

### OVERVIEW

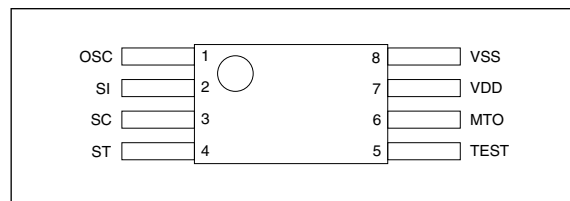
The SM1125 series are melody ICs fabricated in NPC's Molybdenum-gate CMOS for use in mobile telecommunications equipment. A maximum of 16 melodies can be stored in programmable ROM.

### 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)
    - 32.768kHz system: 32.768, 65.536 and 131.072kHz
    - 37.5kHz system: 37.5, 75.0 and 150.0kHz
    - 38.4kHz system: 38.4, 76.8 and 153.6kHz
    - 48.0kHz system: 48.0, 96.0 and 192.0kHz
  - Built-in oscillator versions (4 frequencies)
    - 38.4kHz (standard oscillator frequency)
    - 32.768kHz
    - 37.5kHz
    - 48.0kHz
- 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
- Molybdenum-gate CMOS process
- 8-pin plastic VSOP package

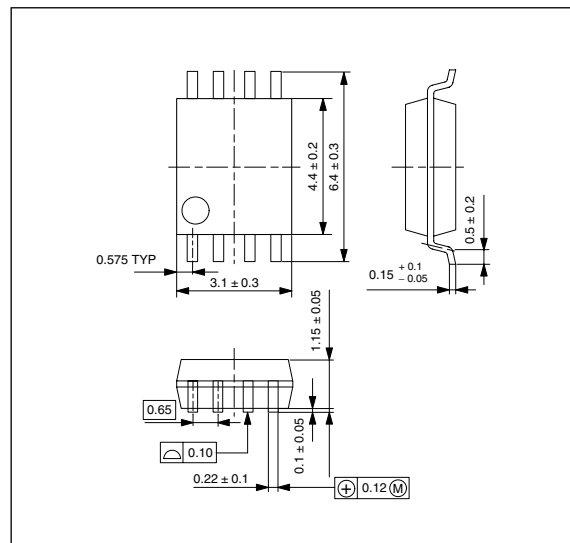
### PINOUT

(Top view)



### PACKAGE DIMENSIONS

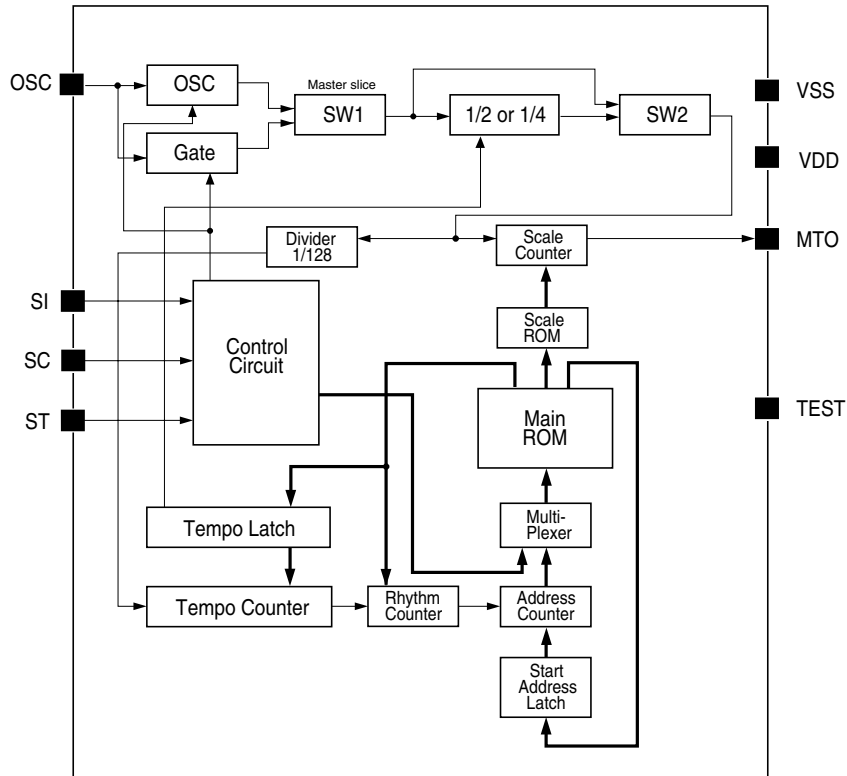
(Unit: mm)



