NIPPON PRECISION CIRCUITS INC.

SM1125 series

Multimelody IC for Pagers

OVERVIEW

The SM1125 series are melody ICs fabricated in NPC's Molybdenum-gate CMOS for use in mobile telecommunications equipment. A maximum of 16 melodies can be stored in programmable ROM.

FEATURES

- Maximum of 16 melody selections (with up to 512 steps)
- Level hold playback mode
- External reference clock input versions and built-in RC oscillator versions available, set by master-slice option (RC oscillator versions require an external resistor and capacitor).
- 12 selectable clock frequencies (fixed for all melodies)
  - External clock input versions (12 frequencies)
    - 32.768 kHz system: 32.768, 65.536 and 131.072 kHz
    - 37.5 kHz system: 37.5, 75.0 and 150.0 kHz
    - 38.4 kHz system: 38.4, 76.8 and 153.6 kHz
    - 48.0 kHz system: 48.0, 96.0 and 192.0 kHz
  - Built-in oscillator versions (4 frequencies)
    - 38.4 kHz (standard oscillator frequency)
    - 32.768 kHz
    - 37.5 kHz
    - 48.0 kHz
- 2-pin serial data melody selection and 1-pin melody playback control
- Power save function
  - External clock input versions
    Clock gating in no-play modes
  - Built-in RC oscillator versions
    Oscillator stopped in no-play modes
- 8-pin plastic VSOP package
- Molybdenum-gate CMOS process

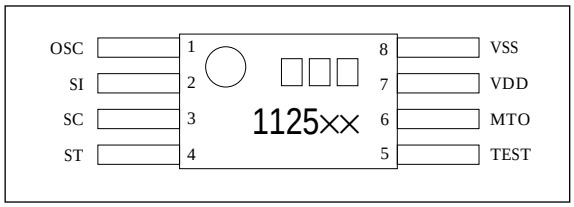
ORDERING INFORMATION

DEVICE	PACKAGE
SM1125××V[1]	8pin VSOP

1. ×× is version name.

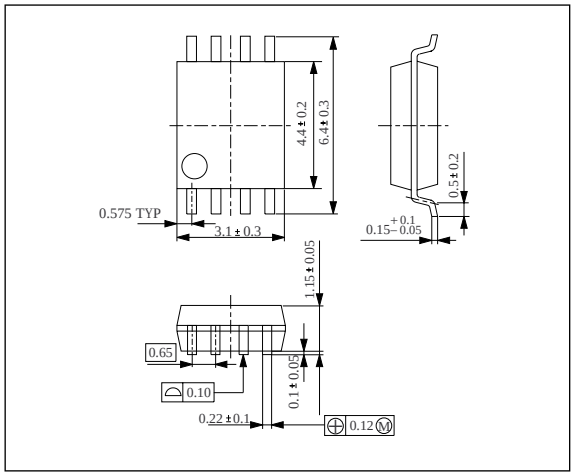
PINOUT (Top View)

