

**Evaluation of a Low Frequency Clock Oscillation Circuit**

VT-200-FL 6.0pF with uPD78F1009GB-16BT [LQFP(10x10) 0.50mm pitch]

Measurement conditions : 3.0V



**New**

**VT-200-FL**

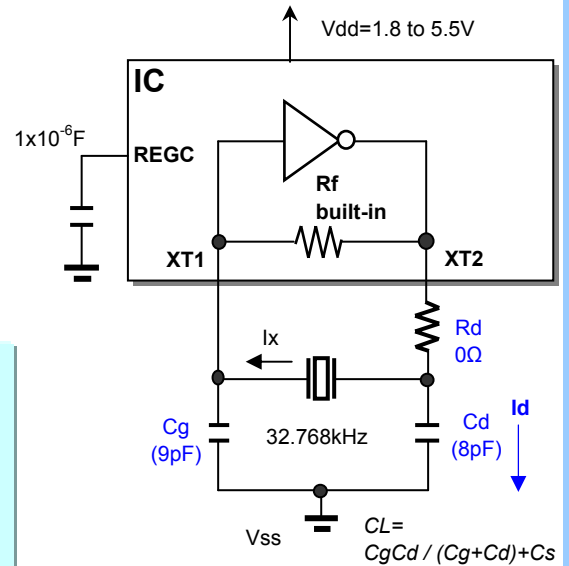
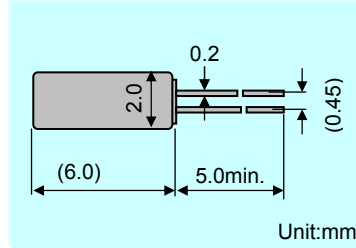


Model :VT-200-FL  
 Frequency :Fo=32.768kHz  
 Frequency tolerance :dF/Fo= +/-17x10<sup>-6</sup>  
 Load capacitance :CL=6.0pF  
 Equivalent series resistance :R1=50kΩ max  
 Max. drive level :DL=1μW max  
 Level of drive :DL=0.01μW typ

**FEATURES**

- 1.Compact tubular package
- 2.Photolithographic process
- 3.Excellent shock resistance and environmental characteristics.
- 4.Real time clocks, Timers, Portable applications

**DIMENSIONS(VT-200)**



Remark) Ix : current through crystal

**Extremely low power consumption 78K0R/Kx3-L and VT-200-FL 6.0pF**

\*1 ; Low current consumption mode (default)

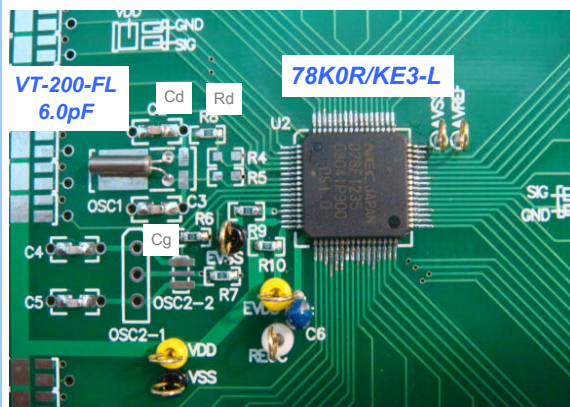
\*2 ; Extremely low current consumption mode

MODEL:VT-200-FL 6.0pF with uPD78F1009GB at 25°C

Key specifications	Low(*2)	Low(*1)	Remarks
Current control resistance : Rd ( kΩ )	0	0	Control drive level & secure phase margin
Capacitance at gate : Cg ( pF )	9	9	Optimal capacitance in response to CL
Capacitance at drain : Cd ( pF )	8	8	( CL = Cd // Cg + stray capacitance )

Circuit characteristics ( at 25°C )	Low(*2)	Low(*1)	Remarks
Matching Accuracy : df / f ( x10 <sup>-6</sup> )	0.2	1.0	Frequency offset volume at specified Vdd
Voltage Fluctuation : +/-df / V ( x10 <sup>-6</sup> )	0.0	0.0	Vdd +/-10% ( Standard operating voltage range )
Drive Level : DL ( μ W )	0.008	0.014	DL=Ix <sup>2</sup> Re < 1x10 <sup>-6</sup> W, Re=R1( 1 + Co / CL ) <sup>2</sup>
Negative resistance :   - RL   ( kΩ )	412	612	5 times larger than R <sub>1MAX</sub>
Oscillation allowance : M ( times )	8	12	Judgmental standard of oscillation stability
<b>Low current consumption : Id (nA)</b>	<b>122</b>	<b>221</b>	Cd charge current, Id = ωCd*Vd < 250nA
Voltage of oscillation start : Vstart ( V )	1.63	1.63	
Voltage of oscillation stop : Vstop ( V )	1.59	1.59	
Oscillation start up time : Ts ( sec )	1.35	0.80	Time to reach 90% of output level<2.5sec

Temperature characteristics of circuit		Low(*2)	Low(*1)	Remarks
at -40°C	Variation : df / T ( x10 <sup>-6</sup> )	-143	-143	Typ.Tp=25°C ( K = -3.5x10 <sup>-8</sup> / °C <sup>2</sup> )
at +85°C	Variation : df / T ( x10 <sup>-6</sup> )	-121	-121	Typ.Tp=25°C ( K = -3.5x10 <sup>-8</sup> / °C <sup>2</sup> )



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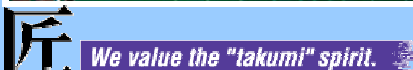
2990,West Lomita Blvd., Torrance, CA 90505, U.S.A  
 Telephone :+1 310-517-7771 Facsimile :+1 310-517-7792  
 Email :info@siu-la.com

**Seiko Instruments GmbH**

Siemensstrasse 9,D-63263 Neu-Isenburg,Germany  
 Telephone :+49-6102-297-0 Facsimile :+49-6102-297-320  
 Email :info@seiko-instruments.de

**Seiko Instruments Inc.**

1-8,Nakase,Mihama-ku,Chiba-shi,Chiba 261-8507,Japan  
 Facsimile :+81-43-211-8030  
 E-mail :component@sii.co.jp



Seiko Instruments Inc.  
 Phone:+81-43-211-1207(Direct)