### ORDERING INFORMATION

Device	Package
SM1125××V	8pin VSOP

**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	$V_{DD} - V_{SS}$		- 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

### Recommended Operating Conditions

$V_{SS} = 0V$

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  $70^\circ\text{C}$ ,  $V_{SS} = 0V$ ,  $V_{DD} = 1.5$  to  $3.6V$

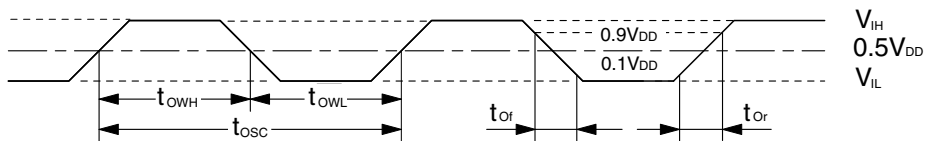
Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply voltage (1)	$V_{DD1}$	External clock input option	1.5	3.0	3.6	V
Supply voltage (2)	$V_{DD2}$	Built-in RC oscillator option	2.0	3.0	3.6	V
Current consumption (1)	$I_{DD1}$	Non-playback mode, $T_a = 25^\circ\text{C}$	-	-	0.5	$\mu\text{A}$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

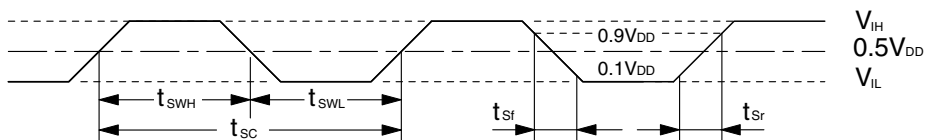
Unless otherwise noted  $T_a = -20$  to  $70^\circ\text{C}$ ,  $V_{SS} = 0\text{V}$ ,  $V_{DD} = 1.5$  to  $3.6\text{V}$

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

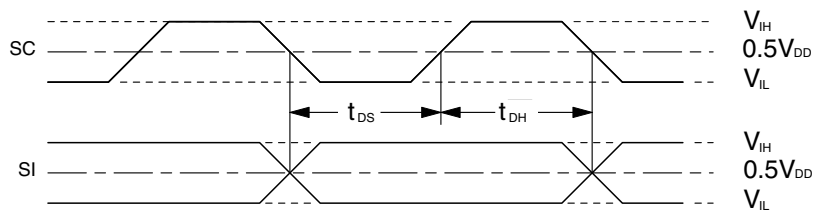
#### OSC input pulse (External clock input option)



#### 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—32.768kHz, 37.5kHz, 38.4kHz (standard frequency) and 48.0kHz.

Table 1. Reference clock frequencies

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

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.

