

## 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-harmonic oscillator.

## FEATURES

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

## SERIES CONFIGURATION

Version <sup>1</sup>	Supply voltage		Recommended operating frequency range (MHz)		Built-in capacitance (pF)		gm ratio	Rf (kΩ)	Output frequency	Output level	Standby output state
	Chip	SOT	3V	5V	C <sub>G</sub>	C <sub>D</sub>					
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	8	15	1	3.3	fo	CMOS	High impedance
SM5021ACH	2.7 to 5.5	2.7 to 5.5	30 to 40	43 to 55	8	15	2	3.9	fo	CMOS	High impedance
SM5021ADH	2.7 to 5.5	2.7 to 5.5	40 to 50	55 to 70	8	15	3	2.7	fo	CMOS	High impedance
SM5021AEH	2.7 to 3.6	×	50 to 70	×	8	12	4	2.7	fo	CMOS	High impedance
SM5021BAH	4.5 to 5.5	4.5 to 5.5	×	22 to 30	8	15	1	6.0	fo	TTL	High impedance
SM5021BBH	4.5 to 5.5	4.5 to 5.5	×	30 to 43	8	15	1	3.3	fo	TTL	High impedance
SM5021BCH	4.5 to 5.5	4.5 to 5.5	×	43 to 55	8	15	2	3.9	fo	TTL	High impedance
SM5021BDH	4.5 to 5.5	4.5 to 5.5	×	55 to 70	8	15	3	2.7	fo	TTL	High impedance
SM5021KDH	2.7 to 5.5	2.7 to 5.5	22 to 50	22 to 70	8	15	3	–	fo	CMOS	High impedance
SM5021KEH	2.7 to 3.6	2.7 to 3.6	50 to 70	×	8	12	4	–	fo	CMOS	High impedance
SM5021LDH	4.5 to 5.5	4.5 to 5.5	×	22 to 70	8	15	3	–	fo	TTL	High impedance

