

### OVERVIEW

The SM5021 series are crystal oscillator module ICs fabricated in NPC's Molybdenum-gate CMOS, that incorporate high-frequency, low current consumption oscillator and output buffer circuits. Highly accurate thin-film feedback resistors and high-frequency capacitors are built-in, eliminating the need for external components to make a stable 3rd overtone oscillator.

### FEATURES

- 3rd overtone oscillation
- Oscillator capacitors  $C_G$ ,  $C_D$  built-in
- Inverter amplifier feedback resistor built-in (A×, B× series)
- TTL input level
- Output drive capability
  - 4mA ( $V_{DD} = 2.7V$ )
  - 8mA ( $V_{DD} = 4.5V$ )
- Output three-state function
- Operating supply voltage range
  - 2.7 to 5.5V (A×, K× series)
  - 4.5 to 5.5V (B×, L× series)
- Oscillator frequency output
- 6-pin SOT (SM5021××H)
- Chip form (CF5021××)

### SERIES CONFIGURATION

Version <sup>*1</sup>	Operating supply voltage range [V]		Recommended operating frequency range <sup>*2</sup> [MHz]		Built-in capacitance [pF]		gm ratio	Rf [kΩ]	Output frequency	Output level	Standby output state
	Chip	SOT	3V operation	5V operation	$C_G$	$C_D$					
SM5021AAH	4.5 to 5.5	4.5 to 5.5	×	22 to 30	8	15	1	6.0	fo	CMOS	High impedance
SM5021ABH	2.7 to 5.5	2.7 to 5.5	22 to 30	30 to 43			1	3.3			
SM5021ACH			30 to 40	43 to 55			2	3.9			
SM5021ADH			40 to 50	55 to 70			3	2.7			
SM5021AEH	2.7 to 3.6	×	50 to 70	×	12	4	2.7				
SM5021BAH	4.5 to 5.5	4.5 to 5.5	×	22 to 30	8	15	1	6.0	fo	TTL	High impedance
SM5021BBH				30 to 43			1	3.3			
SM5021BCH				43 to 55			2	3.9			
SM5021BDH				55 to 70			3	2.7			
SM5021KDH	2.7 to 5.5	2.7 to 5.5	22 to 50 <sup>*3</sup>	22 to 70 <sup>*3</sup>	8	15	3	–	fo	CMOS	High impedance
SM5021KEH	2.7 to 3.6	2.7 to 3.6	50 to 70 <sup>*3</sup>	×	8	12	4	–	fo	CMOS	High impedance
SM5021LDH	4.5 to 5.5	4.5 to 5.5	×	22 to 70 <sup>*3</sup>	8	15	3	–	fo	TTL	High impedance

\*1. Chip form devices have designation CF5021××.

\*2. 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.

\*3. The 3rd overtone frequency range using an external resistor to set the cutoff frequency.

