NIPPON PRECISION CIRCUITS INC.

SM5024 series

Miniature-package Crystal Oscillator Module ICs

OVERVIEW

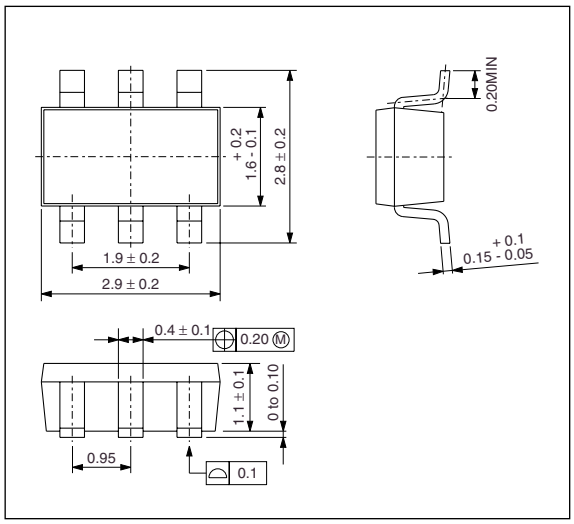
The SM5024 series are fundamental crystal oscillator module ICs. They feature an oscillator circuit with built-in capacitors with excellent frequency response and an output buffer with high output drive capability. They are available in miniature 6-pin packages, making them ideal as DIP-type crystal oscillators.

FEATURES

- Operating supply voltage range
  - 3V operation: 2.7 to 3.6V
  - 5V operation: 4.5 to 5.5V
- Up to 30MHz operating frequency range (fundamental oscillation)
- –40 to 85°C operating temperature range
- Oscillator capacitors C_G, C_D built-in
- Feedback resistor R_f built-in
- f_O, $f_O/2$, $f_O/4$, $f_O/8$ output frequency, determined by internal connection
- Output drive capability
  - 8mA (V_{DD} = 2.7V)
  - 16mA (V_{DD} = 4.5V)
- Output three-state function built-in
  High impedance outputs in standby mode
- CMOS output duty level (1/2VDD)
- Molybdenum-gate CMOS process
- Package: SOT23-6 (SM5024×××H)

PACKAGE DIMENSIONS

(Unit: mm)



APPLICATIONS

- DIP-type crystal oscillator modules

SERIES CONFIGURATION

Version	Operating Supply voltage range [V]	Recommended operating frequency range[1] [MHz]	Built-in capacitance [pF]		Output duty level	Output frequency	INHN input level	Standby mode	
			C_G	C_D				Oscillator stop function	Output state
SM5024AL1H	2.7 to 5.5	4 to 30	8	10	CMOS	f_O	TTL	Yes	Hi-Z
SM5024AL2H						$f_O/2$			
SM5024AL3H						$f_O/4$			
SM5024AL4H						$f_O/8$			

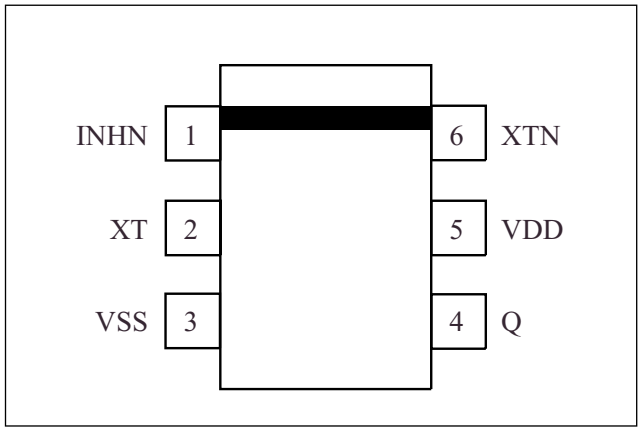
1. The recommended operating frequency is a yardstick value derived from the crystal used for NPC characteristics authentication. However, the oscillator frequency band is not guaranteed. Specifically, the characteristics can vary greatly due to crystal characteristics and mounting conditions, so the oscillation characteristics of components must be carefully evaluated.