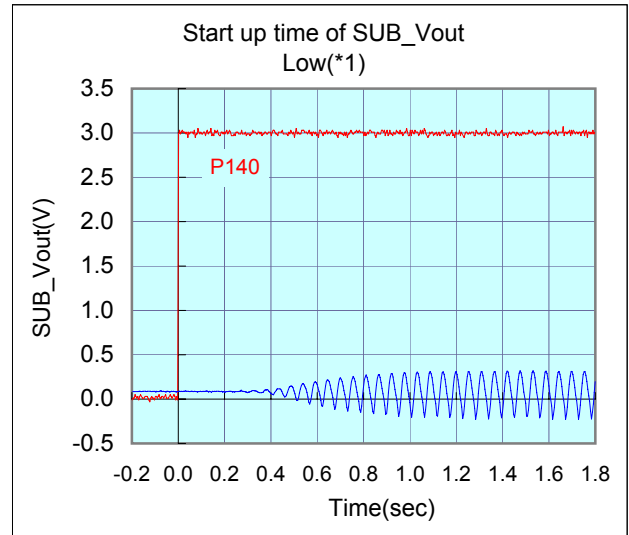
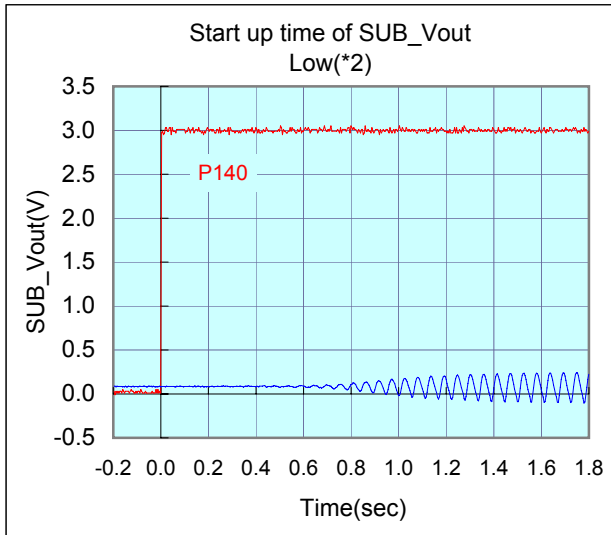
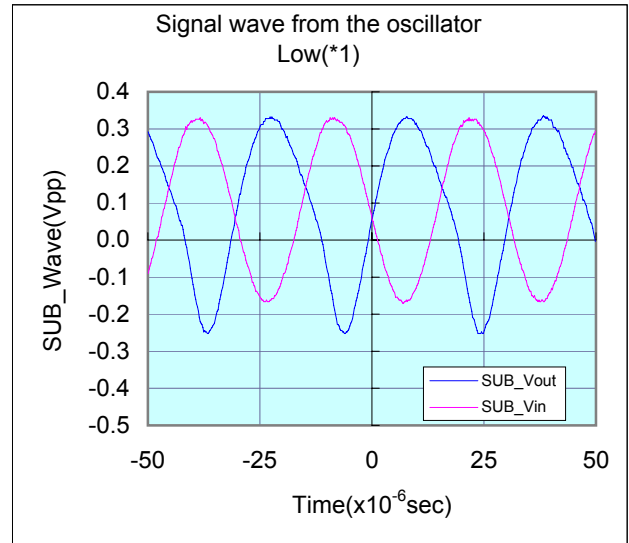
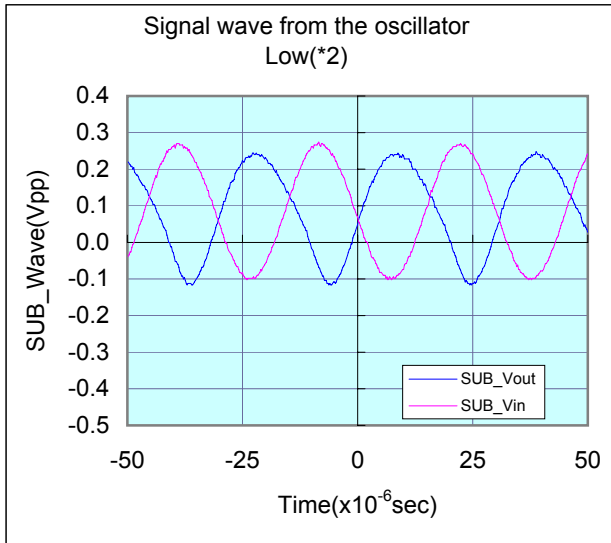
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Measurement conditions : 3.0V

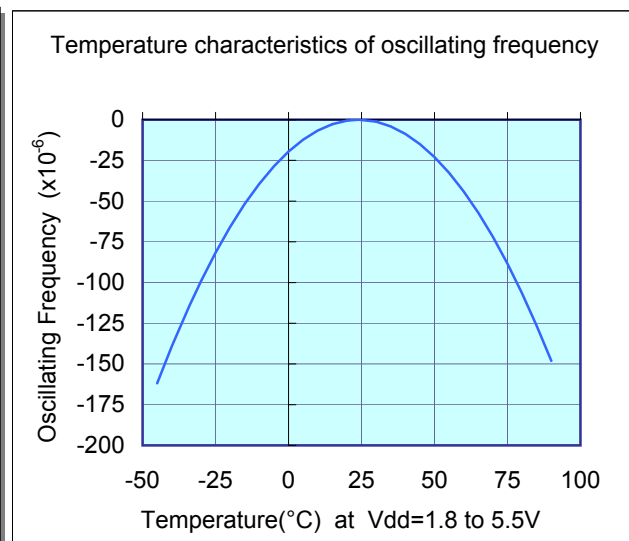
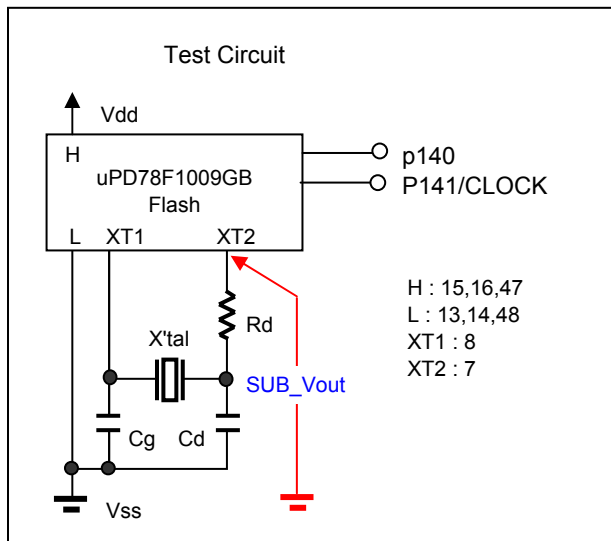


