mode (MODE=LOW)

A melody of 1 to 6 is selected according to the condition (0000 to 1111) of S0 to S3.

Serial select mode (MODE=HIGH)

In serial select mode, the next melody is selected by cycling through the melodies in the order #N→ #N + 1…#N-1→#N when the STN input goes LOW. Note that when melody output is stopped using the STOP input, the melody-select counter increments.

One-shot melody output (LH=LOW)

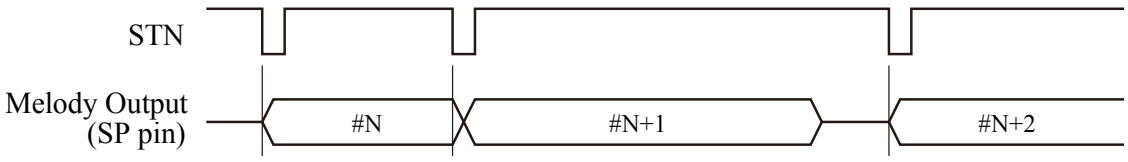


Figure 8. One-shot mode (serial select)

Level hold melody output (LH=HIGH)

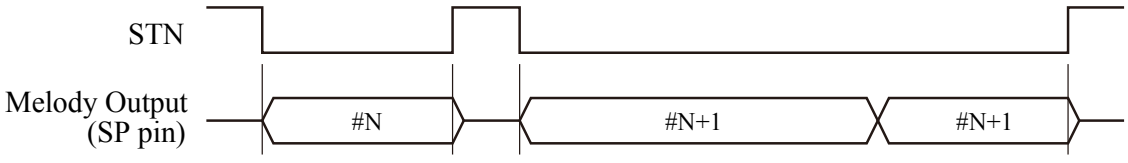


Figure 9. Level hold mode (serial select)

The melody selection in serial mode is controlled by S0 and S1 as shown in the following table. The states of S0 and S1 are read in immediately after startup and the change of S0 and S1 during melody output is invalid.

S1	S0	Melody counter
LOW	−	Increments when melody output stops
HIGH	LOW	No increment
HIGH	HIGH	Increments when melody output starts

Stable 1. S0, S1 resistor and melody counter

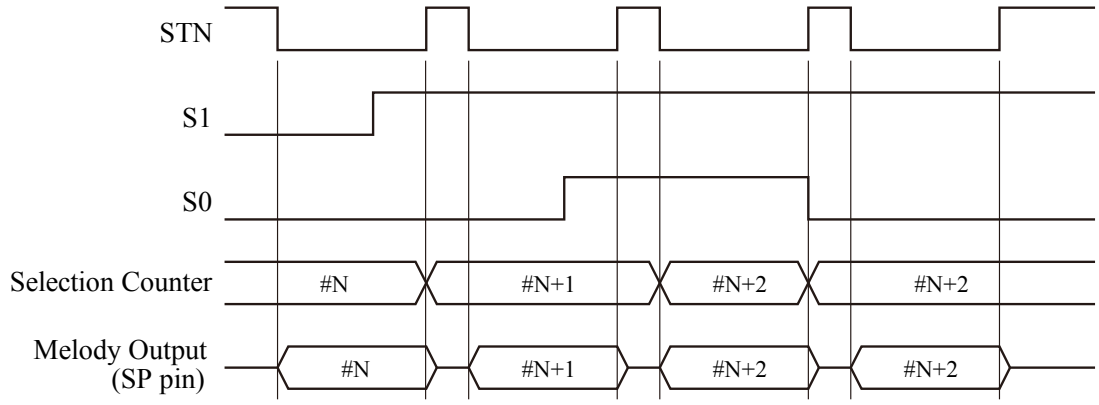


Figure 10. S0, S1 melody output control timing

STOP pin

One-shot output mode stops when STOP goes from HIGH to LOW. The STOP input is ignored in level hold output mode and is also ignored in one-shot mode when STN is LOW. Note that even when STOP is LOW, STN has higher priority.

CT pin

A pulse in sync with selected notes or rests is output on CT. 16.4ms pulse is output when a note or rest occurs for which the corresponding CT data in score ROM is set to 1.