8-pin VSOP

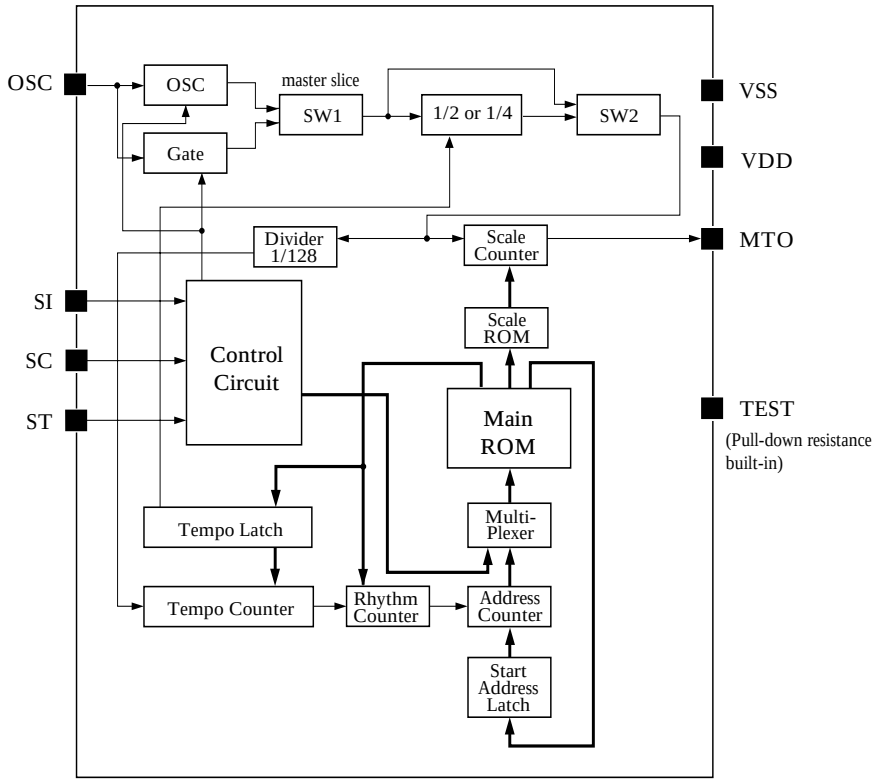


PACKAGE DIMENSIONS

Unit: mm



BLOCK DIAGRAM



PIN DESCRIPTION

Number	Name	I/O	Function
1	OSC	I	Built-in RC oscillator option: External resistor and capacitor connection pins External clock input option: External reference clock input (gate circuit built-in)
2	SI	I	Playback control serial interface data input
3	SC	I	Playback control serial interface clock input
4	ST	I	Playback start/stop control signal input
5	TEST	I	Test input pin. Leave open or tie to VSS. (Pull-down resistance built-in)
6	MTO	O	Playback melody signal output
7	VDD	–	Supply pin (+)
8	VSS	–	Ground pin

SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Symbol	Condition	Rating	Unit
Supply voltage range	V_{DD} – VSS		– 0.3 to 5.0	V
Input voltage range	V_{IN}		V_{SS} – 0.2 to V_{DD} + 0.2	V
Power dissipation	P_D		100	mW
Storage temperature range	T_{stg}		– 40 to 125	°C
Soldering temperature	T_{sld}		255	°C
Soldering time	t_{sld}		10	s

Recommended Operating Conditions

V_{SS} = 0 V

Parameter	Symbol	Condition	Rating	Unit
Supply voltage	V_{DD}		2.0 to 3.6	V
Operating temperature	T_{opr}		–20 to 70	°C

DC Characteristics

Unless otherwise noted T_a = –20 to 70 °C, V_{SS} = 0 V, V_{DD} = 1.5 to 3.6 V

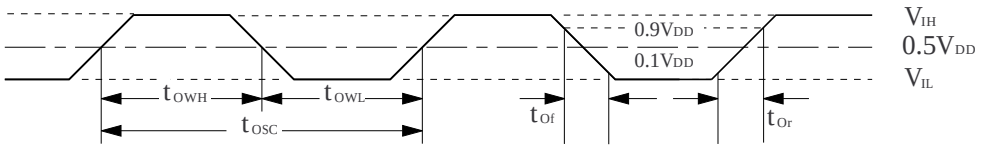
Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply voltage (1)	V_{DD1}	External clock input option	1.5	3.0	3.6	V
Supply voltage (2)	V_{DD2}	Built-in RC oscillator option	2.0	3.0	3.6	V
Current consumption (1)	I_{DD1}	Non-playback mode, T_a = 25°C	–	–	0.5	µA
Current consumption (2)	I_{DD2}	External clock input option: Playback mode, MTO pin open	–	25	200	µA
Current consumption (3)	I_{DD3}	Built-in RC oscillator option: Playback mode, MTO pin open	–	215	600	µA
Input voltage	V_{IH}	ST, SI, SC and OSC (External clock input option) pins	V_{DD} – 0.2	–	V_{DD}	V
	V_{IL}		V_{SS}	–	V_{SS} + 0.2	V
Input current (1)	I_{IH1}	ST, SI, SC and OSC (External clock input option) pins, V_{IH} = V_{DD}, T_a = 25°C	–	–	0.5	µA
	I_{IL1}	ST, SI, SC and OSC (External clock input option) pins, V_{IL} = 0 V, T_a = 25°C	–	–	0.5	µA
Input current (2)	I_{IH2}	TEST pin, V_{IH} = V_{DD}	–	–	200	µA
Open voltage	V_{OPN}	TEST pin	–	–	0.1	V
Output voltage	V_{OH}	MTO pin, I_{OH} = 1 mA	V_{DD} – 0.4	–	V_{DD}	V
	V_{OL}	MTO pin, I_{OL} = 1 mA	V_{SS}	–	V_{SS} + 0.4	V
Oscillator frequency	f_{OSC}	Built-in RC oscillator option: NPC test board measurement, R_O = 91 kΩ, C_O = 200 pF V_{DD} = 2.0 to 3.6V	34.5	38.4	42.5	kHz
Frequency stability	Δf/f	Built-in RC oscillator option	–	0.1	–	%/0.1V
Oscillator start voltage	V_{DOB}	Built-in RC oscillator option	–	–	1.6	V
Oscillator stop voltage	V_{DOS}	Built-in RC oscillator option	–	–	1.6	V

