

## 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<br>SM5002LAS | 30 to 40                                    | 1.0                    | 8                    | 15         | 5.6                    | 22         | CMOS              | 8                   | Yes              |
| CF5002LB<br>SM5002LBS | 40 to 50                                    | 1.5                    | 8                    | 15         | 4.7                    | 22         | CMOS              | 8                   | Yes              |
| CF5002LC<br>SM5002LCS | 50 to 70                                    | 1.5                    | 8                    | 10         | 3.9                    | 22         | CMOS              | 8                   | Yes              |
| CF5002LD<br>SM5002LDS | 70 to 90                                    | 2.0                    | 8                    | 10         | 3.9                    | 22         | CMOS              | 8                   | Yes              |
| CF5002LE<br>SM5002LES | 85 to 100                                   | 2.0                    | 8                    | 10         | 2.7                    | 22         | CMOS              | 8                   | Yes              |
| CF5002LF<br>SM5002LFS | 25 to 30                                    | 1.0                    | 10                   | 15         | 8.5                    | 22         | CMOS              | 8                   | Yes              |

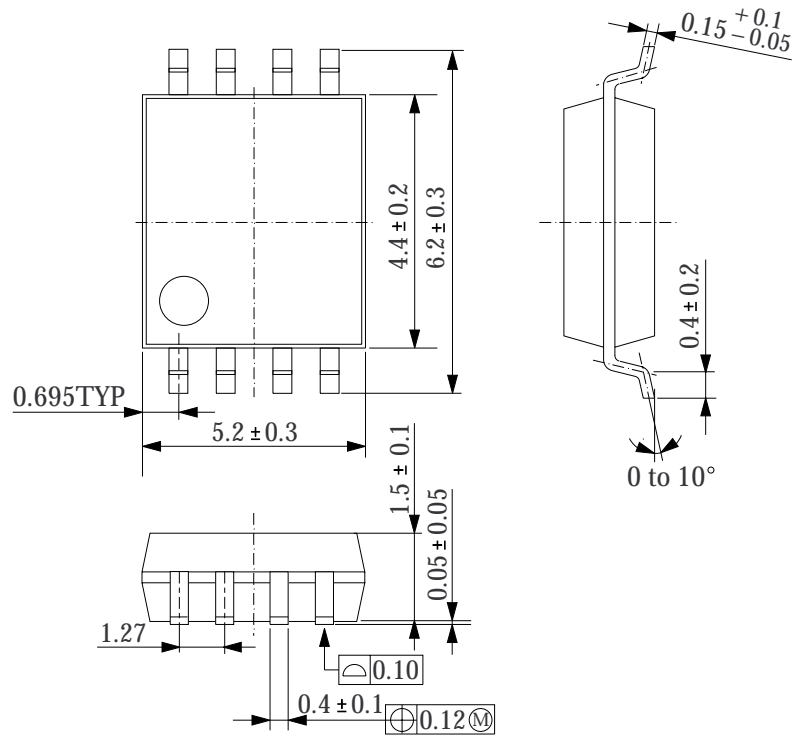
## ORDERING INFORMATION

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

**PACKAGE DIMENSIONS**

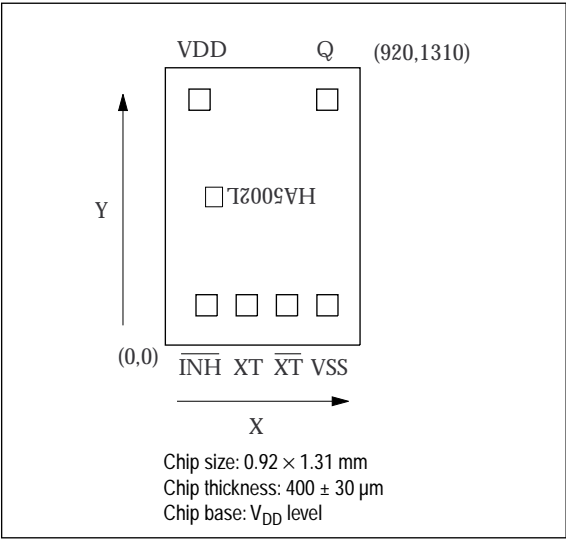
(UNIT : mm)