Test Data at 25°C



\*2 ; Extremely low current consumption mode

\*1 ; Low current consumption mode



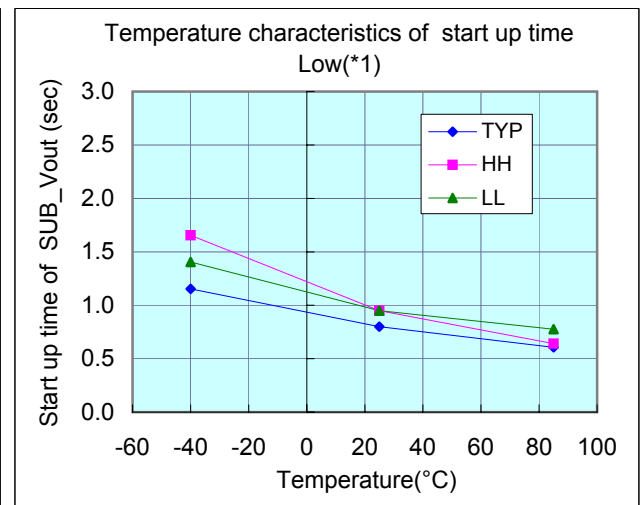
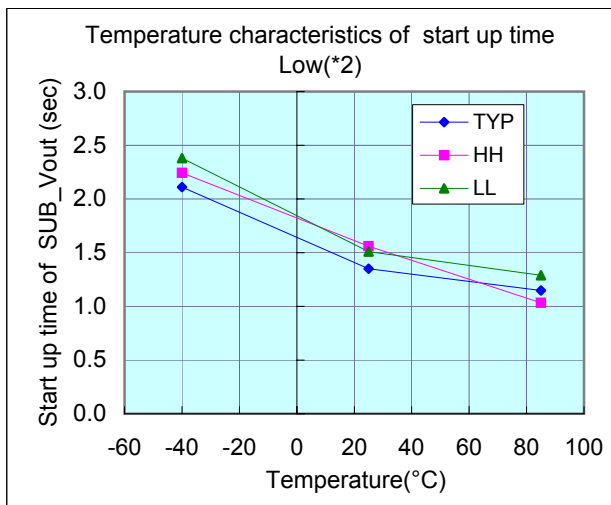
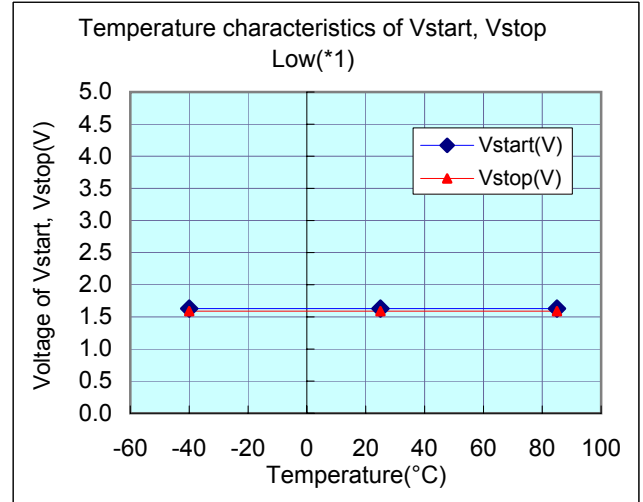
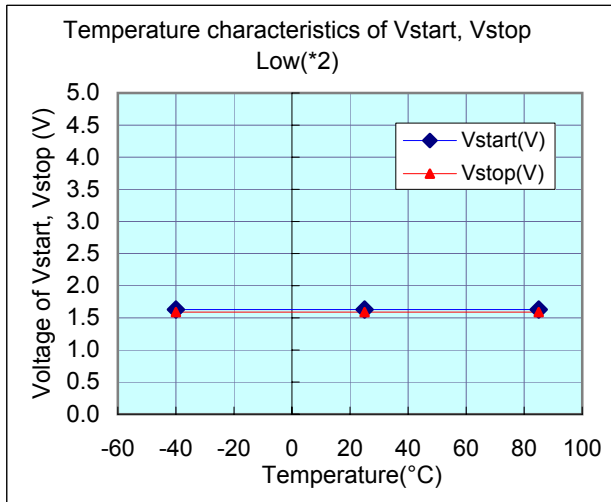
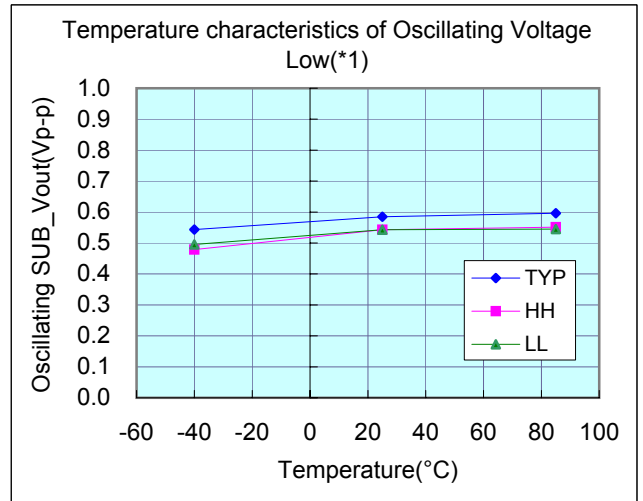
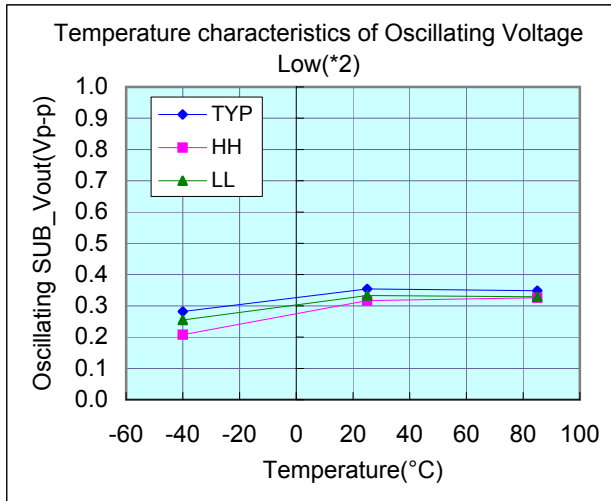
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Measurement conditions : 3.0V



Test Data : Temperature characteristics



\*2 ; Extremely low current consumption current mode      \*1 ; Low currrt consumption mode

The above mentioned value is only for your reference. The value is for the arbitrary samples and does not guarantee the product's characteristics. Please review and check above parameters at customer's end.

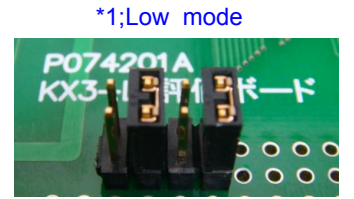
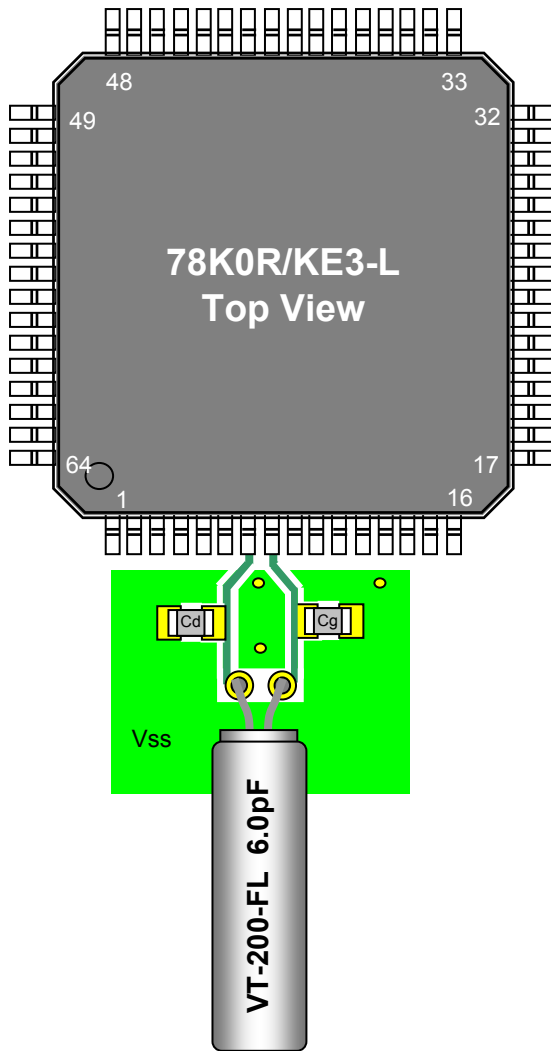
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Measurement conditions : 3.0V