AC Characteristics

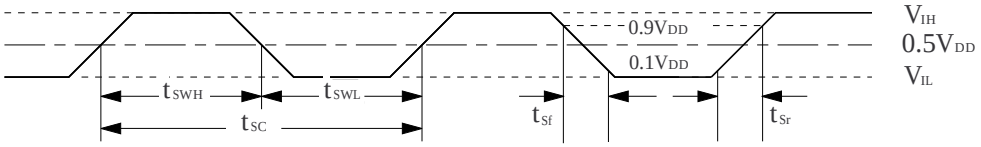
Unless otherwise noted T_a = –20 to 70 °C, V_{SS} = 0 V, V_{DD} = 1.5 to 3.6 V

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
OSC pulse cycle	t_{OSC}	"OSC input pulse (External clock input option)" timing	5.0	–	–	µs
OSC HIGH-level pulsewidth	t_{OWH}		2.0	–	–	µs
OSC LOW-level pulsewidth	t_{OWL}		2.0	–	–	µs
OSC pulse rise time	t_{Or}		–	–	200	ns
OSC pulse fall time	t_{Of}		–	–	200	ns
SC pulse cycle	t_{SC}	"SC input pulse" timing	5.0	–	–	µs
SC HIGH-level pulsewidth	t_{SWH}		2.0	–	–	µs
SC LOW-level pulsewidth	t_{SWL}		2.0	–	–	µs
SC pulse rise time	t_{Sr}		–	–	200	ns
SC pulse fall time	t_{Sf}		–	–	200	ns
SI-SC setup time	t_{DS}	"SC-SI serial input pulse" timing	2.0	–	–	µs
SI-SC hold time	t_{DH}		2.0	–	–	µs

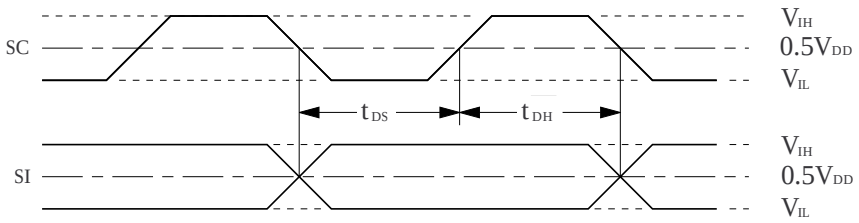
OSC input pulse (External clock input option)



SC input pulse



SC-SI serial input pulse



FUNCTIONAL DESCRIPTION

Control Functions

Reference clock

SM1125 series devices are available in external clock input versions and built-in RC oscillator versions, set by master-slice option. In the case of the built-in RC oscillator option, an external resistor and capacitor is required for the oscillator function.

SM1125 series can operate at 12 selectable reference clock frequencies. All melodies playback at the fixed speed set by the reference clock frequency. External clock input versions operate at one of 12 selectable clock frequencies, as shown in table 1. Built-in RC oscillator versions operate at one of 4 selectable oscillator frequencies—32.768 kHz, 37.5 kHz, 38.4 kHz (standard frequency) and 48.0 kHz.

Table 1. Reference clock frequencies

Frequency system	Selectable frequencies		
32.768 kHz	32.768 kHz	65.536 kHz	131.072 kHz
37.5 kHz	37.5 kHz	75.0 kHz	150.0 kHz
38.4 kHz	38.4 kHz	76.8 kHz	153.6 kHz
48.0 kHz	48.0 kHz	96.0 kHz	192.0 kHz

In external clock input versions, the external reference clock input is used during playback mode only and is otherwise ignored. If a clock signal is input when not in playback mode (when ST is LOW), the gate circuit switches to cutoff the external reference clock signal from entering the device, preventing unwanted current flow.

In built-in RC oscillator versions, the oscillator is stopped when not in playback mode (when ST is LOW), preventing unwanted current flow.