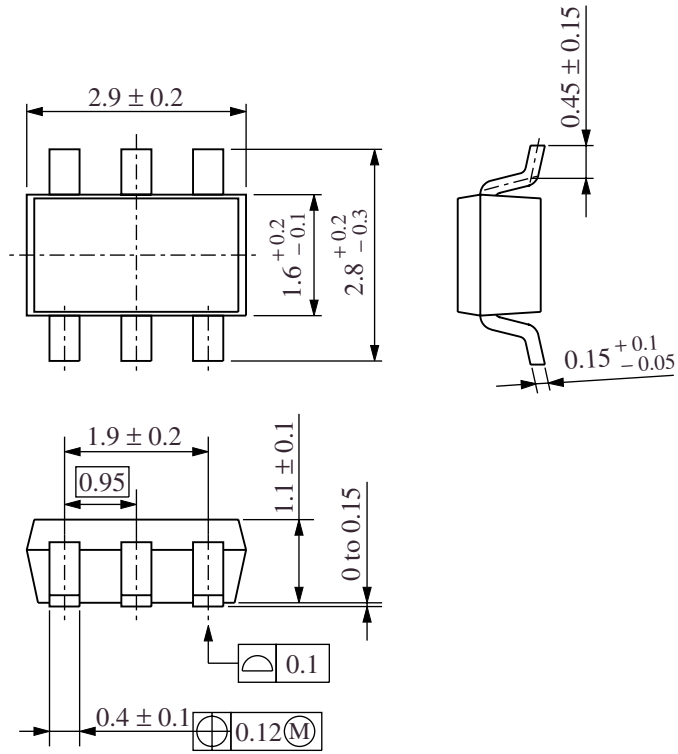
### ORDERING INFORMATION

Device	Package
SM5021××H	SOT23-6
CF5021××-2	Chip form

**PACKAGE DIMENSIONS**

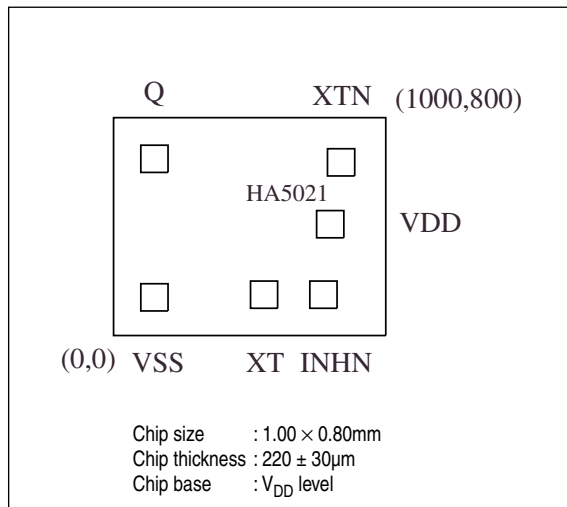
(Unit: mm)

- 6-pin SOT



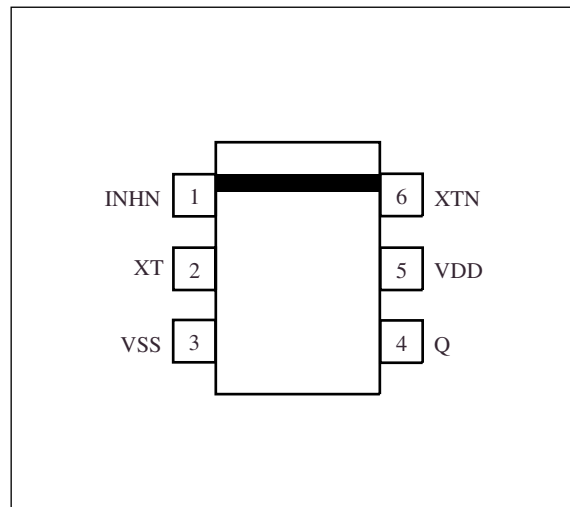
**PAD LAYOUT**

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



**PINOUT**

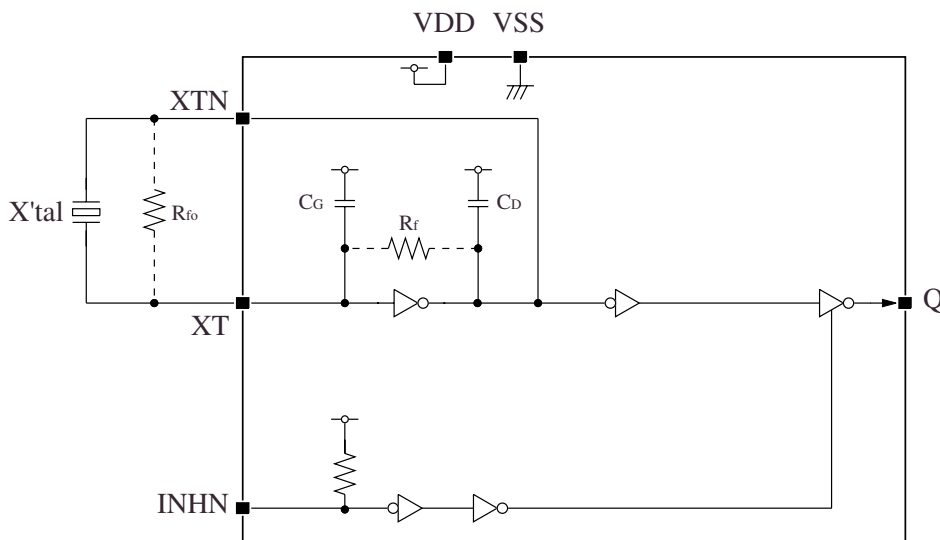
(Top view)