**Referential components layout(see Figure 1)**



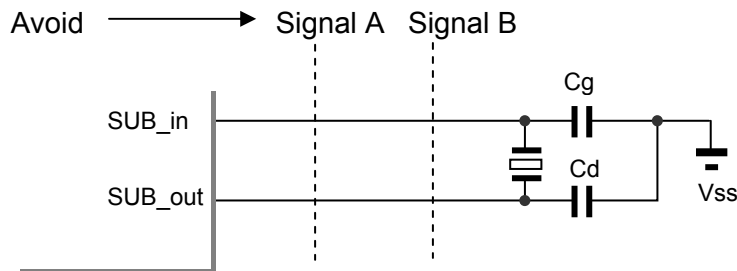
- Vdd:15 (H)
- EVdd:16(H)
- AVREF:47(H)
- AVss:48 (L)
- Vss:13(L)
- Evss:14(L)
- FLMD0:9(L)
- XT1:8 (SUB\_in)
- XT2:7 (SUB\_out)
- RESET:6
- REGC:12
- P140:64

**Figure 1 Referential components layout**

**Notes Board Design**

When using a crystal resonator, place the resonator and its load capacitors as close as possible to SUB\_in and SUB\_out pins.

Other signal lines should be routed away from the resonator circuit to prevent induction from interfering with correct oscillation (see figure 2).



**Figure 2 Example of Incorrect Board Design**

**Remark** When using the subsystem clock, insert a resistor, Rd, in series on the SUB\_out side.

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Measurement conditions : 3.0V

**[Evaluation Sample at 25°C]**

SAMPLE	No.	CL (pF)	Fo (Hz)	fr (Hz)	R1 (kΩ)	Co (pF)	C1 (fF)	Q (k)
VT-200-FL	1	6.0	32768.02	32763.09	39.4	0.86	2.065	59.7
	2	6.0	32768.05	32763.10	38.8	0.85	2.068	60.6
	3	6.0	32768.11	32763.13	38.6	0.87	2.088	60.3

**[IC Test Data : IC Sample Rd=0Ω,Cg=9pF,Cd=8pF at 25°C]**

Power mode	IC Sample	Fosc (Hz)	df / f (x10 <sup>-6</sup> )	DL(μW)	-RL  (kΩ)	M(times)	Id (nA)	Vstart (V)	Ts(sec)
Low(*1)	TYP	32768.05	1.04	0.014	612	12	221	1.63	0.80
	HH	32768.06	1.19	0.016	612	12	205	1.63	0.95
	LL	32768.04	0.55	0.012	612	12	206	1.63	0.95
	HL	32768.05	1.01	0.016	612	12	209	1.63	1.04
	LH	32768.23	6.41	0.012	612	12	214	1.63	1.10

\*1; Low current consumption mode

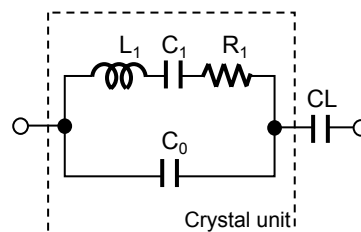
**[IC Test Data : IC Sample Rd=0Ω,Cg=9pF,Cd=8pF at 25°C]**

Power mode	IC Sample	Fosc (Hz)	df / f (x10 <sup>-6</sup> )	DL(μW)	-RL  (kΩ)	M(times)	Id (nA)	Vstart (V)	Ts(sec)
Low(*2)	TYP	32768.03	0.21	0.008	412	8	122	1.63	1.35
	HH	32767.99	-0.92	0.007	382	8	110	1.63	1.56
	LL	32768.03	0.37	0.007	412	8	115	1.63	1.51
	HL	32768.00	-0.76	0.008	412	8	132	1.63	1.52
	LH	32768.25	7.02	0.008	412	8	121	1.63	1.65

\*2; Extremely low current consumption mode

**Remark ( see figure 3 )**

$$F_o = f_r \times \{ C_1 / ( 2 \times ( C_o + C_L ) ) + 1 \} \quad (\text{Hz})$$



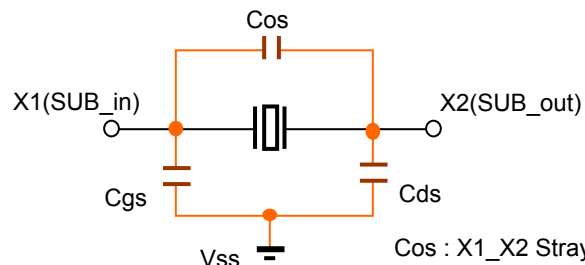
Fo : Load resonance frequency  
fr : Resonance frequency  
R1 : Motional resistance  
C1 : Motional capacitance  
Co : Shunt capacitance  
CL : Load Capacitance

**Figure 3 Equivalent circuit of crystal unit, and CL****Remark ( see figure 4 )**

Approximate formula of the load capacitance of the circuit CL,

$$C_L = C_g \times C_d / (C_g + C_d) + C_s \quad (\text{pF})$$

$$C_s = C_{gs} \times C_{ds} / (C_{gs} + C_{ds}) + C_{os} \quad (\text{pF})$$



Cos : X1\_X2 Stray capacitance  
Cgs : X1\_Vss Stray capacitance  
Cds : X2\_Vss Stray capacitance

where Cs(=1.5 to 2.5pF) stands for stray capacitance of the circuit.

**Figure 4 Stray capacitance Cos,Cgs,Cds of the circuit**

Resonator circuit constants differ depending on the resonator element, stray capacitance in its interconnecting circuit, and other factors. Suitable constants should be determined in consultation with the resonator element manufacturer.