1. Chip form devices have designation CF5021××.

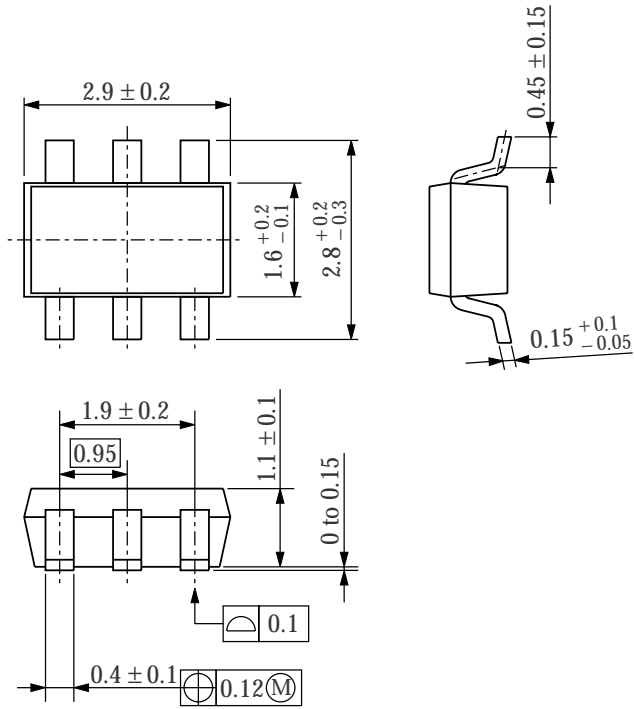
## ORDERING INFORMATION

Devicez	Package
SM5021××H	6-pin SOT
CF5021××-2	Chip form

**PACKAGE DIMENSIONS**

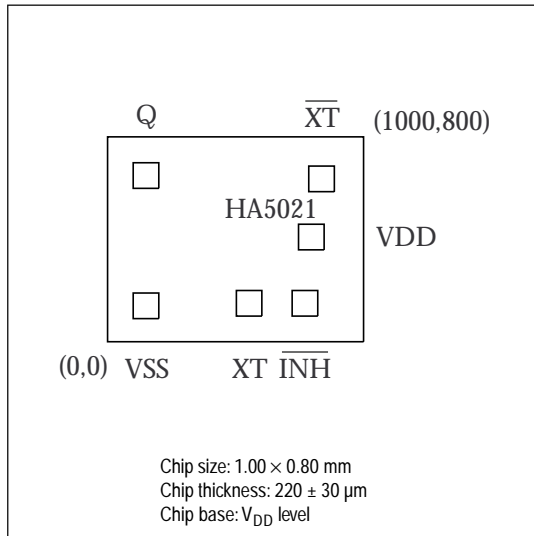
(UNIT : mm)

- 6-pin SOT



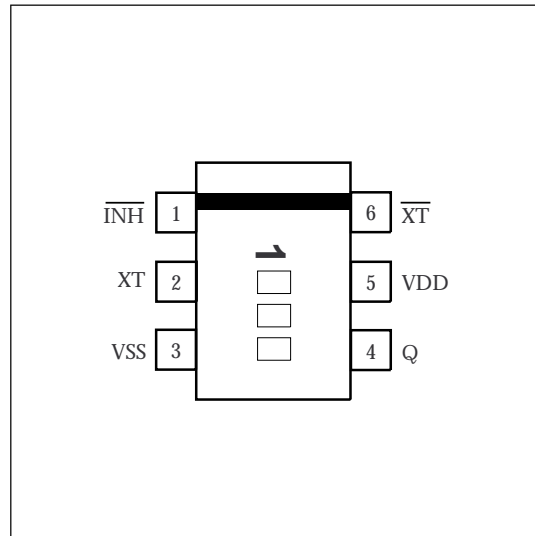
**PAD LAYOUT**

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



**PINOUT**

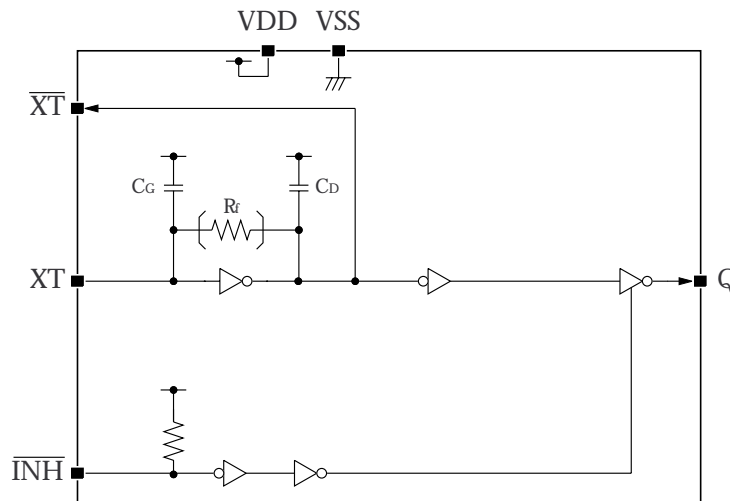
(Top View)



**PIN DESCRIPTION and PAD DIMENSIONS**

Number	Name	I/O	Description	Pad dimensions [ $\mu\text{m}$ ]	
				X	Y
1	$\overline{\text{INH}}$	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 connected between XT and $\overline{\text{XT}}$	553	150
3	VSS	-	Ground	150	140
4	Q	O	Output. Output frequency ( $f_O$ )	150	649
5	VDD	-	Supply voltage	796	409
6	$\overline{\text{XT}}$	O	Amplifier output. Crystal oscillator connection pins. Crystal oscillator connected between XT and $\overline{\text{XT}}$	836	636

**BLOCK DIAGRAM**



## SPECIFICATIONS

### Absolute Maximum Ratings

$V_{SS} = 0\text{ V}$

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
		6-pin SOT	-55 to 125	
Output current	$I_{OUT}$		13	mA
Power dissipation	$P_D$	6-pin SOT	250	mW

### Recommended Operating Conditions

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

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.