**PIN DESCRIPTION and PAD DIMENSIONS**

Number	Name	I/O	Description	Pad dimensions [ $\mu\text{m}$ ]	
				X	Y
1	INHN	I	Output state control input. High impedance when LOW. Pull-up resistor built in	771	150
2	XT	I	Amplifier input. Crystal oscillator connection pins. Crystal oscillator is connected between XT and XTN	553	150
3	VSS	-	Ground	150	140
4	Q	O	Output. Output frequency ( $f_0$ )	150	649
5	VDD	-	Supply voltage	796	409
6	XTN	O	Amplifier output. Crystal oscillator connection pins. Crystal oscillator is connected between XT and XTN	836	636

**BLOCK DIAGRAM**



## 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	$T_{stg}$	Chip form	- 65 to + 150	°C
		SOT23-6	- 55 to + 125	
Output current	$I_{OUT}$		13	mA
Power dissipation	$P_D$	SOT23-6	250	mW

### Recommended Operating Conditions

$$V_{SS} = 0V, f \leq 70MHz, C_L \leq 15pF$$

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Supply voltage	$V_{DD}$		2.7	-	5.5	V
Input voltage	$V_{IN}$		$V_{SS}$	-	$V_{DD}$	V
Operating temperature	$T_{OPR}$		- 20	-	+ 80	°C

Note: Recommended operating conditions will change in accordance with operating frequency, load capacitance, or power dissipation.

SM5021 series

Electrical Characteristics

3V operation: AA, AB, AC, AD, AE, KD, KE series

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

Parameter	Symbol	Condition		Rating			Unit	
				min	typ	max		
HIGH-level output voltage	$V_{OH}$	Q: Measurement cct 1, $V_{DD} = 2.7V$ , $I_{OH} = 4mA$	SM5021×AH, CF5021×A SM5021×BH, CF5021×B SM5021×CH, CF5021×C SM5021×DH, CF5021×D	2.1	2.4	–	V	
		Q: Measurement cct 1, $V_{DD} = 2.7V$ , $I_{OH} = 8mA$	SM5021×EH, CF5021×E					
LOW-level output voltage	$V_{OL}$	Q: Measurement cct 2, $V_{DD} = 2.7V$ , $I_{OL} = 4mA$	SM5021×AH, CF5021×A SM5021×BH, CF5021×B SM5021×CH, CF5021×C SM5021×DH, CF5021×D	–	0.3	0.4	V	
		Q: Measurement cct 2, $V_{DD} = 2.7V$ , $I_{OL} = 8mA$	SM5021×EH, CF5021×E					
HIGH-level input voltage	$V_{IH}$	INH N		2.0	–	–	V	
LOW-level input voltage	$V_{IL}$	INH N		–	–	0.5	V	
Output leakage current	$I_Z$	Q: Measurement cct 2, $V_{DD} = 3.3V$ , INH N = LOW, $V_{OH} = V_{DD}$		–	–	10	$\mu A$	
		Q: Measurement cct 2, $V_{DD} = 3.3V$ , INH N = LOW, $V_{OL} = V_{SS}$		–	–	10		
Current consumption	$I_{DD}$	70MHz crystal oscillator, measurement cct 3, load cct 1, INH N = open, $C_L = 15pF$	SM5021A×H, CF5021A× SM5021K×H, CF5021K×	–	13	25	mA	
INH N pull-up resistance	$R_{UP}$	Measurement cct 4		25	100	250	k $\Omega$	
Feedback resistance (A× series only)	$R_f$	Measurement cct 5		SM5021×AH, CF5021×A	5.1	6.0	6.9	k $\Omega$
				SM5021×BH, CF5021×B	2.8	3.3	3.8	
				SM5021×CH, CF5021×C	3.3	3.9	4.5	
				SM5021×DH, CF5021×D SM5021×EH, CF5021×E	2.3	2.7	3.1	
Built-in capacitance	$C_G$	Design value. A monitor pattern on a wafer is tested.		7.44	8	8.56	pF	
	$C_D$	Design value. A monitor pattern on a wafer is tested.		SM5021×AH, CF5021×A SM5021×BH, CF5021×B SM5021×CH, CF5021×C SM5021×DH, CF5021×D	13.95	15	16.05	pF
				SM5021×EH, CF5021×E	11.16	12	12.84	

