SM5023 series

Miniature-package Crystal Oscillator Module ICs

OVERVIEW

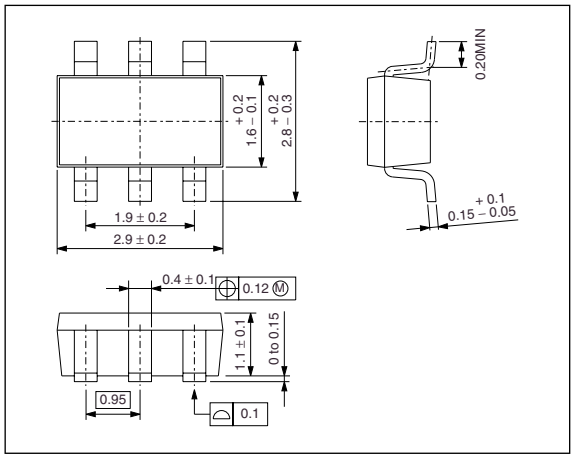
The SM5023 series are 3rd overtone crystal oscillator module ICs. They feature built-in oscillator capacitors with excellent frequency response. As cutoff frequency can be configured by using an external feedback resistor R_{fo}, a favorable 3rd overtone oscillation can be realized with a few external components. The oscillator circuit characteristics are optimized for a 3rd overtone oscillation by round blank. They also feature a built-in output buffer with high output drive capability and are available in miniature 6-pin package, 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
- 4MHz to 70MHz operating frequency range (Oscillation frequency is settable by external components)
- –40 to 85°C operating temperature range
- Oscillator capacitors C_G, C_D built-in (BN×H version only)
- Cutoff frequency setting using external feedback resistor R_{fo}
- Output drive capability
  - 8mA (V_{DD} = 2.7V)
  - 16mA (V_{DD} = 4.5V)
- Output three-state function built-in
  - High impedance output in standby mode
- CMOS output duty level (1/2VDD)
- Molybdenum-gate CMOS process
- Package: SOT23-6 (SM5023×××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]	Oscillator circuit constants				Output duty level	Standby mode	
			gm ratio	Built-in capacitance		Rf [kΩ]		Oscillator	Output state
				C_G [pF]	C_D [pF]				
SM5023BNDH	2.7 to 3.6	22 to 70	3	8	15	–	CMOS	Operation	Hi-Z
	4.5 to 5.5								
SM5023BNEH	2.7 to 3.6	50 to 70	4	8	12	–	CMOS	Operation	Hi-Z
SM5023CNDH	2.7 to 3.6	4 to 70	3	–	–	–	CMOS	Operation	Hi-Z
	4.5 to 5.5								

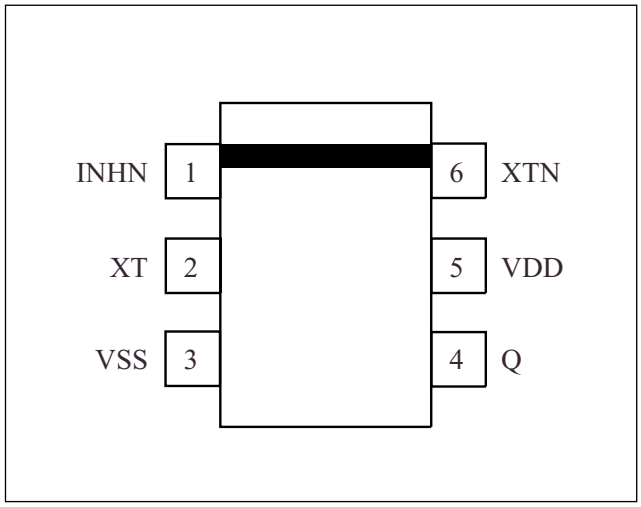
1. The 3rd overtone frequency range using an external resistor to set the cutoff frequency. The recommended operating frequency is a yardstick value derived from the crystal used for NPC characteristics authentication. However, the oscillator frequency band is not guaranteed. Specifically, the characteristics can vary greatly due to crystal characteristics and mounting conditions, so the oscillation characteristics of components must be carefully evaluated.