## Electrical Characteristics

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

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

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

SM5021 series

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

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

Parameter	Symbol	Condition	Rating			Unit	
			min	typ	max		
HIGH-level output voltage	$V_{OH}$	Q: Measurement cct 1, $V_{DD} = 4.5$ V, $I_{OH} = 8$ mA	3.9	4.2	–	V	
LOW-level output voltage	$V_{OL}$	Q: Measurement cct 2, $V_{DD} = 4.5$ V, $I_{OL} = 8$ mA	–	0.3	0.4	V	
Output leakage current	$I_Z$	Q: Measurement cct 2, $V_{DD} = 5.5$ V, $\overline{INH} = LOW$ , $V_{OH} = V_{DD}$	–	–	10	$\mu$ A	
		Q: Measurement cct 2, $V_{DD} = 5.5$ V, $\overline{INH} = LOW$ , $V_{OL} = V_{SS}$	–	–	10		
HIGH-level input voltage	$V_{IH}$	$\overline{INH}$	2.0	–	–	V	
LOW-level input voltage	$V_{IL}$	$\overline{INH}$	–	–	0.8	V	
Current consumption	$I_{DD}$	$\overline{INH} = open$ , Measurement cct 3, load cct 1, $C_L = 15$ pF, 70 MHz crystal oscillator	–	18	35	mA	
		$\overline{INH} = open$ , Measurement cct 3, load cct 2, $C_L = 15$ pF, 70 MHz crystal oscillator	–	18	35		
$\overline{INH}$ pull-up resistance	$R_{UP}$	Measurement cct 4	25	100	250	k $\Omega$	
Feedback resistance (A $\times$ , B $\times$ series only)	$R_f$	Measurement cct 5	SM5021 $\times$ AH, CF5021 $\times$ A	5.1	6.0	6.9	k $\Omega$
			SM5021 $\times$ BH, CF5021 $\times$ B	2.8	3.3	3.8	
			SM5021 $\times$ CH, CF5021 $\times$ C	3.3	3.9	4.5	
			SM5021 $\times$ DH, CF5021 $\times$ D	2.3	2.7	3.1	
Built-in capacitance	$C_G$	Design value, determined by the internal wafer pattern	SM5021 $\times$ AH, CF5021 $\times$ A	7.44	8	8.56	pF
	$C_D$		SM5021 $\times$ BH, CF5021 $\times$ B SM5021 $\times$ CH, CF5021 $\times$ C SM5021 $\times$ DH, CF5021 $\times$ D	13.95	15	16.05	pF

## Switching Characteristics

### CMOS

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

$V_{DD} = 2.7$  to  $3.6$  V,  $V_{SS} = 0$  V,  $T_a = -20$  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 $0.9V_{DD}$ , $C_L = 15$ pF	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 $0.8V_{DD}$ , $C_L = 15$ pF	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 $0.1V_{DD}$ , $C_L = 15$ pF	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 $0.2V_{DD}$ , $C_L = 15$ pF	SM5021AAH, CF5021AA SM5021ABH, CF5021AB SM5021ACH, CF5021AC SM5021ADH, CF5021AD SM5021KDH, CF5021KD	–	3.5	7		
Output duty cycle <sup>1</sup>	Duty	Measurement cct 6, load cct 1, $T_a = 25$ °C, $V_{DD} = 3$ V, $C_L = 15$ pF, $f \leq 70$ MHz	45	–	55	%	
Output disable delay time	$t_{PLZ}$	Measurement cct 6, load cct 1, $T_a = 25$ °C, $V_{DD} = 3$ V, $C_L = 15$ pF	–	–	100	ns	
Output enable delay time	$t_{PZL}$		–	–	100	ns	

1. Determined by the lot monitor.

5 V operation: AA, AB, AC, AD series/ KD series

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

1. Determined by the lot monitor.

**TTL**

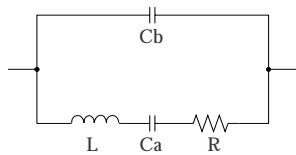
5 V operation: BA, BB, BC, BD series/ LD series