- 8-pin SOP



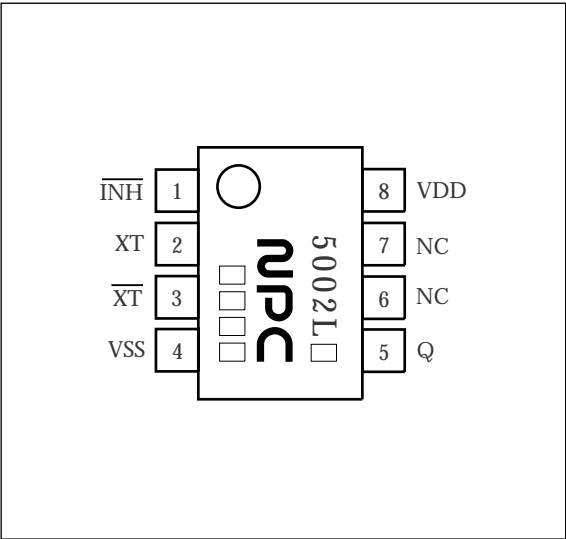
PAD LAYOUT

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



PINOUT

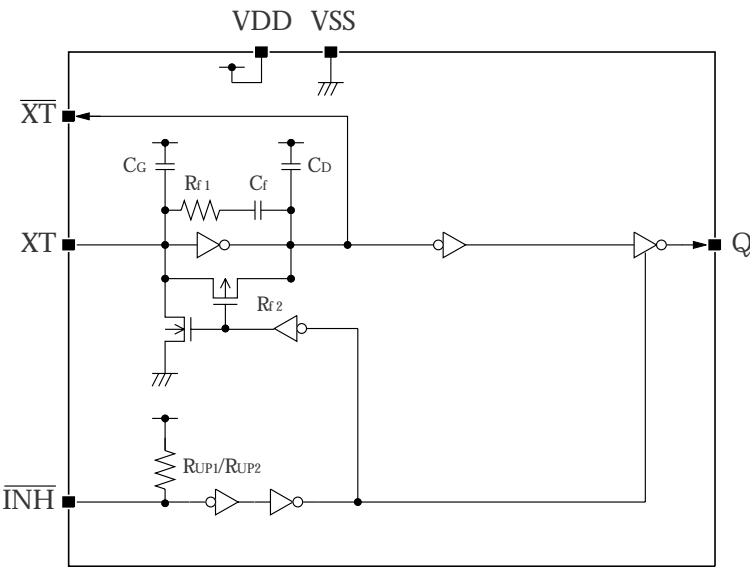
(Top View)