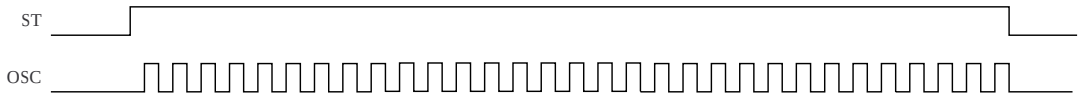


Figure 1. External clock input version: Input during playback mode only

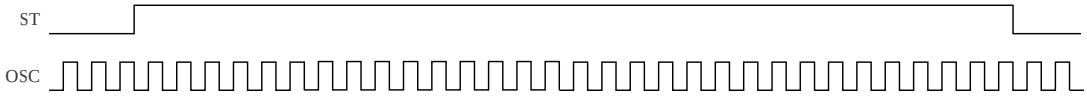


Figure 2. External clock input version: Input during non-playback mode

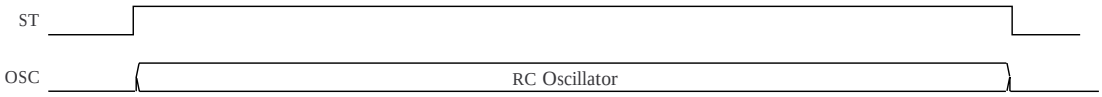
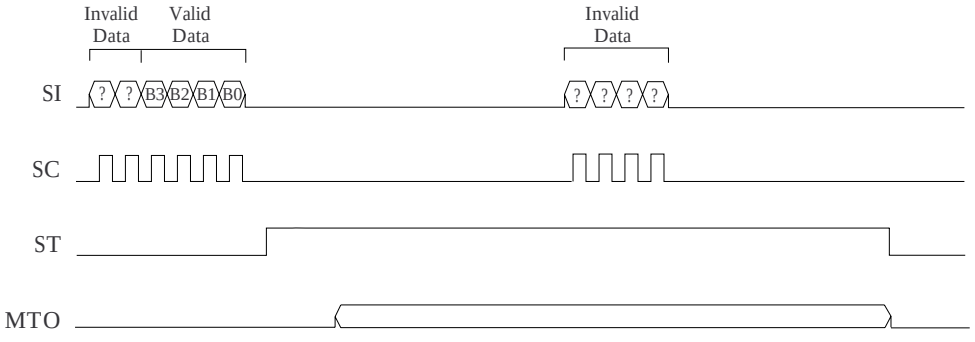


Figure 3. Built-in RC oscillator version

Playback control

The ST pin controls the start of playback. While ST is HIGH, the melody is played repeatedly, and when ST goes LOW, playback stops. Melodies are selected by input serial data on pins SI and SC, as shown in table 2. The final 4 serial data bits in any input data string form the valid selection data, and this data is retained even after playback. If serial data is input during playback, the data is ignored and playback continues.



Pin SC should be LOW when either a LOW-to-HIGH or HIGH-to-LOW transition occurs on pin ST.

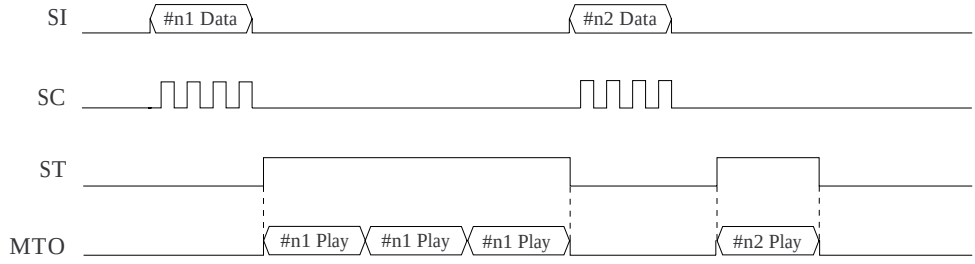
Figure 4. Serial data input timing

Serial data selection

Table 2. Serial data melody select

B3	B2	B1	B0	ST	Melody
L	L	L	L	L → H	1st melody
L	L	L	H	L → H	2nd melody
L	L	H	L	L → H	3rd melody
L	L	H	H	L → H	4th melody
L	H	L	L	L → H	5th melody
L	H	L	H	L → H	6th melody
L	H	H	L	L → H	7th melody
L	H	H	H	L → H	8th melody

B3	B2	B1	B0	ST	Melody
H	L	L	L	L → H	9th melody
H	L	L	H	L → H	10th melody
H	L	H	L	L → H	11th melody
H	L	H	H	L → H	12th melody
H	H	L	L	L → H	13th melody
H	H	L	H	L → H	14th melody
H	H	H	L	L → H	15th melody
H	H	H	H	L → H	16th melody



Melody plays repeatedly when ST is HIGH, and stops immediately when ST goes LOW.