ORDERING INFORMATION

Device	Package
SM5024×××H	SOT23-6

PINOUT

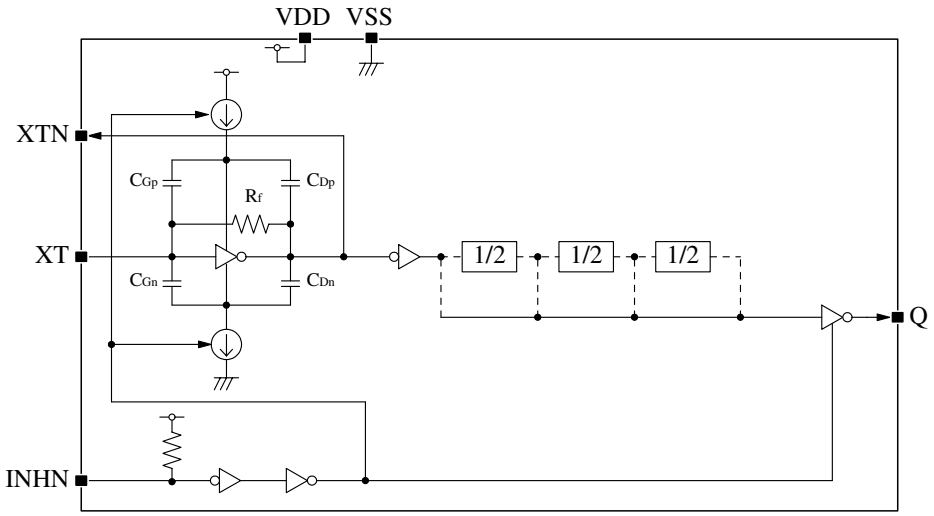
(Top view)



PIN DESCRIPTION

Name	I/O	Description	
INHN	I	Output state control input. High impedance when LOW. Pull-up resistor built-in.	
XT	I	Amplifier input	Crystal connection pins. Crystal is connected between XT and XTN.
XTN	O	Amplifier output	
VSS	–	Ground	
Q	O	Output. Output frequency (f_O, $f_O/2$, $f_O/4$, $f_O/8$) determined by internal connection	
VDD	–	Supply voltage	

BLOCK DIAGRAM



INHN = LOW active

Notes. The SM5024 series reduce crystal current by limiting driving current of oscillating-stage inverter and inhibiting oscillating amplitude. Depending on the characteristics of using crystal or the mounting condition, they may not oscillate normally. Please evaluate the oscillation start-up characteristics adequately with your actual device. When this device is used for buffer application, please pay attention to input amplitude to the XT pin. If it's low input amplitude, the SM5024 series may not operate normally.

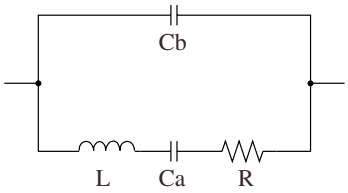
FUNCTIONAL DESCRIPTION

Standby Function

When INHN goes LOW, the oscillator stops and the oscillator output on Q becomes high impedance.

INHN	Q	Oscillator
HIGH (or open)	Any f_O, $f_O/2$, $f_O/4$, or $f_O/8$ output frequency	Normal operation
LOW	High impedance	Stopped

Current consumption and Output waveform with NPC's standard crystal



f [MHz]	R [Ω]	L [mH]	Ca [fF]	Cb [pF]
30	5.26	2.82	1.00	2.68

SPECIFICATIONS

Absolute Maximum Ratings

V_{SS} = 0V

Parameter	Symbol	Condition	Rating	Unit
Supply voltage range	V_{DD}		–0.5 to +7.0	V
Input voltage range	V_{IN}		–0.5 to V_{DD} + 0.5	V
Output voltage range	V_{OUT}		–0.5 to V_{DD} + 0.5	V
Operating temperature range	T_{opr}		–40 to +85	°C
Storage temperature range	T_{STG}		–55 to +125	°C
Output current	I_{OUT}		20	mA
Power dissipation	P_D		250	mW

Recommended Operating Conditions

3V operation

V_{SS} = 0V, f ≤ 30MHz, C_L ≤ 15pF unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
Operating supply voltage	V_{DD}		2.7	–	3.6	V
Input voltage	V_{IN}		V_{SS}	–	V_{DD}	V
Operating temperature	T_{OPR}		–20	–	+80	°C

5V operation

V_{SS} = 0V, f ≤ 30MHz, C_L ≤ 50pF unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
Operating supply voltage	V_{DD}		4.5	–	5.5	V
Input voltage	V_{IN}		V_{SS}	–	V_{DD}	V
Operating temperature	T_{OPR}		–40	–	+85	°C

Electrical Characteristics

3V operation

V_{SS} = 0V, recommended operating conditions unless otherwise noted.

