

## OVERVIEW

The SM5002L series crystal oscillator module ICs fabricated in NPC's Molybdenum-gate CMOS. They comprise low-voltage low-current consumption oscillator circuits and output buffers. They incorporate built-in oscillation capacitance with superior frequency response to realize stable 3rd overtone oscillation without any external components.

## FEATURES

- Oscillation frequency up to 100 MHz
- Third harmonic
- Capacitors  $C_G$  and  $C_D$  built-in
- Standby function (oscillator stops)
- 3  $\mu$ A (typ) low standby current
- Inverter amplifier feedback resistance built-in
- $\overline{\text{INH}}$  pin pull-up resistance built-in
  - $\overline{\text{INH}} = \text{L}$  : 2M $\Omega$  typ
  - $\overline{\text{INH}} = \text{H}$  : 90k $\Omega$  typ
- CMOS input level
- 8 mA ( $V_{DD} = 3.0$  V) output drive capability
- CMOS output duty level
- Output three-state function
- 2.7 to 3.6 V supply voltage
- Oscillator frequency output
- 8-pin SOP (SM5002L $\times$ S)
- Chip form (CF5002L $\times$ )

## SERIES CONFIGURATION

Version	Recommended operating frequency range (MHz)	$g_m$ (relative value)	Built-in capacitance		$R_{f1}$ (k $\Omega$ )	$C_f$ (pF)	Output duty level	Output current (mA)	Standby function
			$C_G$ (pF)	$C_D$ (pF)					
CF5002LA SM5002LAS	30 to 40	1.0	8	15	5.6	22	CMOS	8	Yes
CF5002LB SM5002LBS	40 to 50	1.5	8	15	4.7	22	CMOS	8	Yes
CF5002LC SM5002LCS	50 to 70	1.5	8	10	3.9	22	CMOS	8	Yes
CF5002LD SM5002LDS	70 to 90	2.0	8	10	3.9	22	CMOS	8	Yes
CF5002LE SM5002LES	85 to 100	2.0	8	10	2.7	22	CMOS	8	Yes
CF5002LF SM5002LFS	25 to 30	1.0	10	15	8.5	22	CMOS	8	Yes