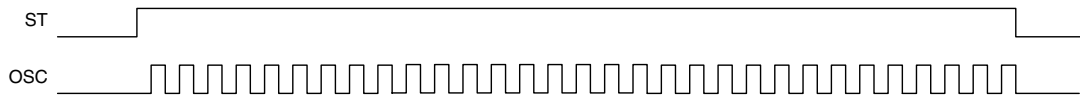


Figure 1. External clock input version: Input during playback mode only

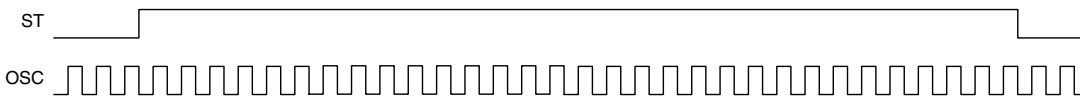


Figure 2. External clock input version: Input during non-playback mode

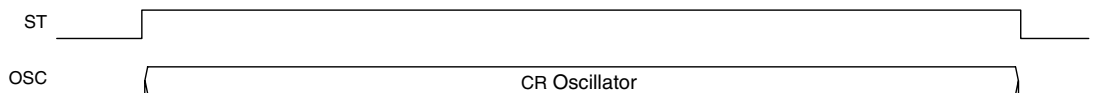


Figure 3. Built-in RC oscillator version

**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.

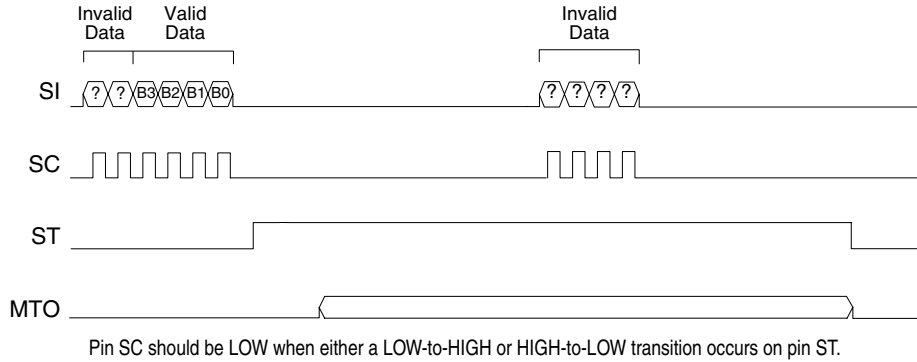


Figure 4. Serial data input timing

**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

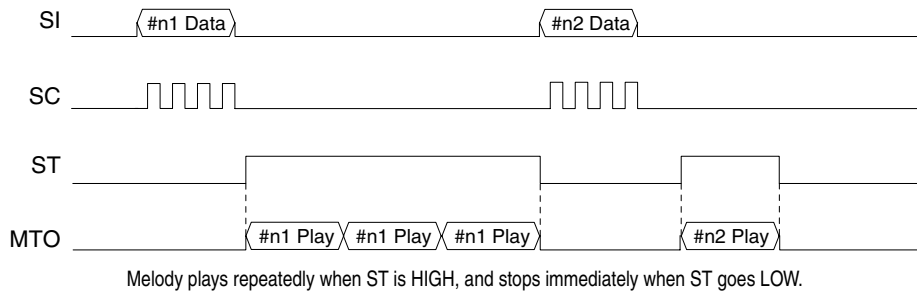


Figure 5. Melody repetition timing

**Playback timing diagrams**

**Playback start**

Playback starts  $128 \pm 1$  OSC clock cycles after ST goes HIGH.