Figure 5. Melody repetition timing

Playback timing diagrams

Playback start

Playback starts 128 ± 1 OSC clock cycles after ST goes HIGH.

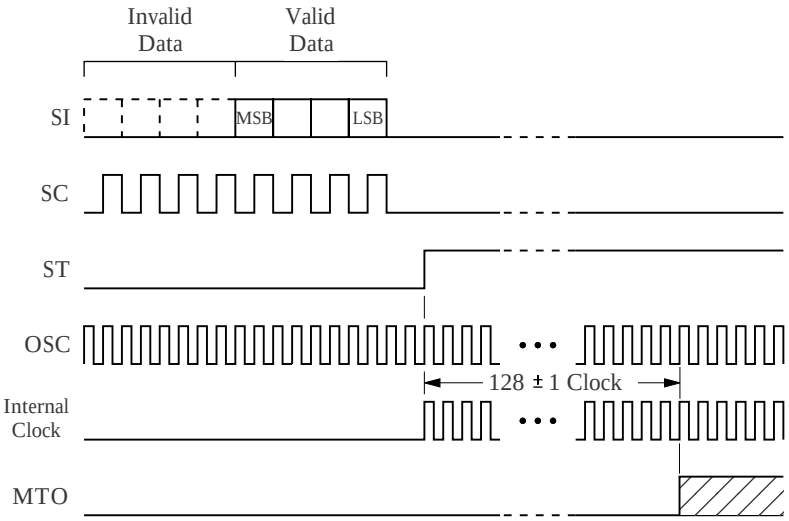


Figure 6. Start timing

Playback stop

Playback stops immediately when ST goes LOW.

In external clock input versions, the IC internal clock also stops when ST goes LOW, regardless of whether or not there is a clock input signal on pin OSC.

In built-in RC oscillator versions, the oscillator also stops when ST goes LOW.

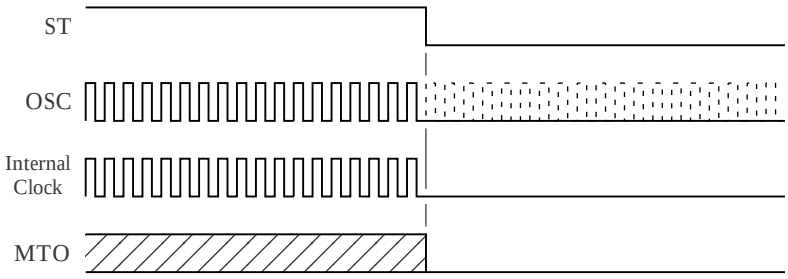


Figure 7. Stop timing

Musical Specifications

Maximum program steps

The mask for the built-in ROM can be programmed with up to a maximum of 512 steps, where each step represents either a note (sound pitch and length) or a rest.

Note length (including rests)

Eight rhythm values for notes and rests can be programmed. Also, 2 or more notes can be musically tied.

Table 3. Rhythm values

	0	1	2	3	4	5	6	7
Note	𝅘𝅥𝅯	𝅘𝅥𝅮	𝅘𝅥𝅮.	𝅘𝅥	𝅘𝅥𝅮 (3)	𝅘𝅥.	𝅘𝅥 (3)	𝅗𝅥
Rest	𝄿	𝄾	𝄾·	𝄽	𝄾 (3)	𝄽.	𝄽 (3)	𝄻

Pitch and scale

SM1125 series devices perform uniform interval length processing to reduce the error at high pitches. This maintains the relative phase when the frequency varies from the input value.

The pitch varies with the clock frequency, as shown in the frequency listing in table 4.

The frequency variation from the input frequency is the sum of the relative error, shown in the frequency table, plus the pitch error.