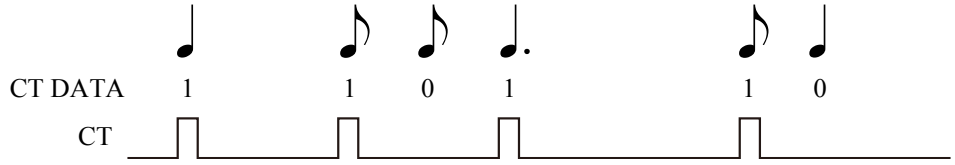


Figure 11. CT pulse mode output

Fast Damping

When melody output stops, the D/A converter output amplitude dose not fall to zero instantaneously, instead the output converges to zero within a maximum of 8.2ms to prevent noise being generated. Also, when one-shot melody output mode is retriggered, melody output restarts after the fast damping interval. When melody out is stopped by ICN input, it instantaneously becomes 0 level.

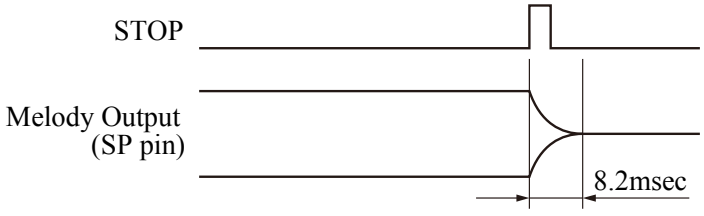


Figure 12. Fast damping timing

TIMING DIAGRAMS

One-shot Melody Mode

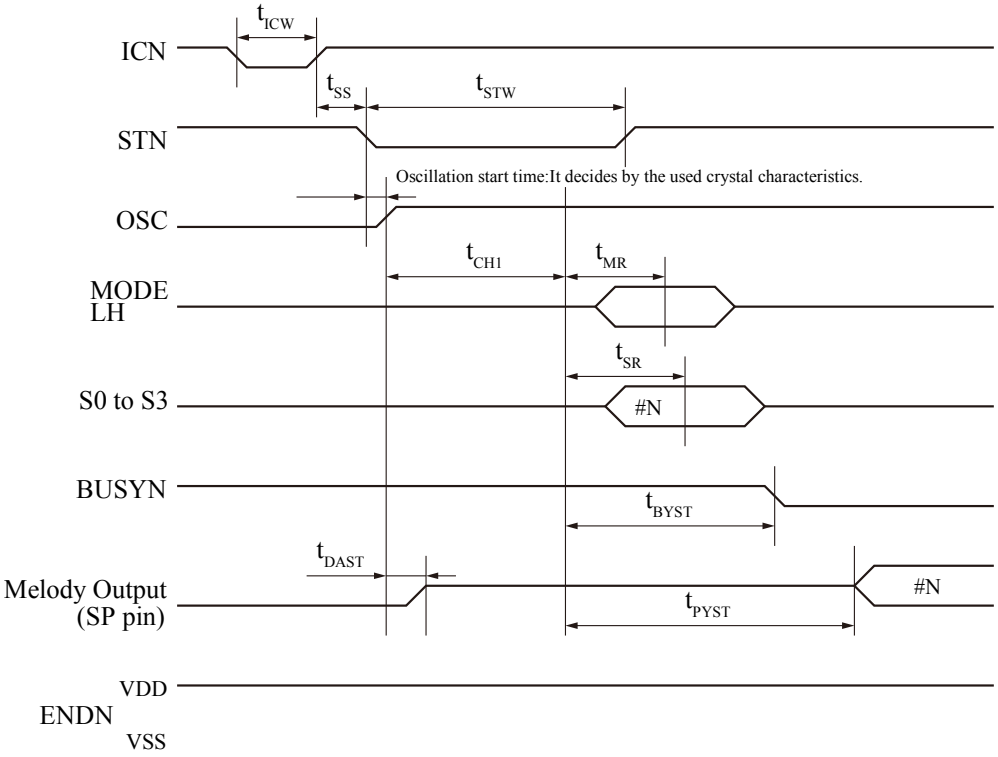


Figure 13. One-shot mode (standby to melody start)