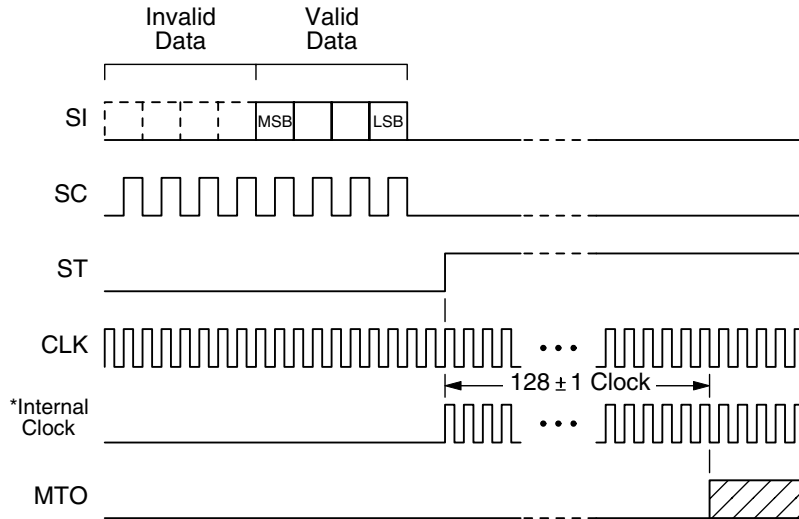


Figure 6. Start timing

**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.

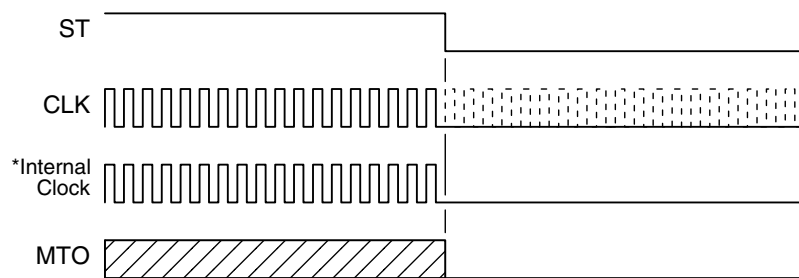


Figure 7. Stop timing

## 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								
Rest								

### 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) 38.4kHz system, A4 note

Relative error: 8.99 cent

Pitch error: -3.58 cent

Total: +5.41 cent

### Error calculation:

$$\begin{aligned}
 1200 \times \log_2 \frac{\text{Output frequency}}{\text{Reference frequency}} &= 1200 \times \frac{\log_{10} \frac{\text{Output frequency}}{\text{Reference frequency}}}{\log_{10} 2} \\
 &\approx 3986.3 \times \log_{10} \frac{\text{Output frequency}}{\text{Reference frequency}} \\
 &\approx 3986.3 \times \log_{10} \frac{441.379}{440.000} \\
 &\approx 5.41 \text{ cent}
 \end{aligned}$$