(Ex) 38.4 kHz system, A4 note
Relative error: 8.99 cent
Pitch error: −3.58 cent
Total: +5.41 cent

Error calculation:

$$1200 \times \log_2 \frac{\text{Output frequency}}{\text{Reference frequency}} = 1200 \times \frac{\log_{10} \frac{\text{Output frequency}}{\text{Reference frequency}}}{\log_{10} 2}$$

$$\approx 3986.3 \times \log_{10} \frac{\text{Output frequency}}{\text{Reference frequency}}$$

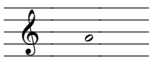
$$\approx 3986.3 \times \log_{10} \frac{441.379}{440.000}$$

$$\approx 5.41 \text{ cent}$$

Table 4. Frequency range

Number	Frequency divider	Relative error (cent)	32.768 kHz system		37.5 kHz system		38.4 kHz system		48 kHz system	
			Pitch	Frequency (Hz)	Pitch	Frequency (Hz)	Pitch	Frequency (Hz)	Pitch	Frequency (Hz)
1	247	2.49	C3	132.664	D#3	151.822	D#3	155.466	G3	194.332
2	233	3.50	C#3	140.635	E3	160.944	E3	164.807	G#3	206.009
3	220	2.89	D3	148.945	F3	170.455	F3	174.545	A3	218.182
4	208	0.00	D#3	157.538	F#3	180.288	F#3	184.615	A#3	230.769
5	196	2.88	E3	167.184	G3	191.327	G3	195.918	B3	244.898
6	185	2.87	F3	177.124	G#3	202.703	G#3	207.568	C4	259.459
7	175	–0.93	F#3	187.246	A3	214.286	A3	219.429	C#4	274.286
8	165	0.94	G3	198.594	A#3	227.273	A#3	232.727	D4	290.909
9	156	–1.96	G#3	210.051	B3	240.385	B3	246.154	D#4	307.692
10	147	0.93	A3	222.912	C4	255.102	C4	261.224	E4	326.531
11	139	–2.21	A#3	235.741	C#4	269.784	C#4	276.259	F4	345.324
12	131	0.42	B3	250.137	D4	286.260	D4	293.130	F#4	366.412
13	124	–4.50	C4	264.258	D#4	302.419	D#4	309.677	G4	387.097
14	117	–3.91	C#4	280.068	E4	320.513	E4	328.205	G#4	410.256
15	110	2.89	D4	297.891	F4	340.909	F4	349.091	A4	436.364
16	104	0.00	D#4	315.077	F#4	360.577	F#4	369.231	A#4	461.538
17	98	2.88	E4	334.367	G4	382.653	G4	391.837	B4	489.796
18	93	–6.46	F4	352.344	G#4	403.226	G#4	412.903	C5	516.129
19	87	8.99	F#4	376.644	A4	431.034	A4	441.379	C#5	551.724
20	83	–9.52	G4	394.795	A#4	451.807	A#4	462.651	D5	578.313
21	78	–1.96	G#4	420.103	B4	480.769	B4	492.308	D#5	615.385
22	74	–10.81	A4	442.811	C5	506.757	C5	518.919	E5	648.649
23	69	10.29	A#4	474.899	C#5	543.478	C#5	556.522	F5	695.652
24	66	–12.74	B4	496.485	D5	568.182	D5	581.818	F#5	727.273
25	62	–4.50	C5	528.516	D#5	604.839	D#5	619.355	G5	774.194
26	58	10.95	C#5	564.966	E5	646.552	E5	662.069	G#5	827.586
27	55	2.89	D5	595.782	F5	681.818	F5	698.182	A5	872.727
28	52	0.00	D#5	630.154	F#5	721.154	F#5	738.462	A#5	923.077
29	49	2.88	E5	668.735	G5	765.306	G5	783.673	B5	979.592
30	46	12.26	F5	712.348	G#5	815.217	G#5	834.783	C6	1043.478
31	44	–10.79	F#5	744.727	A5	852.273	A5	872.727	C#6	1090.909
32	41	11.47	G5	799.220	A#5	914.634	A#5	936.585	D6	1170.732
33	39	–1.96	G#5	840.205	B5	961.538	B5	984.615	D#6	1230.769
34	37	–10.81	A5	885.622	C6	1013.514	C6	1037.838	E6	1297.297
35	35	–14.62	A#5	936.229	C#6	1071.429	C#6	1097.143	F6	1371.429
36	33	–12.74	B5	992.970	D6	1136.364	D6	1163.636	F#6	1454.545
37	31	–4.50	C6	1057.032	D#6	1209.677	D#6	1238.710	G6	1548.387
38	29	10.95	C#6	1129.931	E6	1293.103	E6	1324.138	G#6	1655.172
39	28	–28.30	D6	1170.286	F6	1339.286	F6	1371.429	A6	1714.286
40	26	0.00	D#6	1260.308	F#6	1442.308	F#6	1476.923	A#6	1846.154
41	25	–32.09	E6	1310.720	G6	1500.000	G6	1536.000	B6	1920.000
42	23	12.26	F6	1424.696	G#6	1630.435	G#6	1669.565	C7	2086.957
43	22	–10.79	F#6	1489.455	A6	1704.545	A6	1745.455	C#7	2181.818
44	21	–30.25	G6	1560.381	A#6	1785.714	A#6	1828.571	D7	2285.714
			+21.84 cent pitch error		–44.64 cent pitch error		–3.58 cent pitch error		–17.26 cent pitch error	

(Note) A4 is the following note.