ORDERING INFORMATION

Device	Package
SM5023×××H	SOT23-6

PINOUT

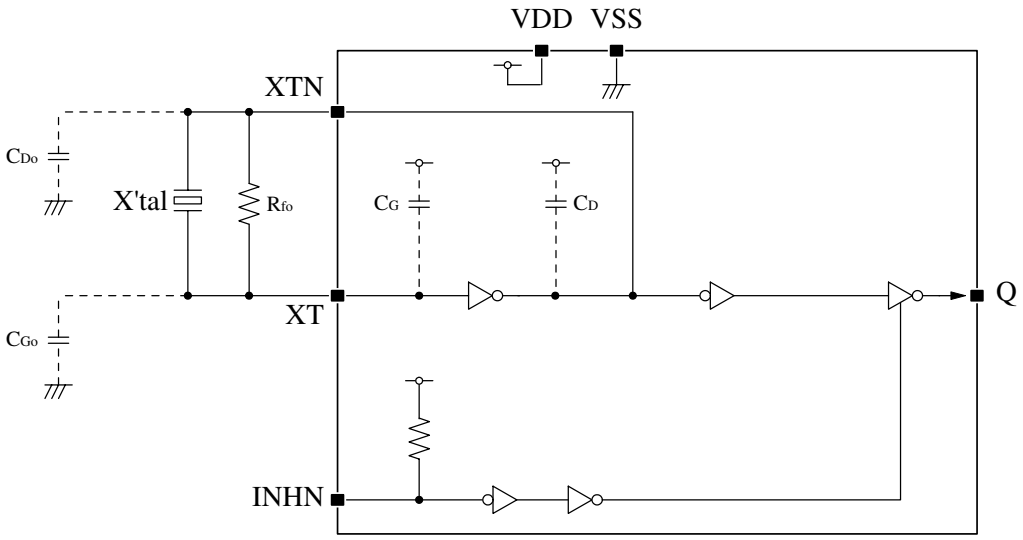
(Top view)



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. f_O (XT pin input frequency)	
VDD	–	Supply voltage	

BLOCK DIAGRAM



INHN = LOW active

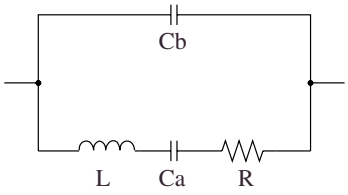
FUNCTIONAL DESCRIPTION

Standby Function

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

INHN	Q	Oscillator
HIGH (or open)	f_O	Normal operation
LOW	High impedance	Normal operation

Current consumption and Output waveform with NPC's standard crystal



f [MHz]	R [Ω]	L [mH]	Ca [fF]	Cb [pF]
30	18.62	16.24	1.733	5.337
40	20.53	11.34	1.396	3.989
50	22.17	7.40	1.370	4.105
60	22.20	5.05	1.388	4.226
70	25.42	4.18	1.254	5.170

SPECIFICATIONS

Absolute Maximum Ratings

V_{SS} = 0V

Parameter	Symbol	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: SM5023BNDH, BNEH, CNDH

V_{SS} = 0V, f ≤ 70MHz, C_L ≤ 15pF unless otherwise noted.

Parameter	Symbol	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: SM5023BNDH, CNDH

V_{SS} = 0V, f ≤ 50MHz, C_L ≤ 50pF unless otherwise noted.
V_{SS} = 0V, f ≤ 70MHz, C_L ≤ 15pF unless otherwise noted.

Parameter	Symbol	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: SM5023BNDH, BNEH, CNDH

V_{DD} = 2.7 to 3.6V, V_{SS} = 0V, Ta = –20 to +80°C 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} = 3.3V	$V_{OH} = V_{DD}$	–	–	10	µA
			$V_{OL} = V_{SS}$	–	–	10	µA
Current consumption	I_{DD}	Measurement cct 3, load cct 1, INHN = open, C_L = 15pF, f = 70MHz		–	15	30	mA
INHN pull-up resistance	R_{UP}	Measurement cct 4		25	100	250	kΩ
Built-in capacitance	C_G	Design value. A monitor pattern on a wafer is tested.	SM5023BNDH SM5023BNEH	7.44	8	8.56	pF
	C_D	Design value. A monitor pattern on a wafer is tested.	SM5023BNDH	13.95	15	16.05	pF
			SM5023BNEH	11.16	12	12.84	pF