**SM5021 series**

**5V operation: AA, AB, AC, AD, BA, BB, BC, BD, KD, LD series**

$V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $T_a = -20$  to  $+80^{\circ}C$  unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit	
			min	typ	max		
HIGH-level output voltage	$V_{OH}$	Q: Measurement cct 1, $V_{DD} = 4.5V$ , $I_{OH} = 8mA$	3.9	4.2	–	V	
LOW-level output voltage	$V_{OL}$	Q: Measurement cct 2, $V_{DD} = 4.5V$ , $I_{OL} = 8mA$	–	0.3	0.4	V	
HIGH-level input voltage	$V_{IH}$	INH N	2.0	–	–	V	
LOW-level input voltage	$V_{IL}$	INH N	–	–	0.8	V	
Output leakage current	$I_Z$	Q: Measurement cct 2, $V_{DD} = 5.5V$ , INH N = LOW, $V_{OH} = V_{DD}$	–	–	10	$\mu A$	
		Q: Measurement cct 2, $V_{DD} = 5.5V$ , INH N = LOW, $V_{OL} = V_{SS}$	–	–	10		
Current consumption	$I_{DD}$	70MHz crystal oscillator, measurement cct 3, load cct 1, INH N = open, $C_L = 15pF$ SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	18	35	mA	
		70MHz crystal oscillator, measurement cct 3, load cct 2, INH N = open, $C_L = 15pF$ SM5021B×H, CF5021B× SM5021L×H, CF5021L×	–	18	35		
INH N pull-up resistance	$R_{UP}$	Measurement cct 4	25	100	250	$k\Omega$	
Feedback resistance (A×, B× series only)	$R_f$	Measurement cct 5	SM5021×AH, CF5021×A	5.1	6.0	6.9	$k\Omega$
			SM5021×BH, CF5021×B	2.8	3.3	3.8	
			SM5021×CH, CF5021×C	3.3	3.9	4.5	
			SM5021×DH, CF5021×D	2.3	2.7	3.1	
Built-in capacitance	$C_G$	Design value. A monitor pattern on a wafer is tested.	SM5021×AH, CF5021×A SM5021×BH, CF5021×B	7.44	8	8.56	pF
	$C_D$		SM5021×CH, CF5021×C SM5021×DH, CF5021×D	13.95	15	16.05	pF