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    |

## 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 <sub>OH</sub>  | Q: Measurement cct 1, V <sub>DD</sub> = 2.7 V, I <sub>OH</sub> = 8 mA                         |   | 2.2                | 2.4 | –                  | V     |
| LOW-level output voltage                   | V <sub>OL</sub>  | Q: Measurement cct 2, V <sub>DD</sub> = 2.7 V, I <sub>OL</sub> = 8 mA                         |   | –                  | 0.3 | 0.4                | V     |
| Output leakage current                     | I <sub>Z</sub>   | Q: Measurement cct 2, $\overline{\text{INH}}$ = LOW, V <sub>DD</sub> = 3.6V                   | V <sub>OH</sub> = V <sub>DD</sub>   | –                  | –   | 10                 | μA    |
|  |                  |   | V <sub>OL</sub> = V <sub>SS</sub>   | –                  | –   | 10                 | μA    |
| HIGH-level input voltage                   | V <sub>IH</sub>  | $\overline{\text{INH}}$ pin   |   | 0.7V <sub>DD</sub> | –   | –                  | V     |
| LOW-level input voltage                    | V <sub>IL</sub>  | $\overline{\text{INH}}$ pin   |   | –                  | –   | 0.3V <sub>DD</sub> | V     |
| Current consumption                        | I <sub>DD</sub>  | $\overline{\text{INH}}$ = open, Measurement cct 3, load cct 1, V <sub>DD</sub> = 3.0 to 3.6 V | SM5002LAS, SM5002LFS<br>CF5002LA, CF5002LF<br>C <sub>L</sub> = 30 pF, f = 30 MHz                                | –                  | 10  | 18                 | mA    |
|  |                  |   | SM5002LBS, CF5002LB<br>C <sub>L</sub> = 30 pF, f = 50 MHz   | –                  | 15  | 25                 | mA    |
|  |                  |   | SM5002LCS, CF5002LC<br>C <sub>L</sub> = 30 pF, f = 70 MHz   | –                  | 20  | 35                 | mA    |
|  |                  |   | SM5002LDS, SM5002LES<br>CF5002LD, CF5002LE<br>C <sub>L</sub> = 15 pF, f = 100 MHz                               | –                  | 25  | 45                 | mA    |
| Standby current                            | I <sub>ST</sub>  | $\overline{\text{INH}}$ = LOW, Measurement cct 3  |   | –                  | 3   | 10                 | μA    |
| $\overline{\text{INH}}$ pull-up resistance | R <sub>UP1</sub> | Measurement cct 4, $\overline{\text{INH}}$ = LOW  |   | 0.4                | –   | 4                  | MΩ    |
|  | R <sub>UP2</sub> | Measurement cct 4, $\overline{\text{INH}}$ = 0.7V <sub>DD</sub>                               |   | 50                 | –   | 150                | kΩ    |
| AC feedback resistance                     | R <sub>f1</sub>  | Design value, determined by the internal wafer pattern  | SM5002LAS, CF5002LA   | 4.7                | 5.6 | 6.5                | kΩ    |
|  |                  |   | SM5002LBS, CF5002LB   | 4.0                | 4.7 | 5.4                | kΩ    |
|  |                  |   | SM5002LCS, SM5002LDS<br>CF5002LC, CF5002LD  | 3.3                | 3.9 | 4.5                | kΩ    |
|  |                  |   | SM5002LES, CF5002LE   | 2.2                | 2.7 | 3.2                | kΩ    |
|  |                  |   | SM5002LFS, CF5002LF   | 7.2                | 8.5 | 9.8                | kΩ    |
| DC feedback resistance                     | R <sub>f2</sub>  | Measurement cct 5   |   | 50                 | –   | 150                | kΩ    |
| AC feedback capacitance                    | C <sub>f</sub>   | Design value, determined by the internal wafer pattern  |   | 19.8               | 22  | 24.2               | pF    |
| Built-in capacitance                       | C <sub>G</sub>   | Design value, determined by the internal wafer pattern  | SM5002LAS, CF5002LA<br>SM5002LBS, CF5002LB<br>SM5002LCS, CF5002LC<br>SM5002LDS, CF5002LD<br>SM5002LES, CF5002LE | 7.2                | 8   | 8.8                | pF    |
|  |                  |   | SM5002LFS, CF5002LF   | 9                  | 10  | 11                 | pF    |
|  | C <sub>D</sub>   |   | SM5002LAS, CF5002LA<br>SM5002LBS, CF5002LB<br>SM5002LFS, CF5002LF   | 13.5               | 15  | 16.5               | pF    |
|  |                  |   | SM5002LCS, CF5002LC<br>SM5002LDS, CF5002LD<br>SM5002LES, CF5002LE   | 9                  | 10  | 11                 | pF    |

## Switching Characteristics

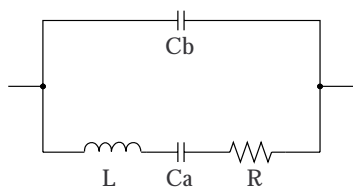
$V_{SS} = 0\text{ V}$ ,  $T_a = -20\text{ to }80\text{ }^{\circ}\text{C}$  unless otherwise noted.