5V operation: SM5023BNDH, CNDH

V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, Ta = –40 to +85°C 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_{DD1}	Measurement cct 3, load cct 1, INHN = open	C_L = 15pF f = 70MHz	–	20	40	mA
	I_{DD2}		C_L = 50pF f = 50MHz	–	25	50	mA
INHN pull-up resistance	R_{UP}	Measurement cct 4		25	100	250	kΩ
Built-in capacitance	C_G	Design value. A monitor pattern on a wafer is tested.	SM5023BNDH	7.44	8	8.56	pF
	C_D	Design value. A monitor pattern on a wafer is tested.	SM5023BNDH	13.95	15	16.05	pF

Switching Characteristics

3V operation: SM5023BNDH, BNEH, CNDH

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 5, load cct 1, $0.1V_{DD}$ to $0.9V_{DD}$, C_L = 15pF	–	2.5	5	ns
Output fall time	t_{f1}	Measurement cct 5, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$, C_L = 15pF	–	2.5	5	ns
Output duty cycle[1]	Duty1	Measurement cct 5, load cct 1, V_{DD} = 3.0V, Ta = 25°C, C_L = 15pF, f ≤ 70MHz	45	–	55	%
Output disable delay time	t_{PLZ}	Measurement cct 5, load cct 1, V_{DD} = 3.0V, Ta = 25°C, C_L = 15pF	–	–	100	ns
Output enable delay time	t_{PZL}		–	–	100	ns

1. The duty cycle characteristic is checked the sample chips of each production lot.

5V operation: SM5023BNDH, CNDH

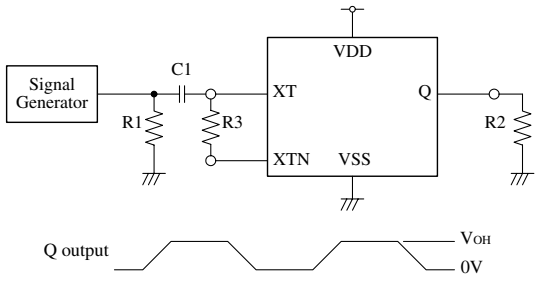
V_{DD} = 4.5 to 5.5V, V_{SS} = 0V, Ta = –40 to +85°C unless otherwise noted.

Parameter	Symbol	Condition		Rating			Unit
				min	typ	max	
Output rise time	t_{r1}	Measurement cct 5, load cct 1, $0.1V_{DD}$ to $0.9V_{DD}$	C_L = 15pF	–	1.5	3	ns
	t_{r2}		C_L = 50pF	–	3	6	
Output fall time	t_{f1}	Measurement cct 5, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$	C_L = 15pF	–	1.5	3	ns
	t_{f2}		C_L = 50pF	–	3	6	
Output duty cycle[1]	Duty1	Measurement cct 5, load cct 1, V_{DD} = 5.0V, Ta = 25°C	C_L = 15pF f ≤ 70MHz	45	–	55	%
	Duty2		C_L = 50pF f ≤ 50MHz	45	–	55	%
Output disable delay time	t_{PLZ}	Measurement cct 5, load cct 1, V_{DD} = 5.0V, Ta = 25°C, C_L = 15pF		–	–	100	ns
Output enable delay time	t_{PZL}			–	–	100	ns

1. The duty cycle characteristic is checked the sample chips of each production lot.

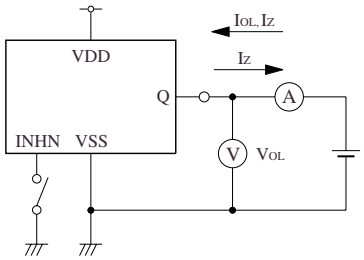
MEASUREMENT CIRCUITS

Measurement cct 1

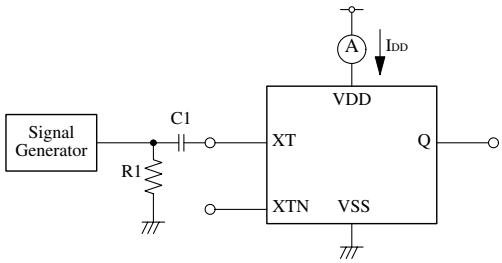


2.0Vp-p, 10MHz sine wave input signal (3V operation)
3.5Vp-p, 10MHz sine wave input signal (5V operation)
C1: 0.001µF
R1: 50Ω
R2: 263Ω (3V operation)
244Ω (5V operation)
R3: 100kΩ