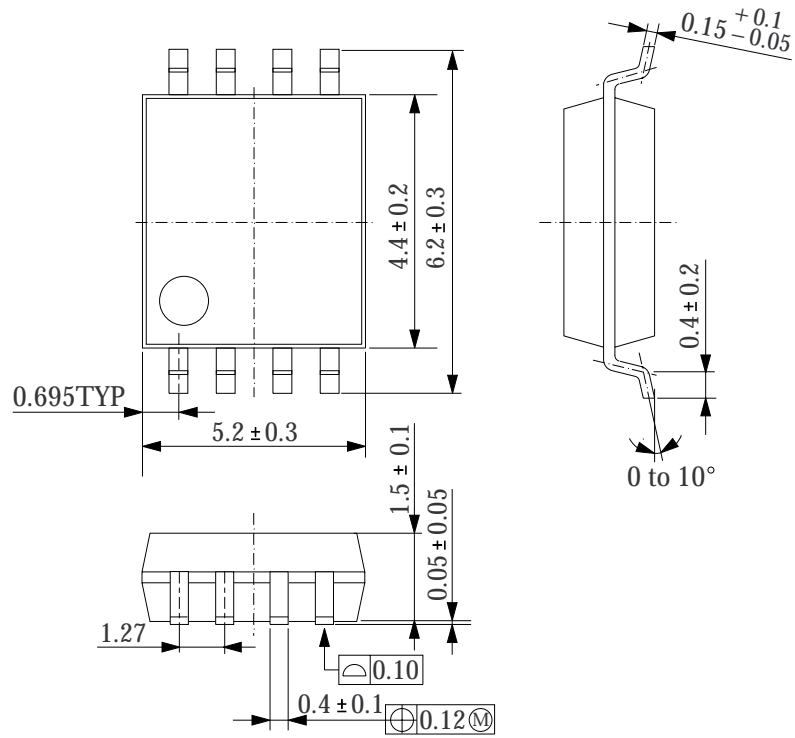
## ORDERING INFORMATION

Device	Package
SM5002L $\times$ S	8-pin SOP
CF5002L $\times$	Chip form

**PACKAGE DIMENSIONS**

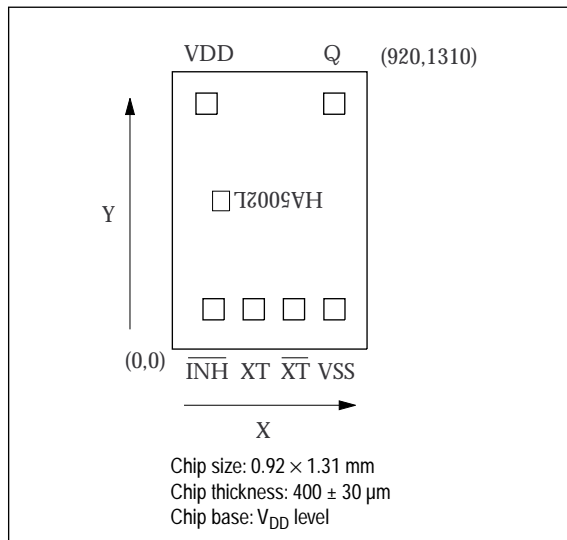
(UNIT : mm)

- 8-pin SOP



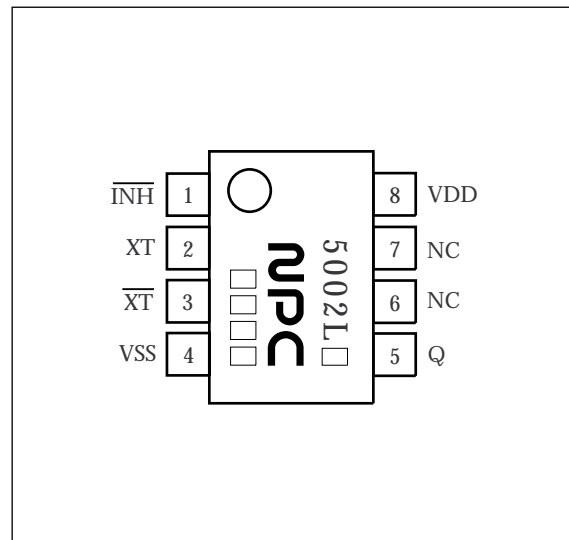
**PAD LAYOUT**

(Unit :  $\mu\text{m}$ )



**PINOUT**

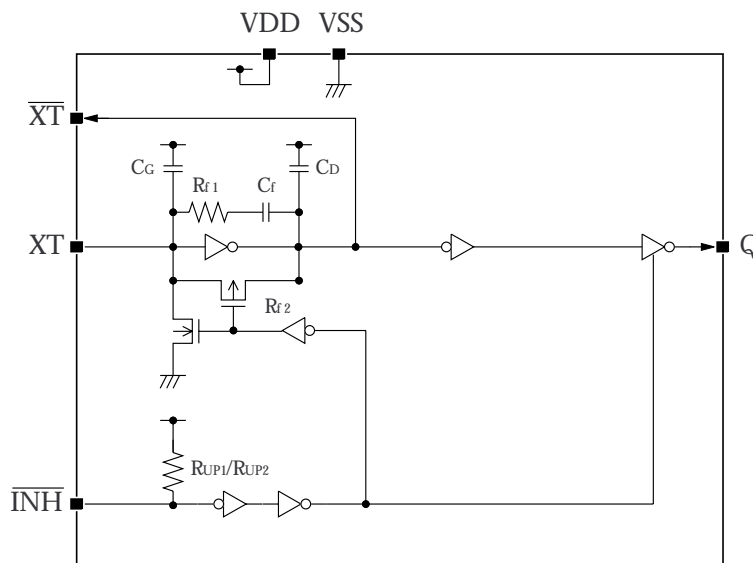
(Top View)



**PIN DESCRIPTION and PAD DIMENSIONS**

Number	Name	I/O	Description	Pad dimensions [ $\mu\text{m}$ ]	
				X	Y
1	$\overline{\text{INH}}$	I	Output state control input. Oscillator stopped when LOW. Power-saving pull-up resistor built in	195	188
2	XT	I	Amplifier input.	385	188
3	$\overline{\text{XT}}$	O	Amplifier output.	575	188
4	VSS	-	Ground	766	188
5	Q	O	Output. Output frequency. High impedance at standby operation	765	1159
6	NC	-	No connection	-	-
7	NC	-	No connection	-	-
8	VDD	-	Supply voltage	162	1159

**BLOCK DIAGRAM**



## SPECIFICATIONS

### Absolute Maximum Ratings

$V_{SS} = 0$  V unless otherwise noted.