| Parameter                              | Symbol           | Conditions  |  | Limits |     |     | Units |
|--|------------------|---|--|--------|-----|-----|-------|
|  |                  |   |  | min    | typ | max |       |
| Output rise time                       | t <sub>r1</sub>  | Measurement cct 3, load cct 1, 0.1V <sub>DD</sub> → 0.9V <sub>DD</sub>                          | V <sub>DD</sub> = 2.7 to 3.6 V, C <sub>L</sub> = 15 pF                           | –      | 2   | 4   | ns    |
|  | t <sub>r2</sub>  |   | V <sub>DD</sub> = 3.0 to 3.6 V, C <sub>L</sub> = 30 pF                           | –      | 2.5 | 5   | ns    |
| Output fall time                       | t <sub>f1</sub>  | Measurement cct 3, load cct 1, 0.9V <sub>DD</sub> → 0.1V <sub>DD</sub>                          | V <sub>DD</sub> = 2.7 to 3.6 V, C <sub>L</sub> = 15 pF                           | –      | 2   | 4   | ns    |
|  | t <sub>f2</sub>  |   | V <sub>DD</sub> = 3.0 to 3.6 V, C <sub>L</sub> = 30 pF                           | –      | 2.5 | 5   | ns    |
| Output duty cycle <sup>1</sup>         | DUTY             | Measurement cct 3, load cct 1, T <sub>a</sub> = 25 °C, V <sub>DD</sub> = 3.0 V                  | SM5002LAS, SM5002LFS<br>CF5002LA, CF5002LF<br>C <sub>L</sub> = 30 pF, f = 30 MHz | 45     | –   | 55  | %     |
|  |                  |   | SM5002LBS, CF5002LB<br>C <sub>L</sub> = 30 pF, f = 50 MHz                        | 45     | –   | 55  | %     |
|  |                  |   | SM5002LCS, CF5002LC<br>C <sub>L</sub> = 30 pF, f = 70 MHz                        | 45     | –   | 55  | %     |
|  |                  |   | SM5002LDS, SM5002LES<br>C <sub>L</sub> = 15 pF, f = 100 MHz                      | 40     | –   | 60  | %     |
|  |                  |   | CF5002LD, CF5002LE<br>C <sub>L</sub> = 15 pF, f = 100 MHz                        | 45     | –   | 55  | %     |
| Output disable delay time <sup>2</sup> | t <sub>PLZ</sub> | Measurement cct 6, T <sub>a</sub> = 25 °C, V <sub>DD</sub> = 2.7 V, load C <sub>L</sub> ≤ 15 pF |  | –      | –   | 100 | ns    |
| Output enable delay time <sup>2</sup>  | t <sub>PZL</sub> |   |  | –      | –   | 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 (Ω) | 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

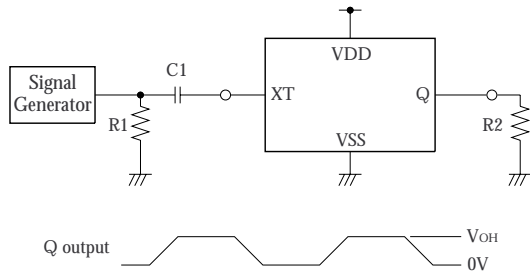
### Standby Function

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          |

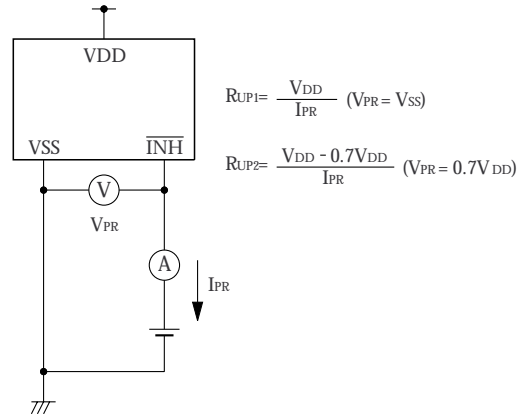
## MEASUREMENT CIRCUITS

### Measurement cct 1

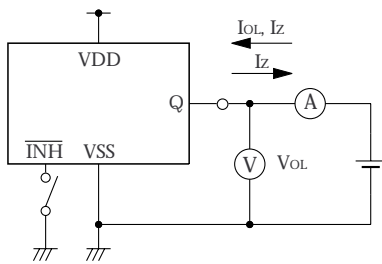


2.5V<sub>P-P</sub>, 10MHz sine wave input signal  
 C1 : 0.001μF  
 R1 : 50Ω  
 R2 : 275Ω