Measurement cct 2

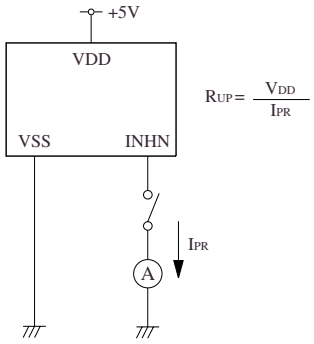


Measurement cct 3

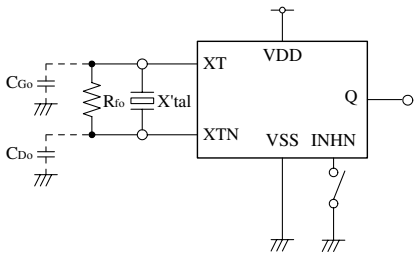


2.0Vp-p, 70MHz sine wave input signal (3V operation)
3.5Vp-p, 70MHz sine wave input signal (5V operation)
C1: 0.001µF
R1: 50Ω

Measurement cct 4

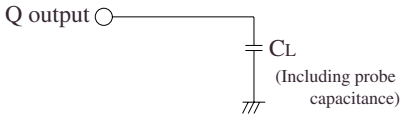


Measurement cct 5



Crystal oscillation
R_{fo}: 1.5kΩ (3V, 70MHz operation)
3.9kΩ (5V, 70MHz operation)
5.6kΩ (5V, 50MHz operation)
SM5023CNDH: C_{Go} = 8pF, C_{Do} = 15pF

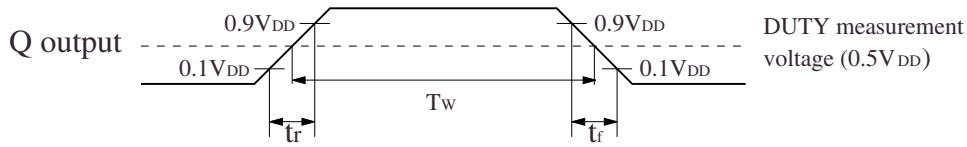
Load cct 1



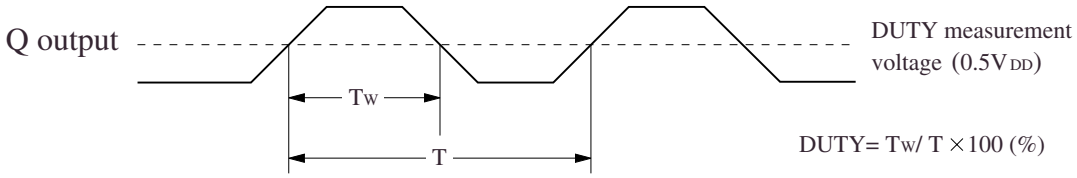
C_L = 15pF: t_{r1}, t_{f1}, Duty1, I_{DD1}
C_L = 50pF: t_{r2}, t_{f2}, Duty2, I_{DD2}

Switching Time Measurement Waveform

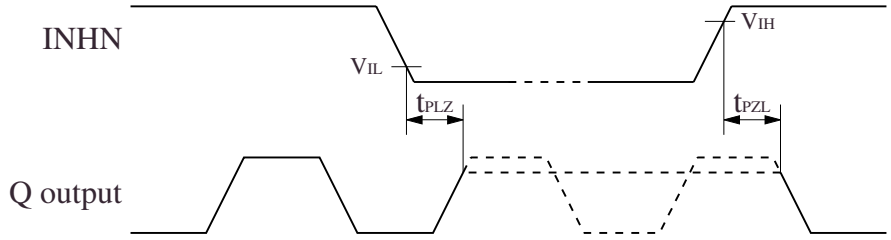
Output duty level, t_r, t_f



Output duty cycle



Output Enable/Disable Delay



INHN input waveform $t_r = t_f \leq 10ns$

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