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	$T_{stg1}$	Chip form	-65 to 150	°C
	$T_{stg2}$	8-pin SOP	-40 to 125	
Output current	$I_{OUT}$		25	mA
Power dissipation	$P_D$	$T_a \leq 85^\circ\text{C}$ , 8-pin SOP	200	mW
Soldering temperature	$T_{sld}$	8-pin SOP	255	°C
Soldering time	$t_{sld}$	8-pin SOP	10	s

### Recommended Operating Conditions

#### CF5002L× series (Chip form)

$V_{SS} = 0$  V unless otherwise noted.

Parameter	Symbol	Conditions	Limits			Units
			min	typ	max	
Supply voltage	$V_{DD}$	$C_L \leq 15\text{pF}$ , $f \leq 70$ MHz	2.7	-	3.6	V
		$C_L \leq 15\text{pF}$ , $70 < f \leq 100$ MHz	3.0	-	3.6	V
		$C_L \leq 30\text{pF}$ , $f \leq 70$ MHz	3.0	-	3.6	V
Input voltage	$V_{IN}$		$V_{SS}$	-	$V_{DD}$	V
Operating temperature	$T_{OPR}$		-20	-	80	°C

#### SM5002L×S series (8-pin SOP)

$V_{SS} = 0$  V unless otherwise noted.

Parameter	Symbol	Conditions	Limits			Units
			min	typ	max	
Supply voltage	$V_{DD}$	$C_L \leq 15\text{pF}$ , $f \leq 50$ MHz	2.7	-	3.6	V
		$C_L \leq 15\text{pF}$ , $50 < f \leq 70$ MHz	3.0	-	3.6	V
		$C_L \leq 30\text{pF}$ , $f \leq 50$ MHz	3.0	-	3.6	V
Input voltage	$V_{IN}$		$V_{SS}$	-	$V_{DD}$	V
Operating temperature	$T_{OPR}$		-20	-	80	°C

SM5002L series

**Electrical Characteristics**

$V_{DD} = 2.7$  to  $3.6$  V,  $V_{SS} = 0$  V,  $T_a = -20$  to  $80$  °C, unless otherwise noted.