A4 (440Hz)

Pitch	Reference frequency
C3	130.8128
C#3	138.5913
D3	146.8325
D#3	155.5635
E3	164.8138
F3	174.6143
F#3	184.9973
G3	195.9978
G#3	207.6525
A3	220.0000
A#3	233.0820
B3	246.9418
C4	261.6255
C#4	277.1825
D4	293.6650
D#4	311.1270
E4	329.6275
F4	349.2285
F#4	369.9945
G4	391.9955
G#4	415.3050
A4	440.0000
A#4	466.1640
B4	493.8835
C5	523.2510
C#5	554.3650
D5	587.3300
D#5	622.2540
E5	659.2550
F5	698.4570
F#5	739.9890
G5	783.9910
G#5	830.6100
A5	880.0000
A#5	932.3280
B5	987.7670
C6	1046.5020
C#6	1108.7300
D6	1174.6600
D#6	1244.5080
E6	1318.5100
F6	1396.9140
F#6	1479.9780
G6	1567.9820
G#6	1661.2200
A6	1760.0000
A#6	1864.6560
B6	1975.5340
C7	2093.0040
C#7	2217.4600
D7	2349.3200

Tempo

There are 29 tempos that can be selected for each melody. The tempo varies with the clock frequency.

Table 5. Tempo range

ROM		32.768 kHz system		37.5 kHz system		38.4 kHz system		48 kHz system	
Code	Frequency divider	Tempo	♩=	Tempo	♩=	Tempo	♩=	Tempo	♩=
03	4	Prestissimo	320.0	Prestissimo	366.2	Prestissimo	375.0	Prestissimo	468.8
04	5		256.0		293.0		300.0		375.0
05	6		213.3		244.1		250.0		312.5
06	7	Presto	182.9		209.3		214.3		267.9
07	8	Allegro	160.0	Presto	183.1	Presto	187.5		234.4
08	9		142.2	Allegro	162.8	Allegro	166.7		208.3
09	10		128.0		146.5		150.0	Presto	187.5
0A	11	Moderato	116.4		133.2		136.4		170.5
0B	12		106.7		122.1		125.0	Allegro	156.3
0C	13	Andante	98.5	Moderato	112.7	Moderato	115.4		144.2
0D	14		91.4	Andante	104.6		107.1		133.9
0E	15		85.3		97.7	Andante	100.0		125.0
0F	16		80.0		91.6		93.8	Moderato	117.2
10	17	Adagio	75.3		86.2		88.2		110.3
11	18		71.1		81.4		83.3	Andante	104.2
12	19		67.4		77.1		78.9		98.7
13	20	Larghetto	64.0	Adagio	73.2	Adagio	75.0		93.8
14	21		61.0		69.8		71.4		89.3
15	22	Largo	58.2		66.6		68.2		85.2
16	23		55.7	Larghetto	63.7	Larghetto	65.2		81.5
17	24		53.3		61.0		62.5		78.1
18	25		51.2	Largo	58.6		60.0	Adagio	75.0
19	26		49.2		56.3	Largo	57.7		72.1
1A	27		47.4		54.3		55.6		69.4
1B	28		45.7		52.3		53.6		67.0
1C	29		44.1		50.5		51.7	Larghetto	64.7
1D	30		42.7		48.8		50.0		62.5
1E	31		41.3		47.3		48.4		60.5
1F	32		40.0		45.8		46.9	Largo	58.6