Parameter	Symbol	Condition		Rating min	Rating typ	Rating max	Unit
HIGH-level output voltage	V_{OH}	Q: Measurement cct 1, V_{DD} = 2.7V, I_{OH} = 8mA		2.1	2.4	–	V
LOW-level output voltage	V_{OL}	Q: Measurement cct 2, V_{DD} = 2.7V, I_{OL} = 8mA		–	0.3	0.5	V
HIGH-level input voltage	V_{IH}	INHN		2.0	–	–	V
LOW-level input voltage	V_{IL}	INHN		–	–	0.5	V
Output leakage current	I_Z	Q: Measurement cct 2, INHN = LOW, V_{DD} = 3.6V	$V_{OH} = V_{DD}$	–	–	10	µA
			$V_{OL} = V_{SS}$	–	–	10	µA
Current consumption	I_{DD1}	Measurement cct 3, load cct 1, INHN = open, C_L = 15pF, f = 30MHz	SM5024AL1H	–	4	8	mA
			SM5024AL2H	–	2.5	5	mA
			SM5024AL3H	–	2	4	mA
			SM5024AL4H	–	1.5	3	mA
INHN pull-up resistance	R_{UP}	Measurement cct 4		25	100	250	kΩ
Feedback resistance	R_f	Measurement cct 5		200	600	1000	kΩ
Built-in capacitance	C_G	Design value. A monitor pattern on a wafer is tested.		7.44	8	8.56	pF
	C_D			9.3	10	10.7	pF

5V operation

V_{SS} = 0V, recommended operating conditions unless otherwise noted.

Parameter	Symbol	Condition		Rating min	Rating typ	Rating max	Unit
HIGH-level output voltage	V_{OH}	Q: Measurement cct 1, V_{DD} = 4.5V, I_{OH} = 16mA		3.9	4.2	–	V
LOW-level output voltage	V_{OL}	Q: Measurement cct 2, V_{DD} = 4.5V, I_{OL} = 16mA		–	0.3	0.5	V
HIGH-level input voltage	V_{IH}	INHN		2.0	–	–	V
LOW-level input voltage	V_{IL}	INHN		–	–	0.8	V
Output leakage current	I_Z	Q: Measurement cct 2, INHN = LOW, V_{DD} = 5.5V	$V_{OH} = V_{DD}$	–	–	10	µA
			$V_{OL} = V_{SS}$	–	–	10	µA
Current consumption	I_{DD2}	Measurement cct 3, load cct 1, INHN = open, C_L = 50pF, f = 30MHz	SM5024AL1H	–	13	26	mA
			SM5024AL2H	–	7	14	mA
			SM5024AL3H	–	4	8	mA
			SM5024AL4H	–	3	6	mA
INHN pull-up resistance	R_{UP}	Measurement cct 4		25	100	250	kΩ
Feedback resistance	R_f	Measurement cct 5		200	600	1000	kΩ
Built-in capacitance	C_G	Design value. A monitor pattern on a wafer is tested.		7.44	8	8.56	pF
	C_D			9.3	10	10.7	pF

Switching Characteristics

3V operation

V_{DD} = 2.7 to 3.6V, V_{SS} = 0V, Ta = –20 to +80°C unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Output rise time	t_{r1}	Measurement cct 6, load cct 1, $0.1V_{DD}$ to $0.9V_{DD}$, C_L = 15pF	–	5	10	ns
Output fall time	t_{f1}	Measurement cct 6, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$, C_L = 15pF	–	5	10	ns
Output duty cycle[1]	Duty1	Measurement cct 6, load cct 1, V_{DD} = 3.0V, Ta = 25°C, C_L = 15pF, f ≤ 30MHz	45	–	55	%
Output disable delay time[2]	t_{PLZ}	Measurement cct 6, load cct 1, V_{DD} = 3.0V, Ta = 25°C, C_L = 15pF	–	–	100	ns
Output enable delay time[2]	t_{PZL}		–	–	100	ns

1. The duty cycle characteristic is checked the sample chips of each production lot.
2. Oscillator stop function is built-in. When INHN goes LOW, normal output stops. When INHN goes HIGH, normal output is not resumed until after the oscillator start-up time has elapsed.