Parameter	Symbol	Conditions	Limits			Units	
			min	typ	max		
HIGH-level output voltage	$V_{OH}$	Q: Measurement cct 1, $V_{DD} = 2.7$ V, $I_{OH} = 8$ mA	2.2	2.4	–	V	
LOW-level output voltage	$V_{OL}$	Q: Measurement cct 2, $V_{DD} = 2.7$ V, $I_{OL} = 8$ mA	–	0.3	0.4	V	
Output leakage current	$I_z$	Q: Measurement cct 2, $V_{OH} = V_{DD}$ $\overline{INH} = \text{LOW}$ , $V_{DD} = 3.6$ V	–	–	10	$\mu$ A	
		$V_{OL} = V_{SS}$	–	–	10	$\mu$ A	
HIGH-level input voltage	$V_{IH}$	$\overline{INH}$ pin	$0.7V_{DD}$	–	–	V	
LOW-level input voltage	$V_{IL}$	$\overline{INH}$ pin	–	–	$0.3V_{DD}$	V	
Current consumption	$I_{DD}$	$\overline{INH} = \text{open}$ , Measurement cct 3, load cct 1, $V_{DD} = 3.0$ to $3.6$ V	SM5002LAS, SM5002LFS CF5002LA, CF5002LF $C_L = 30$ pF, $f = 30$ MHz	–	10	18	mA
			SM5002LBS, CF5002LB $C_L = 30$ pF, $f = 50$ MHz	–	15	25	mA
			SM5002LCS, CF5002LC $C_L = 30$ pF, $f = 70$ MHz	–	20	35	mA
			SM5002LDS, SM5002LES CF5002LD, CF5002LE $C_L = 15$ pF, $f = 100$ MHz	–	25	45	mA
Standby current	$I_{ST}$	$\overline{INH} = \text{LOW}$ , Measurement cct 3	–	3	10	$\mu$ A	
$\overline{INH}$ pull-up resistance	$R_{UP1}$	Measurement cct 4, $\overline{INH} = \text{LOW}$	0.4	–	4	M $\Omega$	
	$R_{UP2}$	Measurement cct 4, $\overline{INH} = 0.7V_{DD}$	50	–	150	k $\Omega$	
AC feedback resistance	$R_{f1}$	Design value, determined by the internal wafer pattern	SM5002LAS, CF5002LA	4.7	5.6	6.5	k $\Omega$
			SM5002LBS, CF5002LB	4.0	4.7	5.4	k $\Omega$
			SM5002LCS, SM5002LDS CF5002LC, CF5002LD	3.3	3.9	4.5	k $\Omega$
			SM5002LES, CF5002LE	2.2	2.7	3.2	k $\Omega$
			SM5002LFS, CF5002LF	7.2	8.5	9.8	k $\Omega$
DC feedback resistance	$R_{f2}$	Measurement cct 5	50	–	150	k $\Omega$	
AC feedback capacitance	$C_f$	Design value, determined by the internal wafer pattern	19.8	22	24.2	pF	
Built-in capacitance	$C_G$	Design value, determined by the internal wafer pattern	SM5002LAS, CF5002LA SM5002LBS, CF5002LB SM5002LCS, CF5002LC SM5002LDS, CF5002LD SM5002LES, CF5002LE	7.2	8	8.8	pF
			SM5002LFS, CF5002LF	9	10	11	pF
	$C_D$		SM5002LAS, CF5002LA SM5002LBS, CF5002LB SM5002LFS, CF5002LF	13.5	15	16.5	pF
			SM5002LCS, CF5002LC SM5002LDS, CF5002LD SM5002LES, CF5002LE	9	10	11	pF

### Switching Characteristics

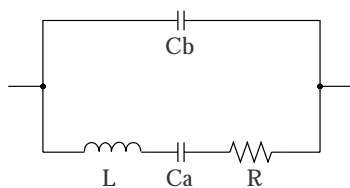
$V_{SS} = 0\text{ V}$ ,  $T_a = -20\text{ to }80\text{ }^\circ\text{C}$  unless otherwise noted.

Parameter	Symbol	Conditions	Limits			Units	
			min	typ	max		
Output rise time	$t_{r1}$	Measurement cct 3, load cct 1, $0.1V_{DD} \rightarrow 0.9V_{DD}$	$V_{DD} = 2.7\text{ to }3.6\text{ V}$ , $C_L = 15\text{ pF}$	-	2	4	ns
	$t_{r2}$		$V_{DD} = 3.0\text{ to }3.6\text{ V}$ , $C_L = 30\text{ pF}$	-	2.5	5	ns
Output fall time	$t_{f1}$	Measurement cct 3, load cct 1, $0.9V_{DD} \rightarrow 0.1V_{DD}$	$V_{DD} = 2.7\text{ to }3.6\text{ V}$ , $C_L = 15\text{ pF}$	-	2	4	ns
	$t_{f2}$		$V_{DD} = 3.0\text{ to }3.6\text{ V}$ , $C_L = 30\text{ pF}$	-	2.5	5	ns
Output duty cycle <sup>1</sup>	DUTY	Measurement cct 3, load cct 1, $T_a = 25\text{ }^\circ\text{C}$ , $V_{DD} = 3.0\text{ V}$	SM5002LAS, SM5002LFS CF5002LA, CF5002LF $C_L = 30\text{ pF}$ , $f = 30\text{ MHz}$	45	-	55	%
			SM5002LBS, CF5002LB $C_L = 30\text{ pF}$ , $f = 50\text{ MHz}$	45	-	55	%
			SM5002LCS, CF5002LC $C_L = 30\text{ pF}$ , $f = 70\text{ MHz}$	45	-	55	%
			SM5002LDS, SM5002LES $C_L = 15\text{ pF}$ , $f = 100\text{ MHz}$	40	-	60	%
			CF5002LD, CF5002LE $C_L = 15\text{ pF}$ , $f = 100\text{ MHz}$	45	-	55	%
Output disable delay time <sup>2</sup>	$t_{PLZ}$	Measurement cct 6, $T_a = 25\text{ }^\circ\text{C}$ , $V_{DD} = 2.7\text{ V}$ , load $C_L \leq 15\text{ pF}$	-	-	100	ns	
Output enable delay time <sup>2</sup>	$t_{PZL}$		-	-	100	ns	