$V_{DD} = 4.5$  to  $5.5$  V,  $V_{SS} = 0$  V,  $T_a = -20$  to  $80$  °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, $C_L = 15$ pF	-	2.5	7	ns
Output fall time	$t_{f2}$	Measurement cct 6, load cct 2, 2.4V to 0.4V, $C_L = 15$ pF	-	2.5	7	ns
Output duty cycle <sup>1</sup>	Duty	Measurement cct 6, load cct 2, $T_a = 25$ °C, $V_{DD} = 5$ V, $C_L = 15$ pF, $f \leq 70$ MHz	45	-	55	%
Output disable delay time	$t_{pLZ}$	Measurement cct 6, load cct 2, $T_a = 25$ °C, $V_{DD} = 5$ V, $C_L = 15$ pF	-	-	100	ns
Output enable delay time	$t_{pZL}$		-	-	100	ns

1. Determined by the lot monitor.

**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

**FUNCTIONAL DESCRIPTION**

**Standby Function**

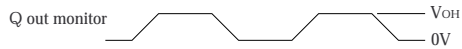
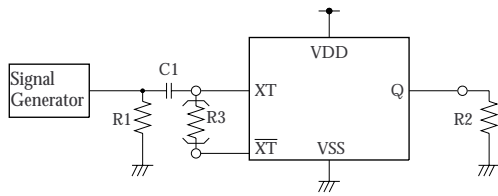
When  $\overline{INH}$  goes LOW, the oscillator output on Q goes high impedance.

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



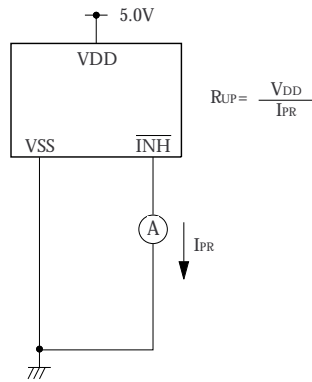
## MEASUREMENT CIRCUITS

### Measurement cct 1

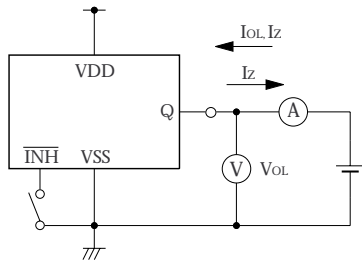


- 2.0V<sub>p-p</sub>, 10MHz sine wave input signal (3V operation)
- 3.5V<sub>p-p</sub>, 10MHz sine wave input signal (5V operation)
- C1 : 0.001μF
- R1 : 50Ω
- R2 : 525Ω (3V operation/ ×A, ×B, ×C, ×D series)  
263Ω (3V operation/ ×E series)
- 490Ω (5V operation)
- R3 : 100kΩ (K×, L× series)

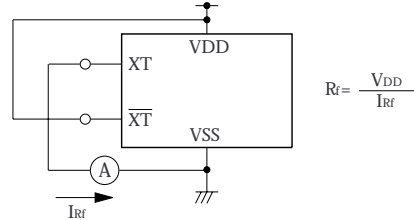
### Measurement cct 4



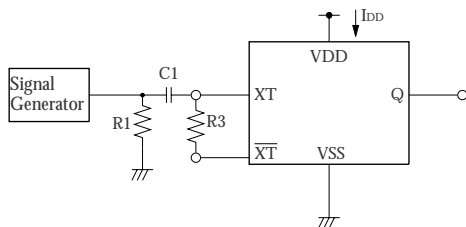
### Measurement cct 2



### Measurement cct 5

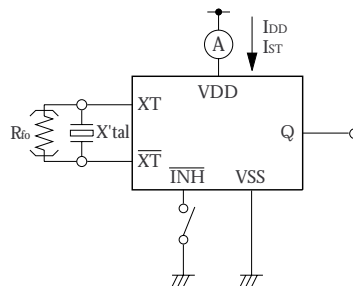


### Measurement cct 3



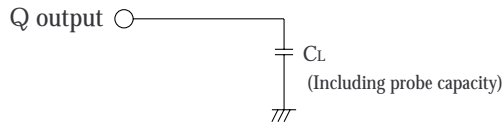
- 2.0V<sub>p-p</sub>, 70MHz sine wave input signal (3V operation)
- 3.5V<sub>p-p</sub>, 70MHz sine wave input signal (5V operation)
- C1 : 0.001μF
- R1 : 50Ω
- R3 : 100kΩ (K×, L× series)