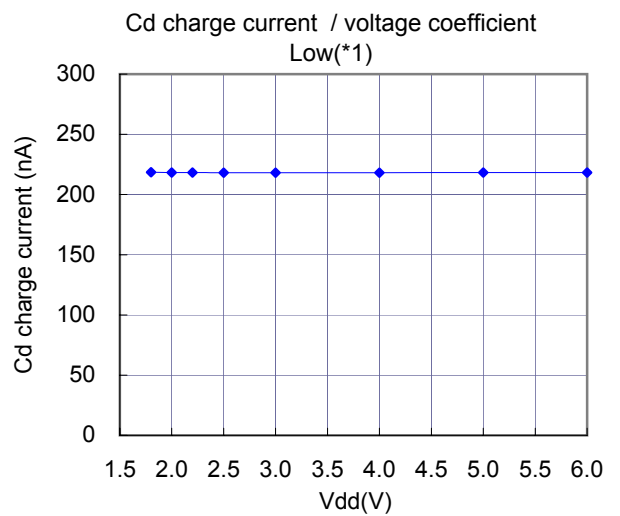
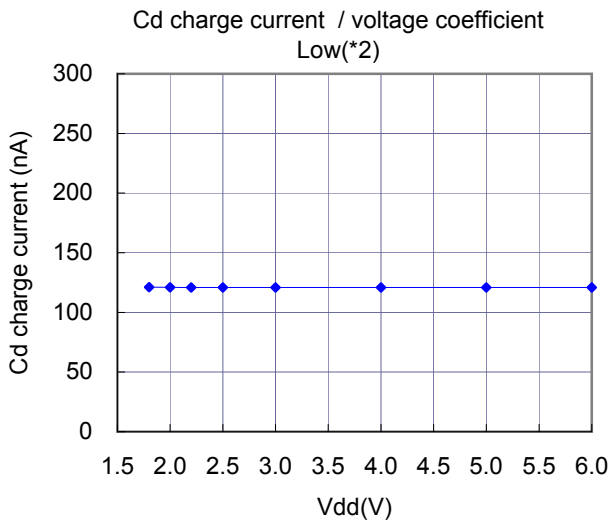
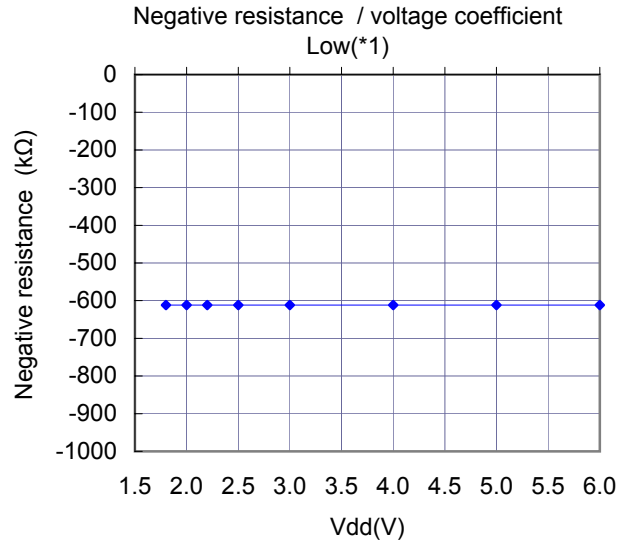
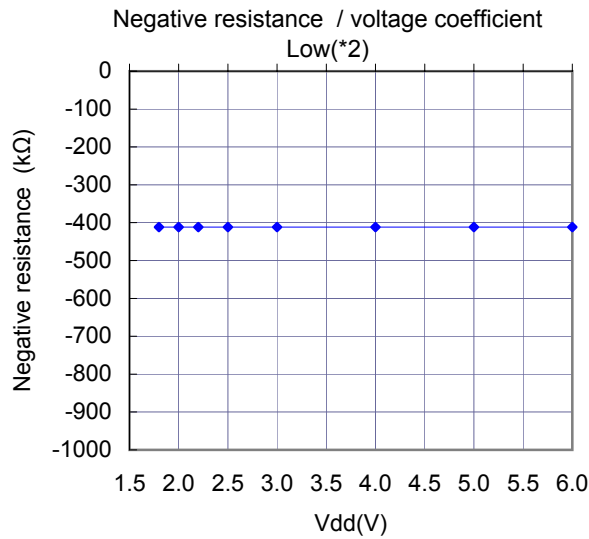
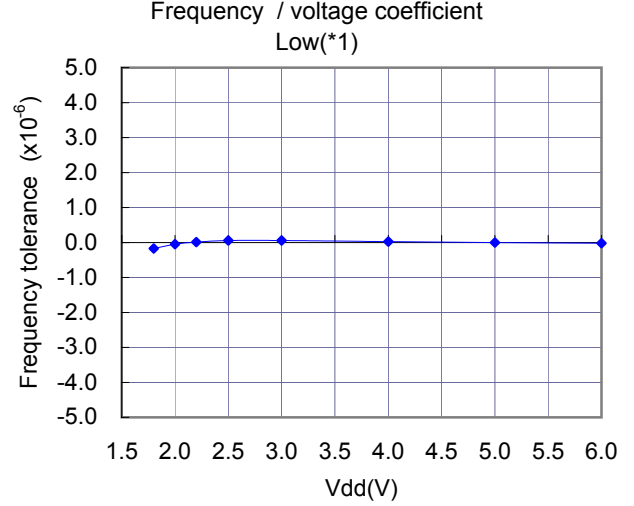
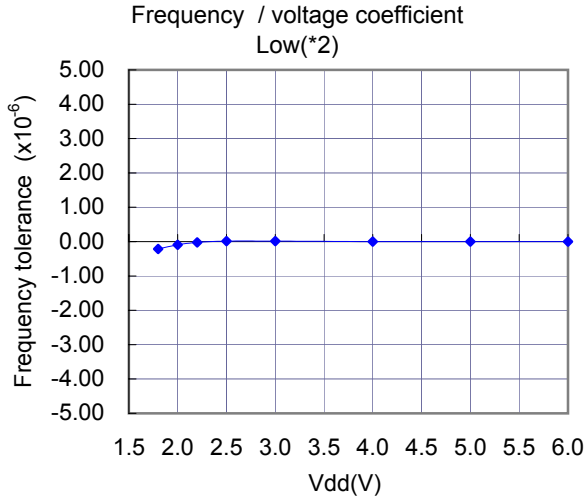
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VT-200-FL 6.0pF with uPD78F1009GB-16BT [LQFP(10x10) 0.50mm pitch]

Measurement conditions : Vdd=1.8V to (6.0)V at 25°C



Referential Data(1): Voltage characteristics



\*2 ; Extremely low current consumption mode

\*1 ; Low current consumption mode

**Evaluation of a Low Frequency Clock Oscillation Circuit**

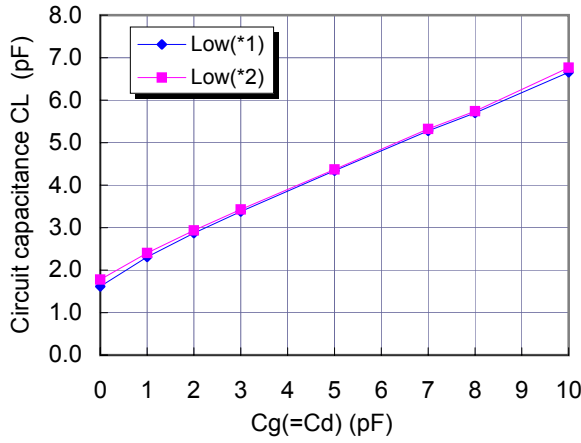
VT-200-FL 6.0pF with uPD78F1009GB-16BT [LQFP(10x10) 0.50mm pitch]