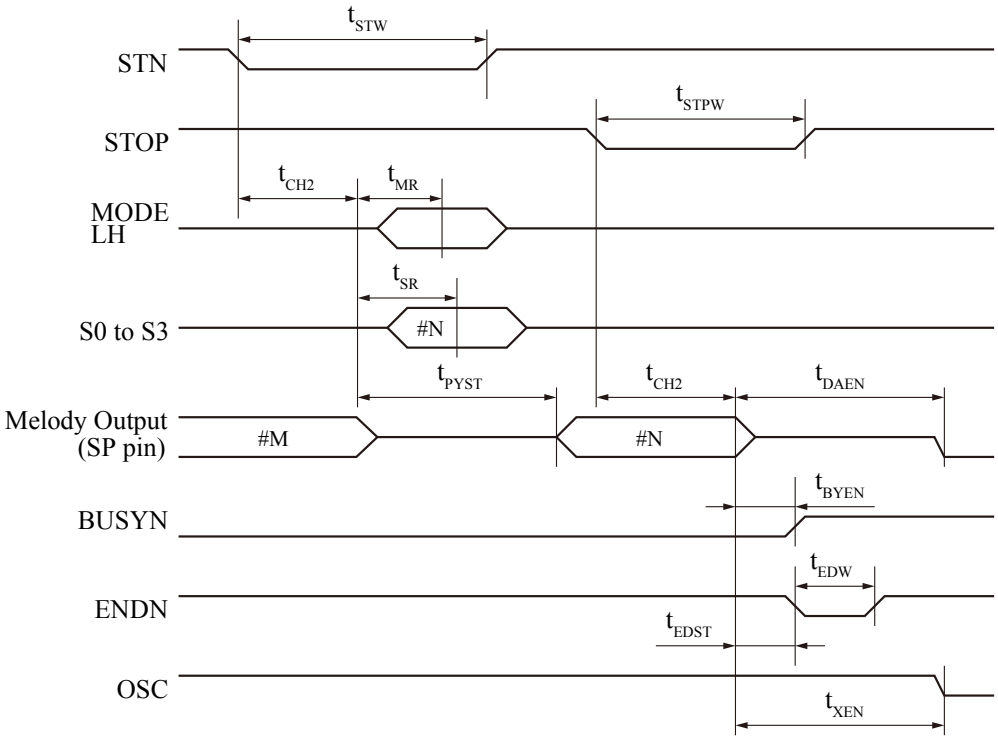


Figure 14. One-shot mode (melody stop by STOP pin)