### Measurement cct 6



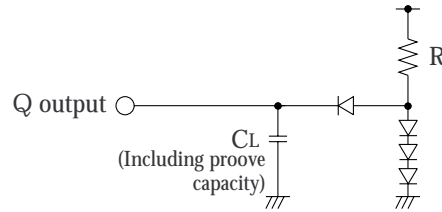
- R<sub>0</sub> : 2.7kΩ (K×, L× series)

**Load cct 1**



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

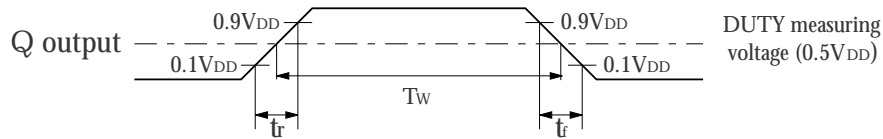
**Load cct 2**



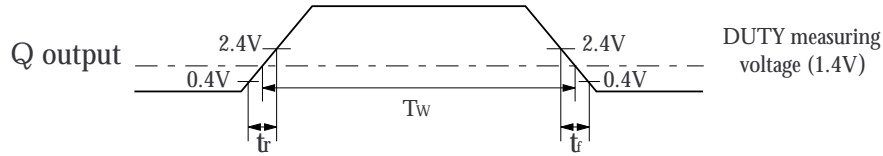
$C_L = 15\text{pF}; t_{r2}, t_{f2}$   
 $R = 800\Omega$

**Switching Time Measurement Waveform**

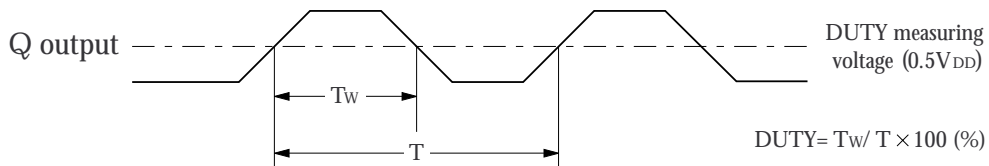
**Output duty level (CMOS)**



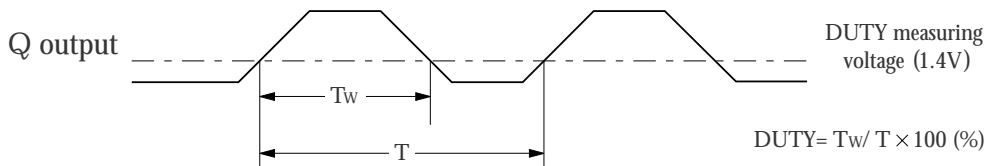
**Output duty level (TTL)**



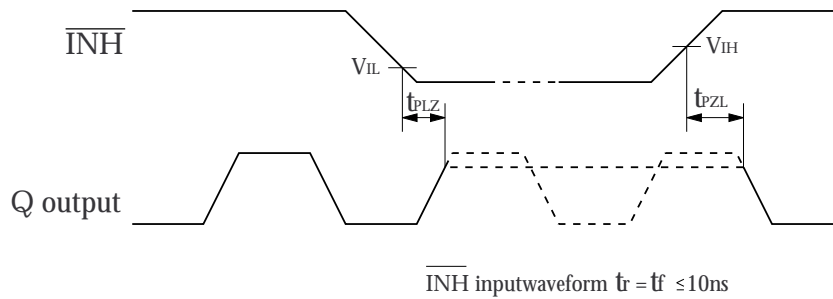
**Output duty cycle (CMOS)**



**Output duty cycle (TTL)**



## Output Enable/Disable Delay



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