## Switching Characteristics

### CMOS Output Version

#### 3V operation: AA, AB, AC, AD, AE, KD, KE series

$V_{DD} = 2.7$  to  $3.6V$ ,  $V_{SS} = 0V$ ,  $T_a = -20$  to  $+80^{\circ}C$  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 $0.9V_{DD}$ , $C_L = 15pF$	SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	5	10	ns
			SM5021AEH, CF5021AE SM5021KEH, CF5021KE	–	3.5	7	
	Measurement cct 6, load cct 1, $0.2V_{DD}$ to $0.8V_{DD}$ , $C_L = 15pF$	SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	3.5	7		
Output fall time	$t_{f1}$	Measurement cct 6, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$ , $C_L = 15pF$	SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	5	10	ns
			SM5021AEH, CF5021AE SM5021KEH, CF5021KE	–	3.5	7	
	Measurement cct 6, load cct 1, $0.8V_{DD}$ to $0.2V_{DD}$ , $C_L = 15pF$	SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	3.5	7		
Output duty cycle*1	Duty	Measurement cct 6, load cct 1, $V_{DD} = 3V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$ , $f \leq 70MHz$	45	–	55	%	
Output disable delay time	$t_{PLZ}$	Measurement cct 6, load cct 1, $V_{DD} = 3V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$	–	–	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: AA, AB, AC, AD, KD series

$V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $T_a = -20$  to  $+80^{\circ}C$  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 $0.9V_{DD}$ , $C_L = 15pF$	–	3.5	7	ns
Output fall time	$t_{f1}$	Measurement cct 6, load cct 1, $0.9V_{DD}$ to $0.1V_{DD}$ , $C_L = 15pF$	–	3.5	7	ns
Output duty cycle*1	Duty	Measurement cct 6, load cct 1, $V_{DD} = 5V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$ , $f \leq 70MHz$	45	–	55	%
Output disable delay time	$t_{PLZ}$	Measurement cct 6, load cct 1, $V_{DD} = 5V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$	–	–	100	ns
Output enable delay time	$t_{PZL}$		–	–	100	ns

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

### TTL Output Version

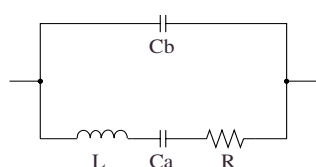
#### 5V operation: BA, BB, BC, BD, LD series

$V_{DD} = 4.5$  to  $5.5V$ ,  $V_{SS} = 0V$ ,  $T_a = -20$  to  $+80^{\circ}C$  unless otherwise noted.

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
Output rise time	$t_{r2}$	Measurement cct 6, load cct 2, 0.4V to 2.4V, $C_L = 15pF$	–	2.5	7	ns
Output fall time	$t_{f2}$	Measurement cct 6, load cct 2, 2.4V to 0.4V, $C_L = 15pF$	–	2.5	7	ns
Output duty cycle*1	Duty	Measurement cct 6, load cct 2, $V_{DD} = 5V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$ , $f \leq 70MHz$	45	–	55	%
Output disable delay time	$t_{PLZ}$	Measurement cct 6, load cct 2, $V_{DD} = 5V$ , $T_a = 25^{\circ}C$ , $C_L = 15pF$	–	–	100	ns
Output enable delay time	$t_{PZL}$		–	–	100	ns

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

### 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
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

## FUNCTIONAL DESCRIPTION

### Standby Function

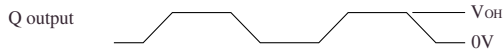
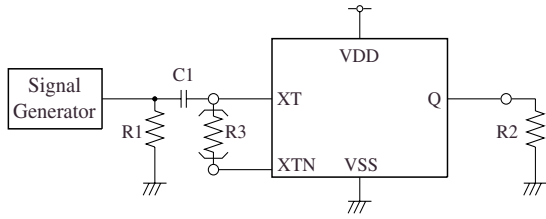
When INHN goes LOW, the oscillator output on Q goes high impedance.