SM1125 series

Table 4. Frequency range

Number	Frequency divider	Relative error [cent]	32.768kHz system		37.5kHz system		38.4kHz system		48kHz system		Pitch	Reference frequency
			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	C3	130.8128
2	233	3.50	C#3	140.635	E3	160.944	E3	164.807	G#3	206.009	C#3	138.5913
3	220	2.89	D3	148.945	F3	170.455	F3	174.545	A3	218.182	D3	146.8325
4	208	0.00	D#3	157.538	F#3	180.288	F#3	184.615	A#3	230.769	D#3	155.5635
5	196	2.88	E3	167.184	G3	191.327	G3	195.918	B3	244.898	E3	164.8138
6	185	2.87	F3	177.124	G#3	202.703	G#3	207.568	C4	259.459	F3	174.6143
7	175	-0.93	F#3	187.246	A3	214.286	A3	219.429	C#4	274.286	F#3	184.9973
8	165	0.94	G3	198.594	A#3	227.273	A#3	232.727	D4	290.909	G3	195.9978
9	156	-1.96	G#3	210.051	B3	240.385	B3	246.154	D#4	307.692	G#3	207.6525
10	147	0.93	A3	222.912	C4	255.102	C4	261.224	E4	326.531	A3	220.0000
11	139	-2.21	A#3	235.741	C#4	269.784	C#4	276.259	F4	345.324	A#3	233.0820
12	131	0.42	B3	250.137	D4	286.260	D4	293.130	F#4	366.412	B3	246.9418
13	124	-4.50	C4	264.258	D#4	302.419	D#4	309.677	G4	387.097	C4	261.6255
14	117	-3.91	C#4	280.068	E4	320.513	E4	328.205	G#4	410.256	C#4	277.1825
15	110	2.89	D4	297.891	F4	340.909	F4	349.091	A4	436.364	D4	293.6650
16	104	0.00	D#4	315.077	F#4	360.577	F#4	369.231	A#4	461.538	D#4	299.6650
17	98	2.88	E4	334.367	G4	382.653	G4	391.837	B4	489.796	E4	329.6275
18	93	-6.46	F4	352.344	G#4	403.226	G#4	412.903	C5	516.129	F4	349.2285
19	87	8.99	F#4	376.644	A4	431.034	A4	441.379	C#5	551.724	F#4	369.9945
20	83	-9.52	G4	394.795	A#4	451.807	A#4	462.651	D5	578.313	G4	391.9955
21	78	-1.96	G#4	420.103	B4	480.769	B4	492.308	D#5	615.385	G#4	415.3050
22	74	-10.81	A4	442.811	C5	506.757	C5	518.919	E5	648.649	A4	440.0000
23	69	10.29	A#4	474.899	C#5	543.478	C#5	556.522	F5	695.652	A#4	466.1640
24	66	-12.74	B4	496.485	D5	568.182	D5	581.818	F#5	727.273	B4	493.8835
25	62	-4.50	C5	528.516	D#5	604.839	D#5	619.355	G5	774.194	C5	523.2510
26	58	10.95	C#5	564.966	E5	646.552	E5	662.069	G#5	827.586	C#5	554.3650
27	55	2.89	D5	595.782	F5	681.818	F5	698.182	A5	872.727	D5	587.3300
28	52	0.00	D#5	630.154	F#5	721.154	F#5	738.462	A#5	923.077	D#5	622.2540
29	49	2.88	E5	668.735	G5	765.306	G5	783.673	B5	979.592	E5	659.2550
30	46	12.26	F5	712.348	G#5	815.217	G#5	834.783	C6	1043.478	F5	698.4570
31	44	-10.79	F#5	744.727	A5	852.273	A5	872.727	C#6	1090.909	F#5	739.9890
32	41	11.47	G5	799.220	A#5	914.634	A#5	936.585	D6	1170.732	G5	783.9910
33	39	-1.96	G#5	840.205	B5	961.538	B5	984.615	D#6	1230.769	G#5	830.6100
34	37	-10.81	A5	885.622	C6	1013.514	C6	1037.838	E6	1297.297	A5	880.0000
35	35	-14.62	A#5	936.229	C#6	1071.429	C#6	1097.143	F6	1371.429	A#5	932.3280
36	33	-12.74	B5	992.970	D6	1136.364	D6	1163.636	F#6	1454.545	B5	987.7670
37	31	-4.50	C6	1057.032	D#6	1209.677	D#6	1238.710	G6	1548.387	C6	1046.5020
38	29	10.95	C#6	1129.931	E6	1293.103	E6	1324.138	G#6	1655.172	C#6	1108.7300
39	28	-28.30	D6	1170.286	F6	1339.286	F6	1371.429	A6	1714.286	D6	1174.6600
40	26	0.00	D#6	1260.308	F#6	1442.308	F#6	1476.923	A#6	1846.154	D#6	1244.5080
41	25	-32.09	E6	1310.720	G6	1500.000	G6	1536.000	B6	1920.000	E6	1318.5100
42	23	12.26	F6	1424.696	G#6	1630.435	G#6	1669.565	C7	2086.957	F6	1396.9140
43	22	-10.79	F#6	1489.455	A6	1704.545	A6	1745.455	C#7	2181.818	F#6	1479.9780
44	21	-30.25	G6	1560.381	A#6	1785.714	A#6	1828.571	D7	2285.714	G6	1567.9820
			+21.84 cent pitch error		-44.64 cent pitch error		-3.58 cent pitch error		-17.26 cent pitch error		G#6	1661.2200
											A6	1760.0000
											A#6	1864.6560
											B6	1975.5340
											C7	2093.0040
											C#7	2217.4600
											D7	2349.3200

(Note) A4 is the following note.



## SM1125 series

### Tempo

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

Table 5. Tempo range

ROM		32.768kHz system		37.5kHz system		38.4kHz system		48kHz 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	Presto	234.4
08	9		142.2	Allegro	162.8	Allegro	166.7		208.3
09	10		128.0		146.5		150.0		187.5
0A	11	Moderato	116.4		133.2		136.4		170.5
0B	12		106.7		122.1		125.0		156.3
0C	13	Andante	98.5	Moderato	112.7	Moderato	115.4	Allegro	144.2
0D	14		91.4	Andante	104.6	Andante	107.1		133.9
0E	15		85.3		97.7		100.0		125.0
0F	16	Adagio	80.0	Adagio	91.6	Adagio	93.8	Moderato	117.2
10	17		75.3		86.2		88.2		110.3
11	18		71.1		81.4		83.3		104.2
12	19		67.4		77.1		78.9		98.7
13	20	Larghetto	64.0	Adagio	73.2	Adagio	75.0	Andante	93.8
14	21		61.0		69.8		71.4		89.3
15	22		58.2		66.6		68.2		85.2
16	23	Largo	55.7	Larghetto	63.7	Larghetto	65.2	Adagio	81.5
17	24		53.3		61.0		62.5		78.1
18	25		51.2		58.6		60.0		75.0
19	26	Largo	49.2	Largo	56.3	Largo	57.7	Larghetto	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		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 =  $1536 \times \text{tempo counter frequency divider} \div \text{clock frequency}$