Measurement conditions : Vdd=1.8V to 5.5V at 25°C

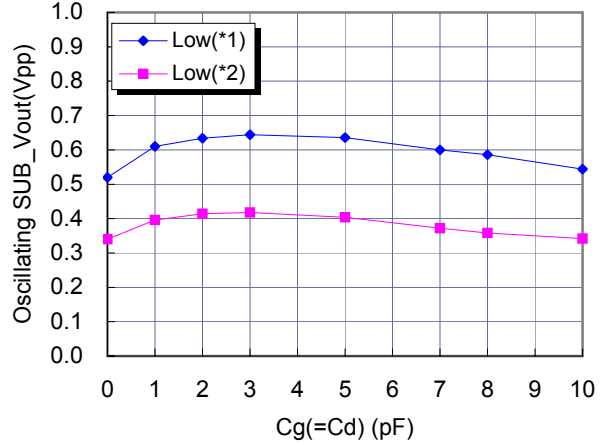


Referential Data(2) : External capacitance Cg,Cd characteristics

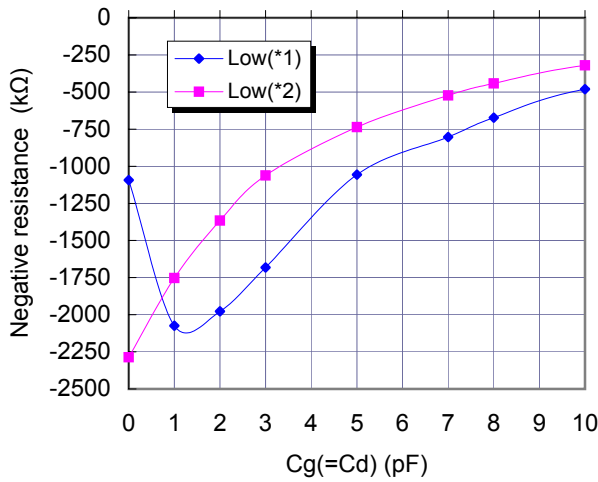
Circuit capacitance CL / external Cg,Cd coefficient



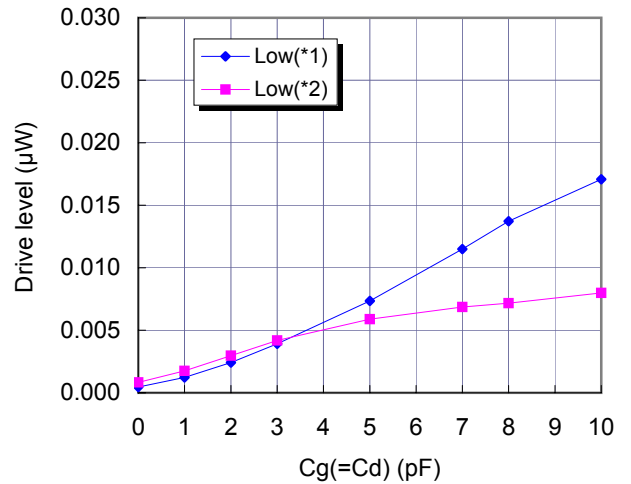
SUB\_Vout / external Cg,Cd coefficient



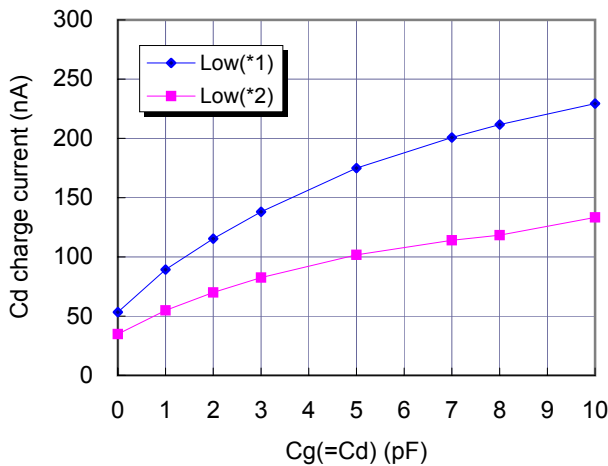
Negative resistance / external Cg,Cd coefficient



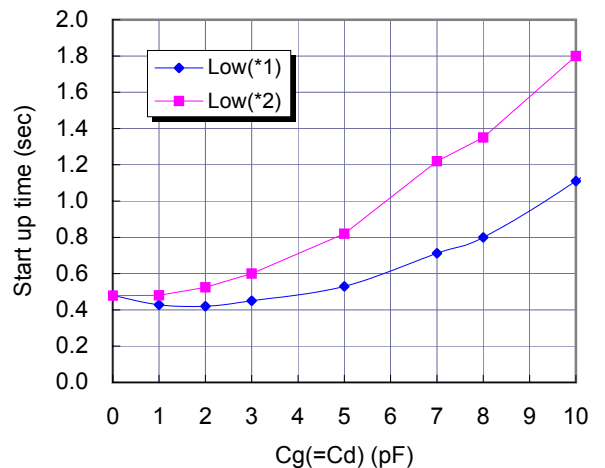
Drive level / external Cg,Cd coefficient