INHN	Q	Oscillator
HIGH (or open)	$f_0$	Normal operation
LOW	High impedance	Normal operation



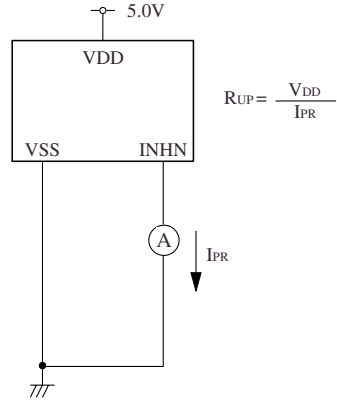
**MEASUREMENT CIRCUITS**

**Measurement cct 1**



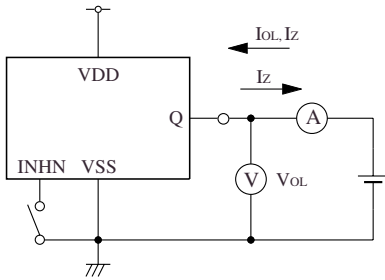
- 2.0Vp-p, 10MHz sine wave input signal (3V operation)
- 3.5Vp-p, 10MHz sine wave input signal (5V operation)
- C1: 0.001μF
- R1: 50Ω
- R2: 525Ω (3V operation/ ×A, ×B, ×C, ×D series)  
263Ω (3V operation/ ×E series)  
490Ω (5V operation)
- R3: 100kΩ (K×, L× series)

**Measurement cct 4**

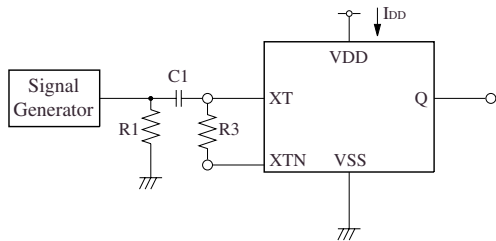


$$R_{UP} = \frac{V_{DD}}{I_{PR}}$$

**Measurement cct 2**

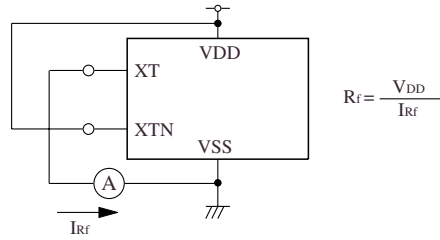


**Measurement cct 3**



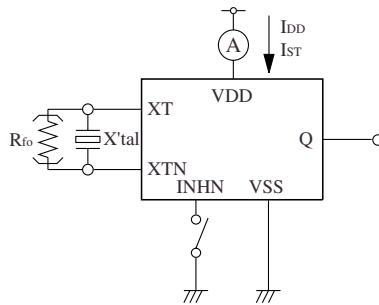
- 2.0Vp-p, 70MHz sine wave input signal (3V operation)
- 3.5Vp-p, 70MHz sine wave input signal (5V operation)
- C1: 0.001μF
- R1: 50Ω
- R3: 100kΩ (K×, L× series)

**Measurement cct 5**



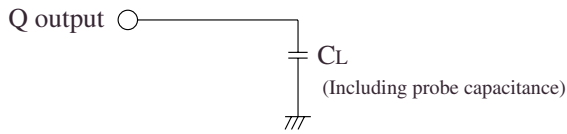
$$R_f = \frac{V_{DD}}{I_{Rf}}$$

**Measurement cct 6**



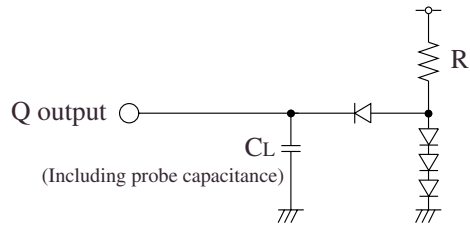
- R<sub>f0</sub>: 2.7kΩ (K×, L× series)