(Ex. 1) Tempo code = 1F (divider = 32), clock frequency = 32.768kHz (32.768kHz system)

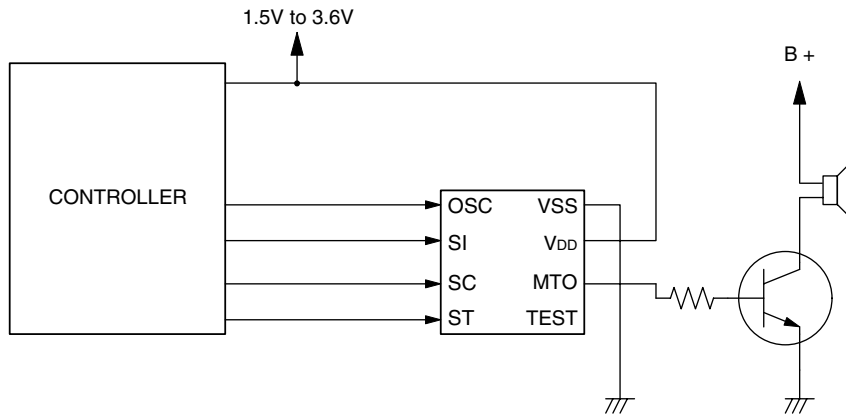
$$1536 \times 32 \div 32768 = 1.5 \text{ (seconds)}$$

(Ex. 2) Tempo code = 18 (divider = 25), CLK frequency = 153.6kHz (38.4kHz system)

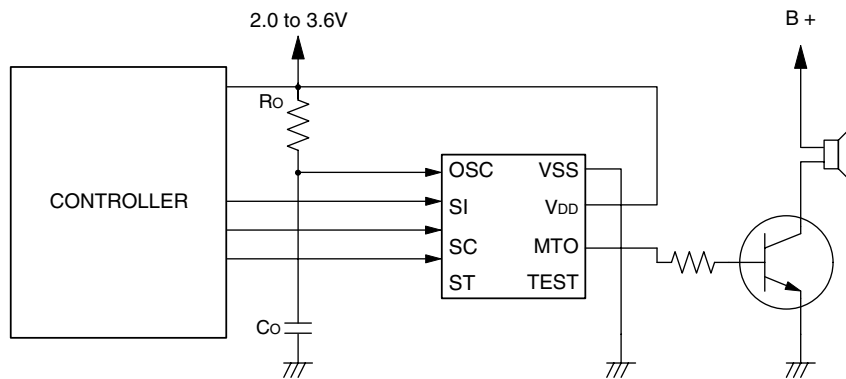
$$1536 \times 25 \div 38400 = 1.0 \text{ (seconds)}$$

## TYPICAL APPLICATION

### External Clock Input Versions



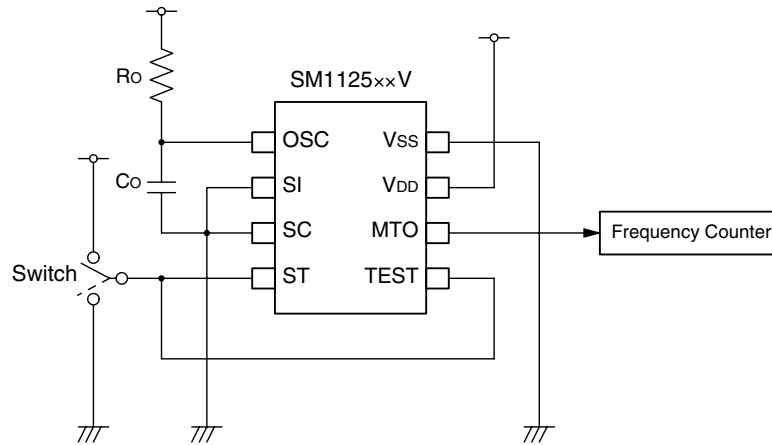
### Built-in RC Oscillator Versions



## 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  $C_O$ .

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

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