Cd charge current / external Cg,Cd coefficient



Start up time / external Cg,Cd coefficient



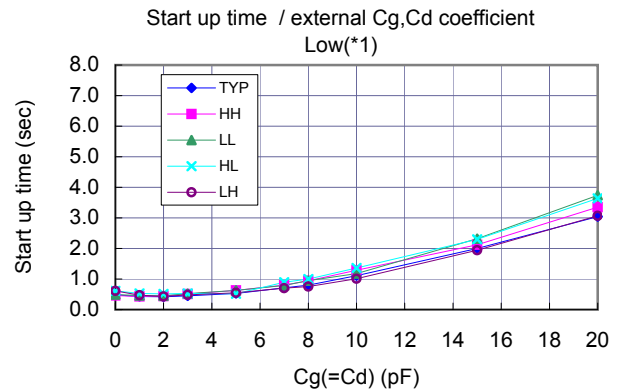
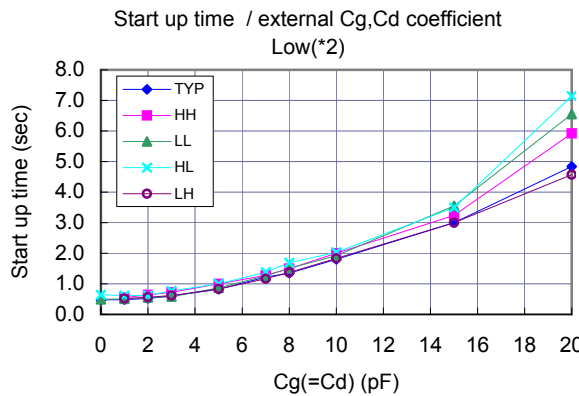
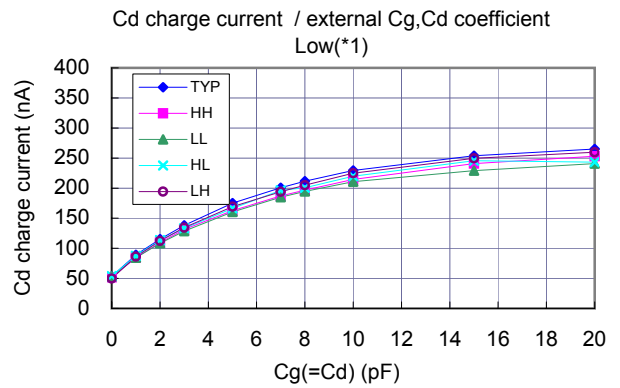
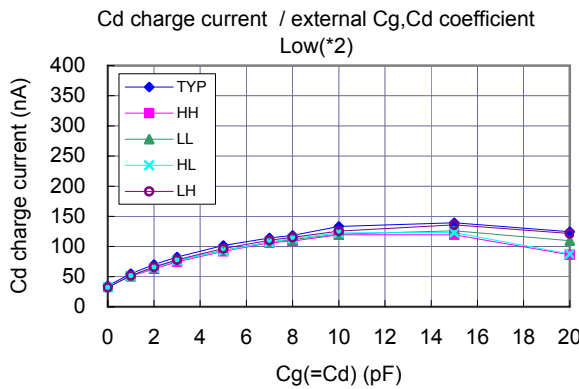
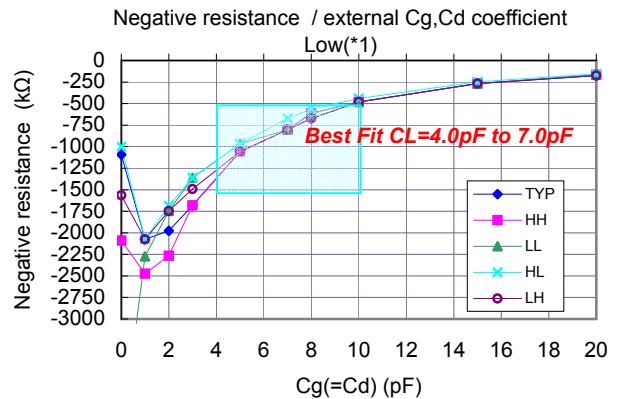
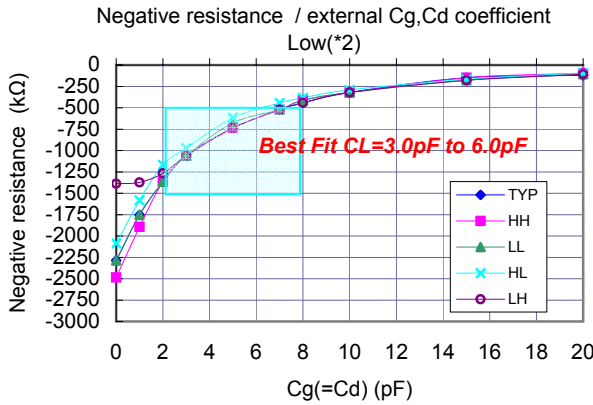
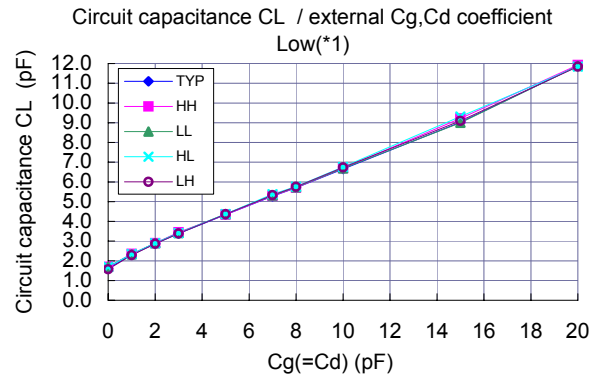
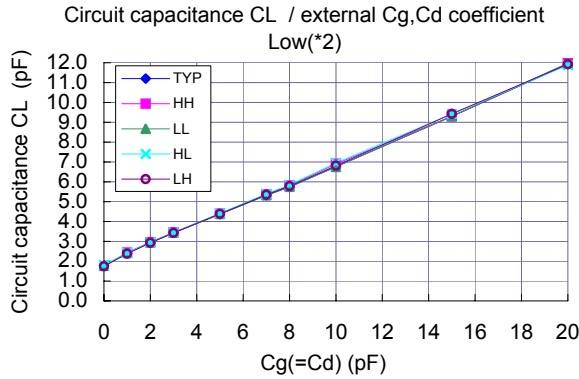
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Referential Data(3) : External capacitance Cg,Cd characteristics