**Load cct 1**



$C_L = 15\text{pF}; t_{r1}, t_{f1}$

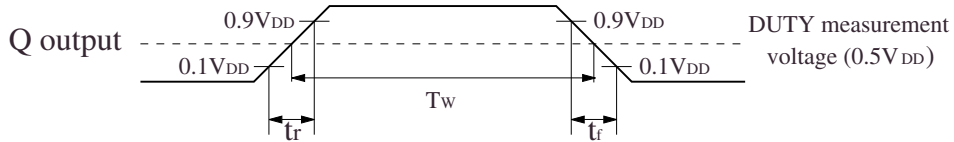
**Load cct 2**



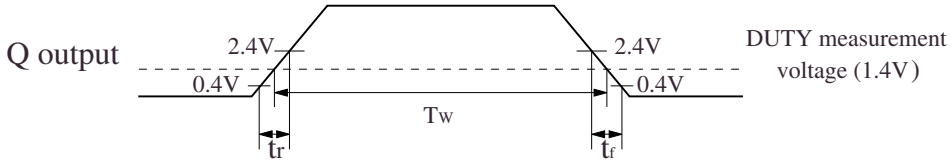
$C_L = 15\text{pF}; t_{r2}, t_{f2}$   
 $R = 800\Omega$

**Switching Time Measurement Waveform**

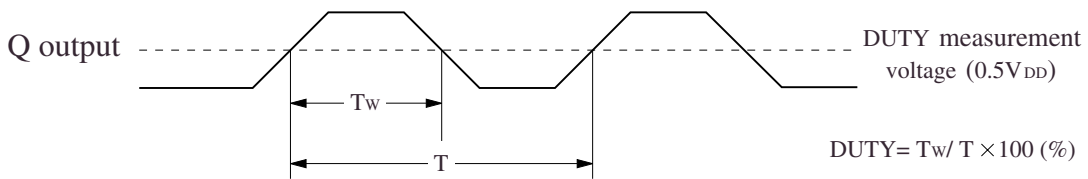
**Output duty level (CMOS)**



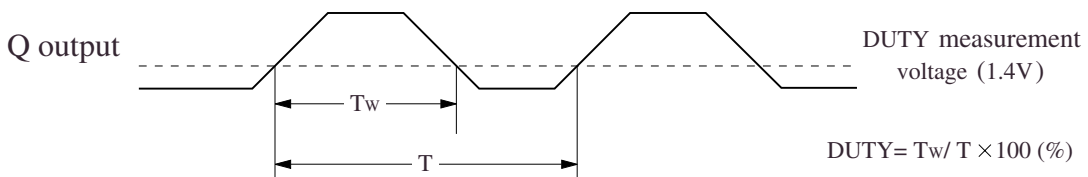
**Output duty level (TTL)**



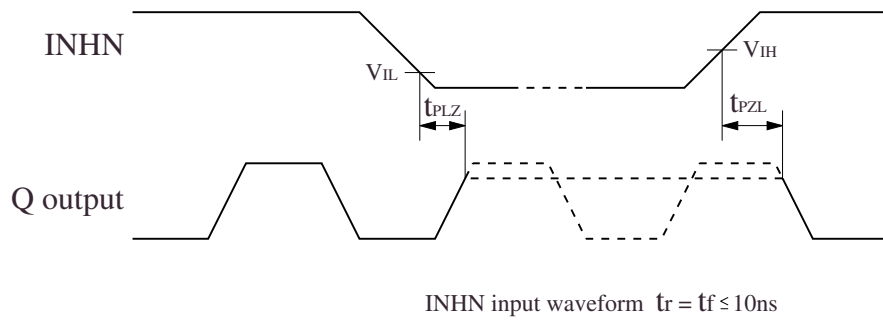
**Output duty cycle (CMOS)**



**Output duty cycle (TTL)**



Output Enable/Disable Delay



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The logo for SEIKO NPC CORPORATION, consisting of the letters 'NPC' in a bold, black, sans-serif font.

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