1. Monitored in sample lots.

2. Oscillator stop function is built-in. When  $\overline{\text{INH}}$  goes LOW, normal output stops. When  $\overline{\text{INH}}$  goes HIGH, normal output is not resumed until after the oscillator start-up time has elapsed.

### Current consumption and Output waveform with NPC's standard crystal



f (MHz)	R ( $\Omega$ )	L (mH)	Ca (fF)	Cb (pF)
30	18.62	16.24	1.733	5.337
50	22.17	7.40	1.370	4.105
70	25.42	4.18	1.254	5.170
100	16.60	3.56	0.726	5.394

## FUNCTIONAL DESCRIPTION

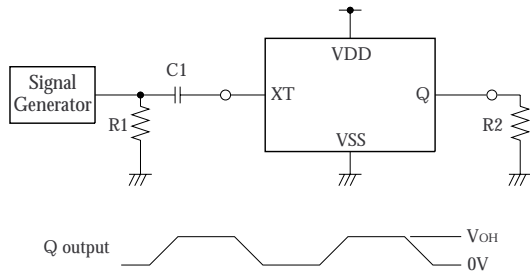
### Standby Function

The oscillator stops when  $\overline{\text{INH}}$  goes LOW. When the oscillator stops, the oscillator output on Q goes high impedance.

$\overline{\text{INH}}$	Q	Oscillator
HIGH (or open)	$f_O$ output frequency	Normal operation
LOW	High impedance	Stopped

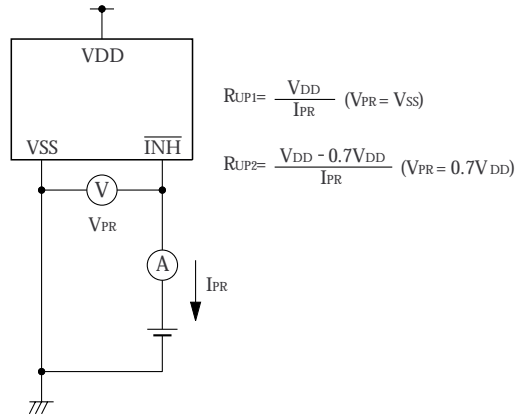
**MEASUREMENT CIRCUITS**

**Measurement cct 1**

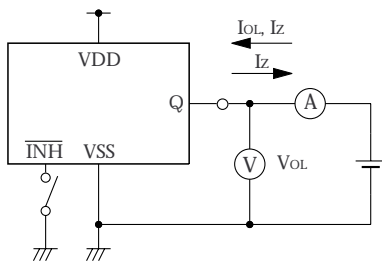


2.5V<sub>p-p</sub>, 10MHz sine wave input signal  
 C1 : 0.001μF  
 R1 : 50Ω  
 R2 : 275Ω