5V operation

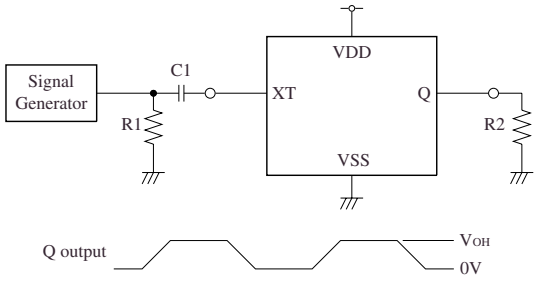
V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, Ta = –40 to +85°C unless otherwise noted.

Parameter	Symbol	Condition		Rating			Unit
				min	typ	max	
Output rise time	t_{r1}	Measurement cct 6, load cct 1, $0.1V_{DD}$ to $0.9V_{DD}$	C_L = 15pF	–	2.5	5	ns
	t_{r2}		C_L = 50pF	–	5	10	
Output fall time	t_{f1}	Measurement cct 6, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$	C_L = 15pF	–	2.5	5	ns
	t_{f2}		C_L = 50pF	–	5	10	
Output duty cycle[1]	Duty2	Measurement cct 6, load cct 1, V_{DD} = 5.0V, Ta = 25°C, C_L = 50pF, f ≤ 30MHz		45	–	55	%
Output disable delay time[2]	t_{PLZ}	Measurement cct 6, load cct 1, V_{DD} = 5.0V, Ta = 25°C, C_L = 15pF		–	–	100	ns
Output enable delay time[2]	t_{PZL}			–	–	100	ns

1. The duty cycle characteristic is checked the sample chips of each production lot.
2. Oscillator stop function is built-in. When INHN goes LOW, normal output stops. When INHN goes HIGH, normal output is not resumed until after the oscillator start-up time has elapsed.

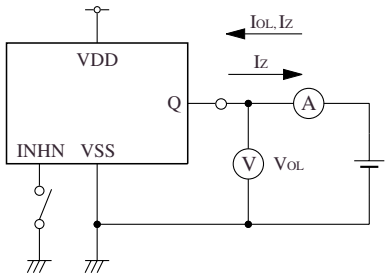
MEASUREMENT CIRCUITS

Measurement cct 1

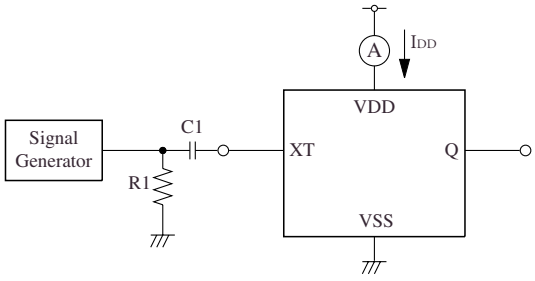


2.0Vp-p, 10MHz sine wave input signal (3V operation)
3.5Vp-p, 10MHz sine wave input signal (5V operation)
C1: 0.001µF
R1: 50Ω
R2: 263Ω (3V operation)
244Ω (5V operation)

Measurement cct 2

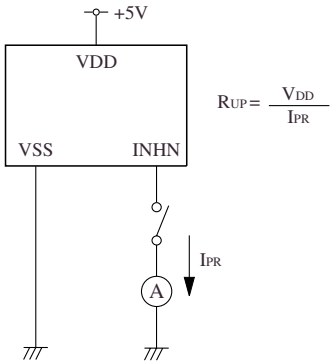


Measurement cct 3

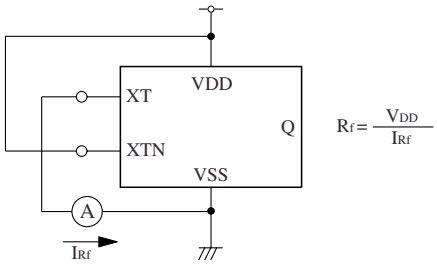


2.0Vp-p, 30MHz sine wave input signal (3V operation)
3.5Vp-p, 30MHz sine wave input signal (5V operation)
C1: 0.001µF
R1: 50Ω