Level Hold Melody Mode

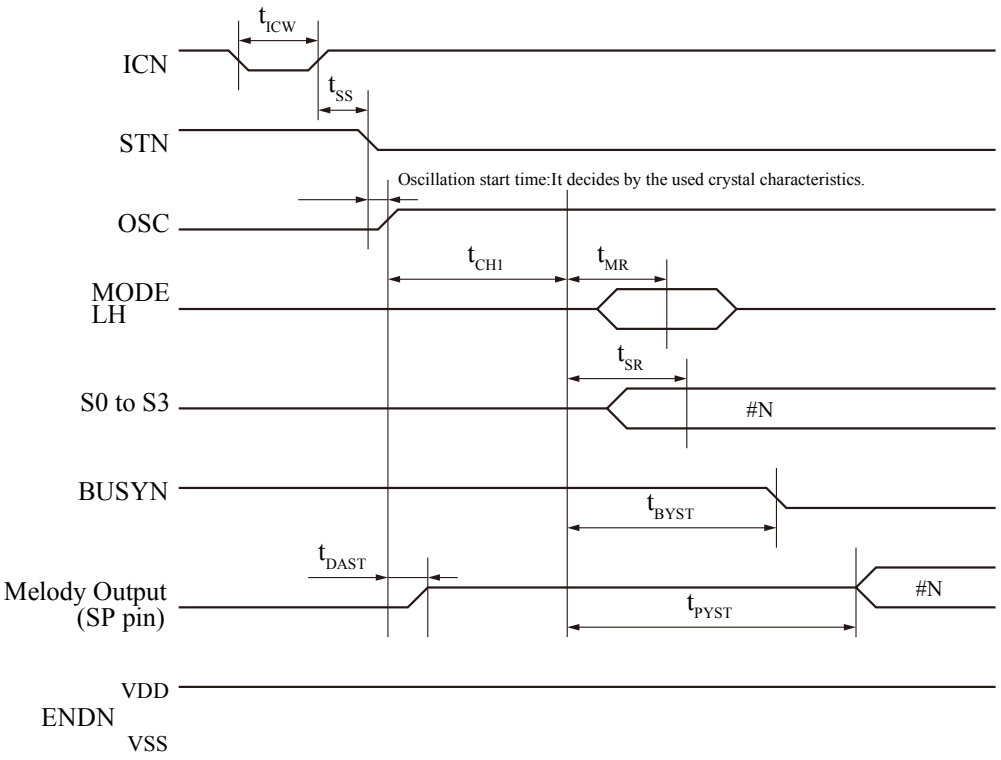


Figure 15. Level hold mode (standby to melody start)

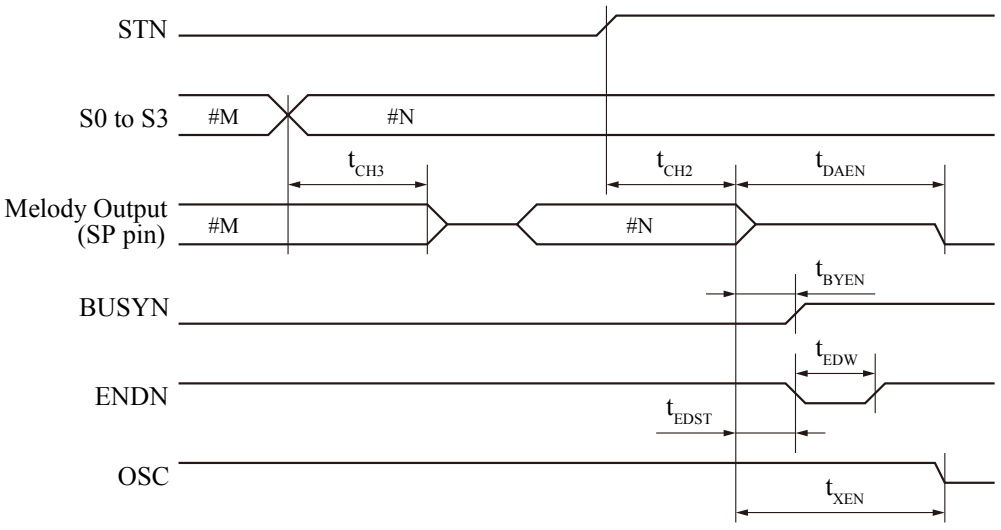
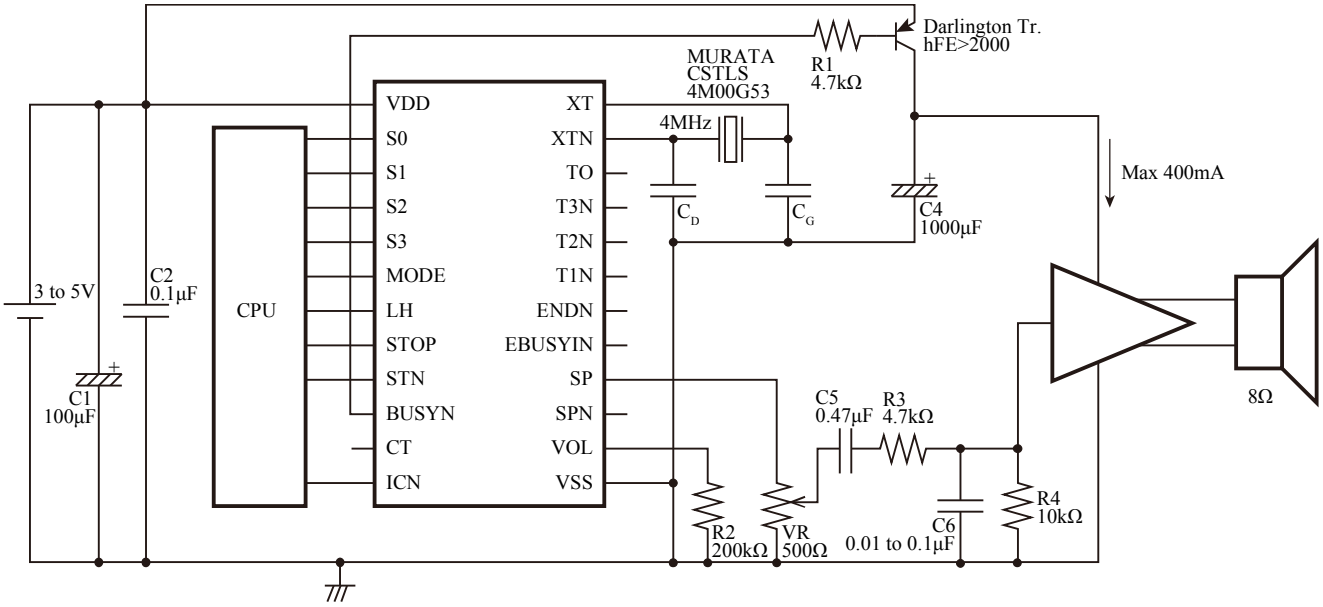