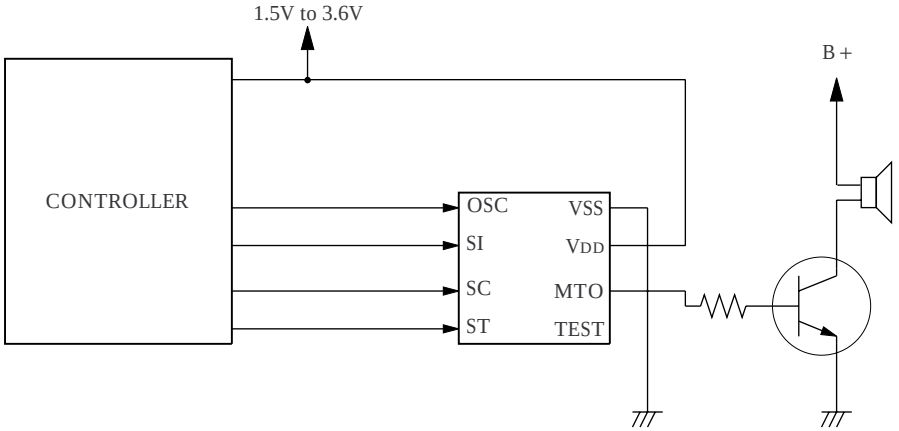
Quarter note (♩) length = 1536 × tempo counter frequency divider ÷ clock frequency

(Ex. 1) Tempo code = 1F (divider = 32), clock frequency = 32.768 kHz (32.768 kHz system)
$1536 \times 32 \div 32768 = 1.5$ (seconds)

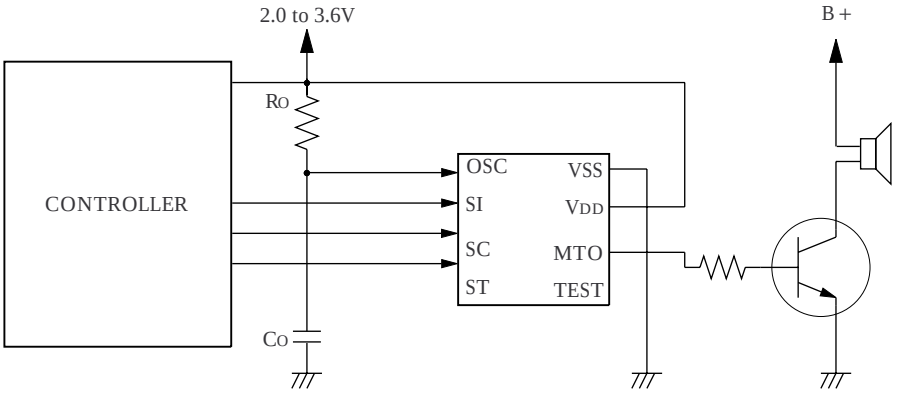
(Ex. 2) Tempo code = 18 (divider = 25), CLK frequency = 153.6 kHz (38.4 kHz system)
$1536 \times 25 \div 38400 = 1.0$ (seconds)

TYPICAL APPLICATION

External Clock Input Versions



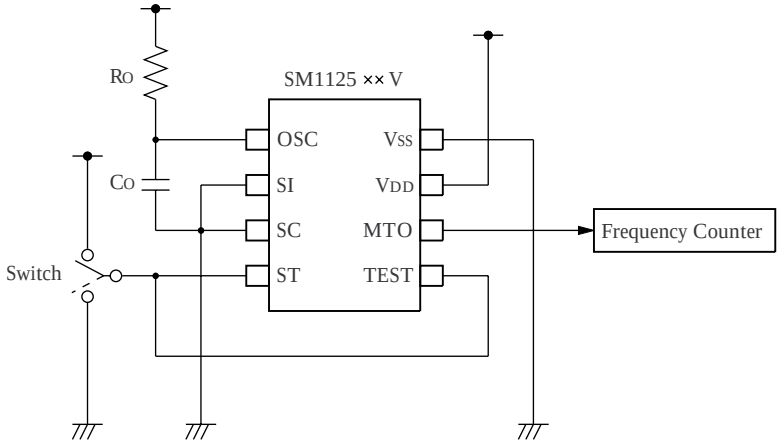
Built-in RC Oscillator Versions



OSCILLATOR FREQUENCY MEASUREMENT

The measurement circuit below shows a SM1125××V with built-in RC oscillator circuit and external RC oscillator components capacitor C_O and resistor R_O.

When ST is switched to V_{DD}, the oscillator starts and outputs a pulse on MTO. The output pulse is counted using a frequency counter.



Note that the board mounting and wiring will marginally affect the output frequency, even for equivalent values for R_O and C_O.

NIPPON PRECISION CIRCUITS INC.

NIPPON PRECISION CIRCUITS INC.

4-3, Fukuzumi 2-chome
Koto-ku, Tokyo 135-8430, Japan
Telephone: 03-3642-6661
Facsimile: 03-3642-6698

NC9628CE 1999.2