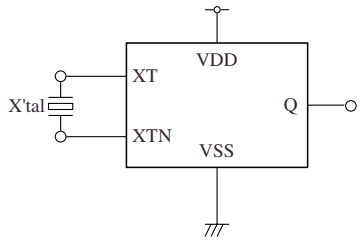
Measurement cct 4



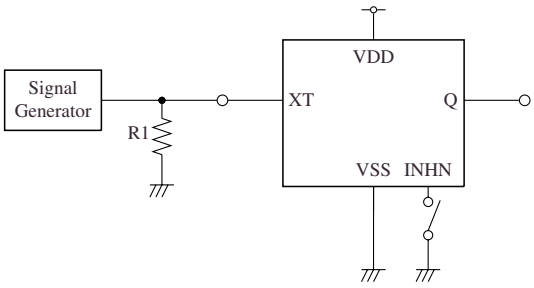
Measurement cct 5



Measurement cct 6

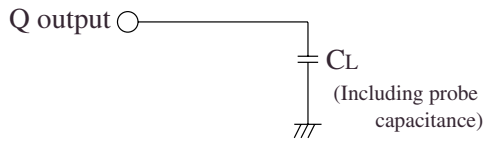


Measurement cct 7



R1: 50Ω

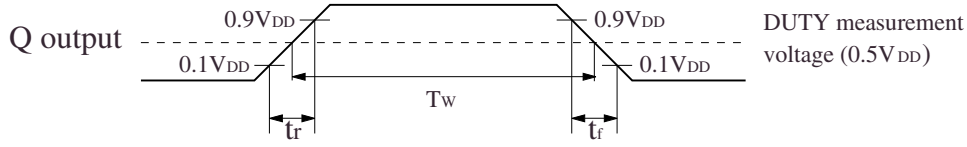
Load cct 1



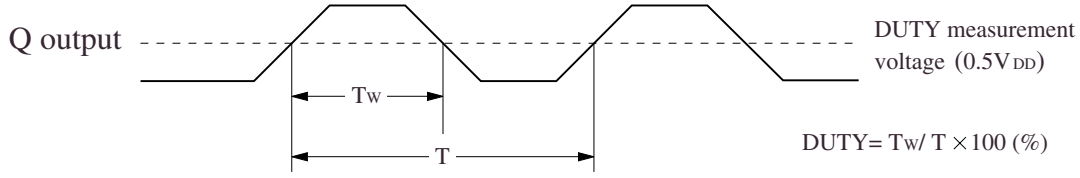
C_L = 15pF: t_{r1}, t_{f1}, Duty1, I_{DD1}
C_L = 50pF: t_{r2}, t_{f2}, Duty2, I_{DD2}

Switching Time Measurement Waveform

Output duty level, t_r, t_f

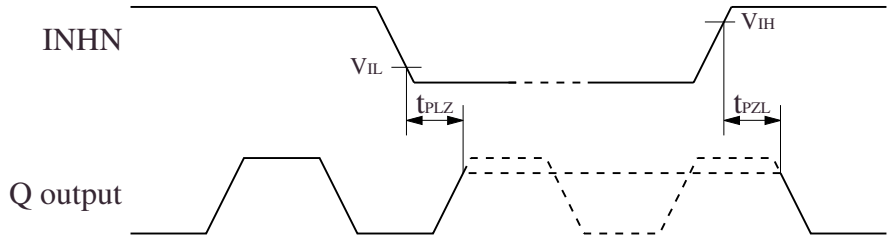


Output duty cycle



Output Enable/Disable Delay

When the device is in standby, the oscillator stops. When standby is released, the oscillator starts and stable oscillator output occurs after a short delay.



INHN input waveform tr = tf ≤ 10ns

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