Figure 16. Level hold mode (melody stop by STN Low → High)

TYPICAL APPLICATIONS



ROM SPECIFICATIONS

Sound Supply

No.	Sound Name	MAIN Wave Pattern Name	SUB Wave Pattern Name
0	p Rhodes	sin	Rhodes M
1	Rhods1	sin	Rhodes M
2	Rhodes	sin	Rhodes M
3	A.GtrL	A.GuitrL	harpsic2
4	StrinM	sin	Strings1
5	StrinL	sin	Strings1
6	Bell	chime22	chime22
7	1stFlute	Flute	Flute
8	E.Piano1	Flute	orglm
9	Rhodes	Flute	Rhodes M
A	Flute1	Flute	Flute
B	STRINGSA	sin	Strings1
C	A.GtrL'	A.GuitrL	harpsic2
D	E.Piano2	Flute	orglm
E	Strings1	sin	Strings1
F	E.Piano	Flute	orglm

Melody name, Tempo, Sound assign, Time interval mode, CT mode

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For products intended for sale outside of Japan, it is the responsibility of the customer to obtain permission to use a melody by following all relevant copyright rules and regulations for the countries concerned.

S0 to S3				Music	Melody name	Tempo	Sound assign				Time interval mode				CT mode
S3	S2	S1	S0	No.			CH1	CH2	CH3	CH4	CH1	CH2	CH3	CH4	
L	L	L	L	1	Hitomi ga hohoemukara	105	2	0	0	1	0	0	0	0	pulse
L	L	L	H	2	Here comes the sun	272	3	3	3	3	1	1	1	1	pulse
L	L	H	L	3	Heigh Ho	215	7	4	4	5	0	0	0	0	pulse
L	L	H	H	4	Mirai yosouzu II	67	E	E	E	E	0	0	0	0	pulse
L	H	L	L	5	I need to be in love	76	F	9	9	9	0	0	0	0	pulse
L	H	L	H	6	Kanon	129	C	8	D	B	0	0	0	0	pulse
L	H	H	L	7	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
L	H	H	H	8	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	L	L	L	9	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	L	L	H	10	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	L	H	L	11	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	L	H	H	12	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	H	L	L	13	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse
H	H	L	H	14	Heigh Ho-2	215	6	4	4	5	0	0	0	0	pulse
H	H	H	L	15	Heigh Ho-3	215	7	4	4	5	0	0	0	0	pulse
H	H	H	H	16	Hitomi ga hohoemukara	119	F	F	F	F	0	0	0	0	pulse

Please pay your attention to the following points at time of using the products shown in this document.

1. The products shown in this document (hereinafter ”Products”) are designed and manufactured to the generally accepted standards of reliability as expected for use in general electronic and electrical equipment, such as personal equipment, machine tools and measurement equipment. The Products are not designed and manufactured to be used in any other special equipment requiring extremely high level of reliability and safety, such as aerospace equipment, nuclear power control equipment, medical equipment, transportation equipment, disaster prevention equipment, security equipment. The Products are not designed and manufactured to be used for the apparatus that exerts harmful influence on the human lives due to the defects, failure or malfunction of the Products.
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