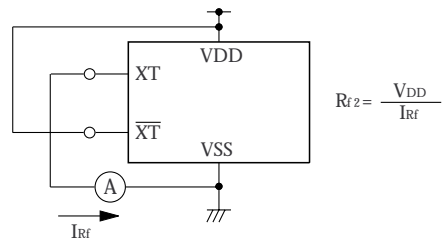
**Measurement cct 4**



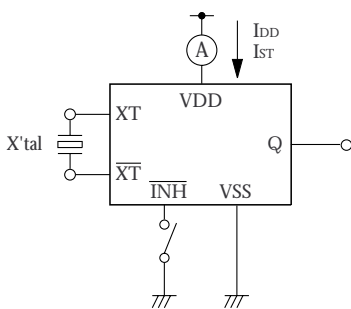
**Measurement cct 2**



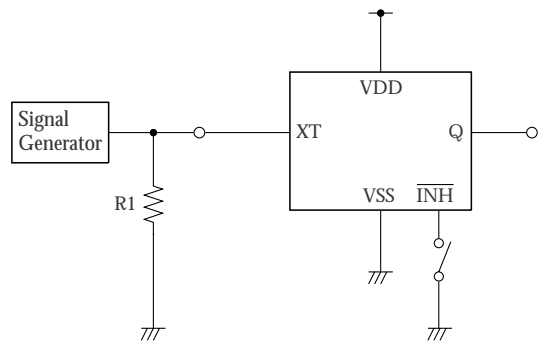
**Measurement cct 5**



**Measurement cct 3**

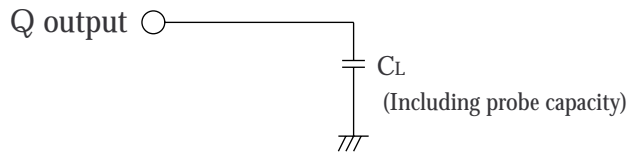


**Measurement cct 6**



R1 : 50Ω

**Load cct 1**

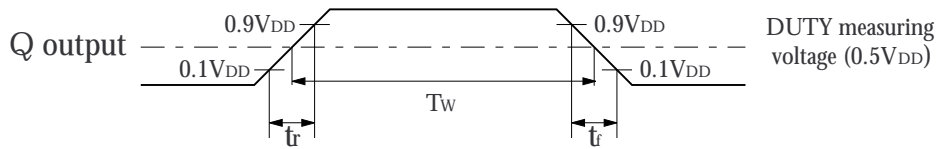


$$C_L = 15\text{pF} : t_{r1}, t_{f1} / \text{DUTY}, I_{DD} \quad (70\text{MHz} < f \leq 100\text{MHz})$$

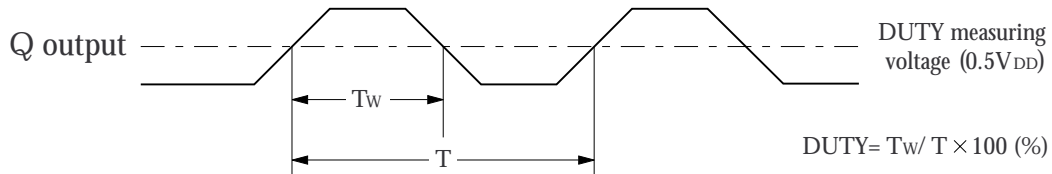
$$C_L = 30\text{pF} : t_{r2}, t_{f2} / \text{DUTY}, I_{DD} \quad (f \leq 70\text{MHz})$$

**Switching Time Measurement Waveform**

**Output duty level (CMOS)**

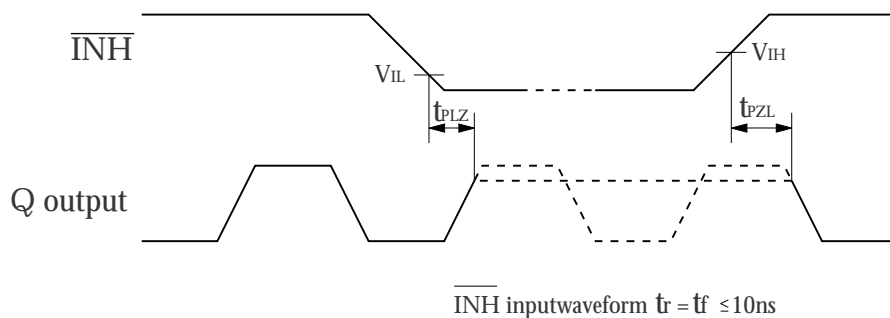


**Output duty cycle (CMOS)**



**Output Enable/Disable Delay**

The following figure shows the oscillator timing during normal operation. Note that 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.





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