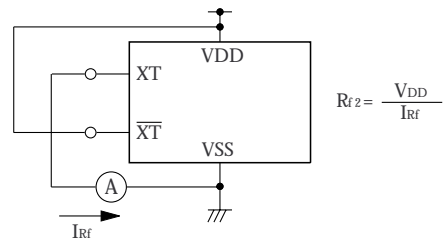
### Measurement cct 4



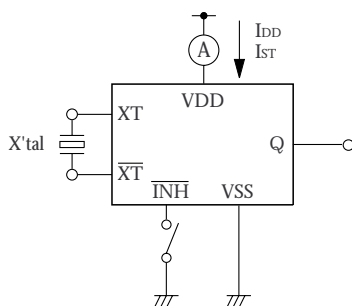
### Measurement cct 2



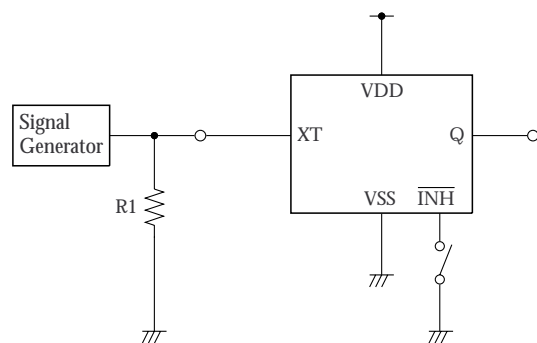
### Measurement cct 5



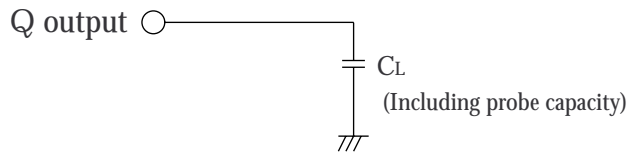
### Measurement cct 3



### Measurement cct 6

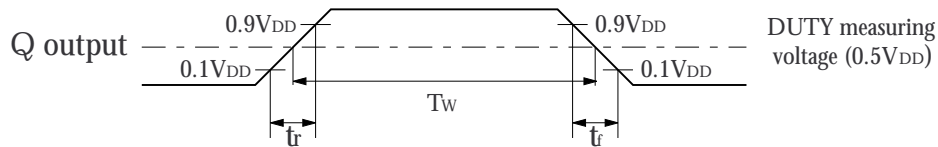
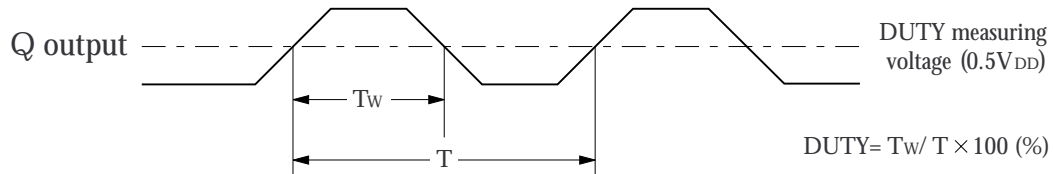


R1 : 50Ω

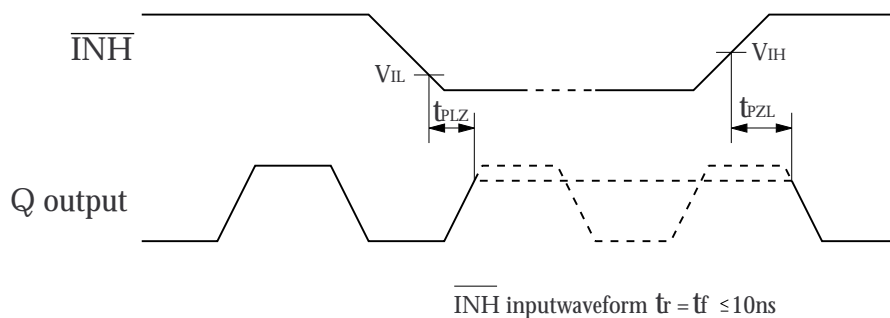
**Load cct 1**

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

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

**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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