\*2 ; Extremely low consumption current mode

\*1 ; Low consumption current mode

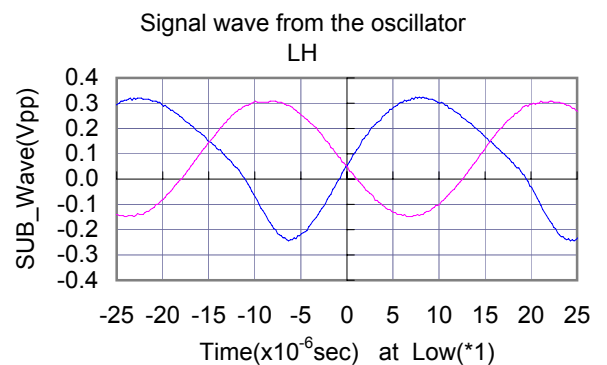
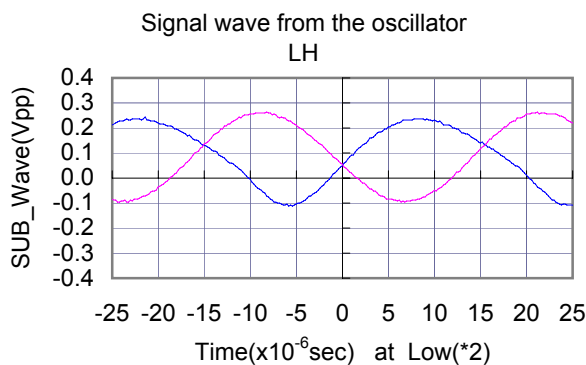
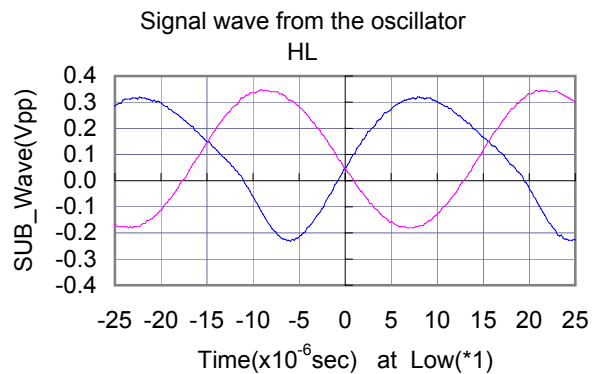
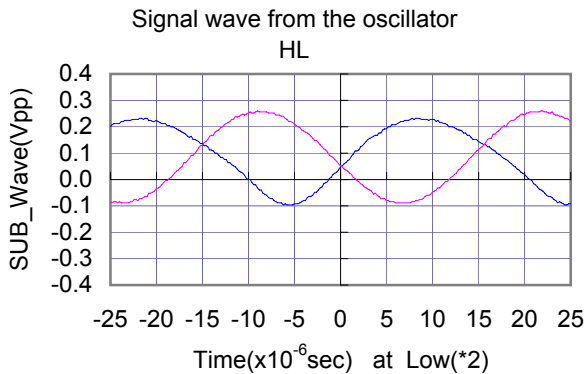
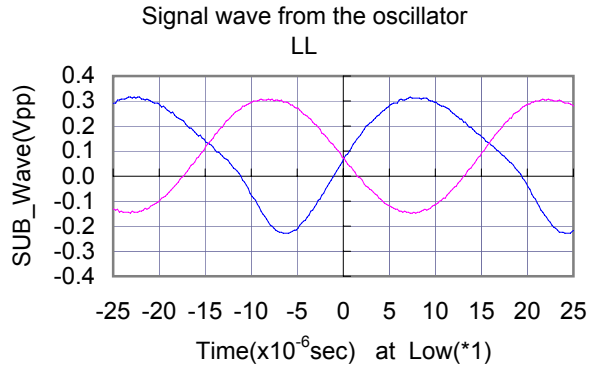
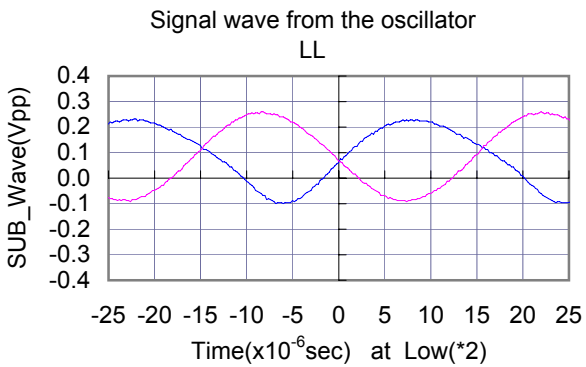
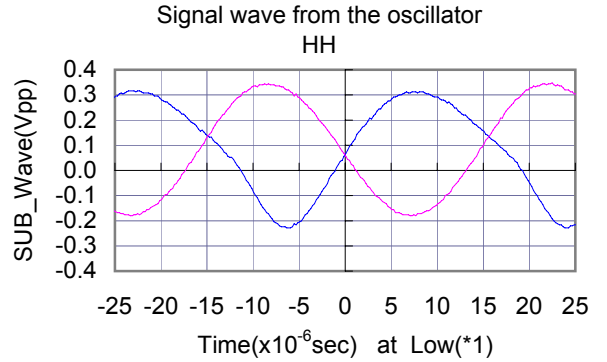
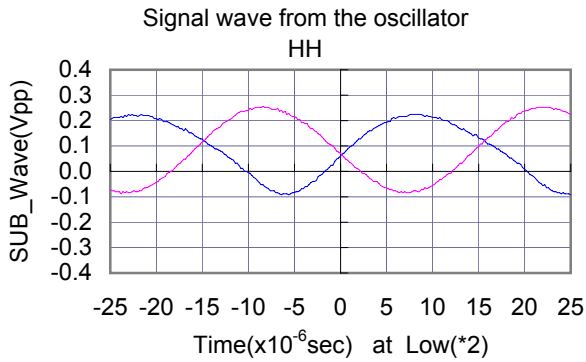
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Measurement conditions : Vdd=1.8V to 5.5V at 25°C



Referential Data(4) : Signal wave from oscillator(HH,HL,LH,LL)



\*2 ; Extremely low current onsumption mode

\*1 ; Low current consumption mode

**Evaluation of a Low Frequency Clock Oscillation Circuit**

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Measurement conditions : V<sub>DD</sub>=1.8V to 5.5V at 25°C

## Referential Data(5) : Negative resistance (RL) &amp; Oscillation allowance (M)\_Map

Negative resistance RL(KΩ) at 25°C

TYP_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	120	175	285	11.9
15	147	267	477	9.3
10	320	480	800	6.8
8	442	672	1052	5.7
5	737	1057	1877	4.4
2	1366	1976	2266	2.9
0	2287	1087	0	1.8

Oscillation allowance M (= RL / R<sub>1max</sub>) at 25°C

TYP_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	2	4	6	11.9
15	3	5	10	9.3
10	6	10	16	6.8
8	9	13	21	5.7
5	15	21	38	4.4
2	27	40	45	2.9
0	46	22	0	1.8

\* R<sub>1max</sub>=50kΩ

Negative resistance RL(KΩ) at 25°C

HH_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	96	165	265	12.0
15	147	267	437	9.3
10	320	480	800	6.9
8	412	612	1152	5.8
5	736	1056	2056	4.4
2	1366	2266	3566	3.0
0	2485	2085	0	1.8

Oscillation allowance M (= RL / R<sub>1max</sub>) at 25°C

HH_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	2	3	5	12.0
15	3	5	9	9.3
10	6	10	16	6.9
8	8	12	23	5.8
5	15	21	41	4.4
2	27	45	71	3.0
0	50	42	0	1.8

\* R<sub>1max</sub>=50kΩ

Negative resistance RL(KΩ) at 25°C

LL_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	107	165	265	12.0
15	177	267	437	9.3
10	320	480	670	6.7
8	412	612	802	5.7
5	677	967	1057	4.4
2	1366	1746	1886	2.9
0	2287	4387	0	1.8

Oscillation allowance M (= RL / R<sub>1max</sub>) at 25°C

LL_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	2	3	5	12.0
15	4	5	9	9.3
10	6	10	13	6.7
8	8	12	16	5.7
5	14	19	21	4.4
2	27	35	38	2.9
0	46	88	0	1.8

\* R<sub>1max</sub>=50kΩ

Negative resistance RL(KΩ) at 25°C

HL_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	92	155	245	11.9
15	167	247	407	9.4
10	290	440	730	7.0
8	382	562	962	5.8
5	616	966	1486	4.4
2	1166	1686	2666	3.0
0	2086	996	0	1.8

Oscillation allowance M (= RL / R<sub>1max</sub>) at 25°C

HL_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	2	3	5	11.9
15	3	5	8	9.4
10	6	9	15	7.0
8	8	11	19	5.8
5	12	19	30	4.4
2	23	34	53	3.0
0	42	20	0	1.8

\* R<sub>1max</sub>=50kΩ

Negative resistance RL(KΩ) at 25°C

LH_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	107	175	285	11.9
15	177	267	477	9.4
10	320	480	800	6.8
8	442	672	1052	5.8
5	737	1057	1567	4.4
2	1266	1746	2666	2.9
0	1388	1558	0	1.7

Oscillation allowance M (= RL / R<sub>1max</sub>) at 25°C

LH_Cg,Cd	Low(*2)	Low(*1)	Normal	CL(pF)
20	2	4	6	11.9
15	4	5	10	9.4
10	6	10	16	6.8
8	9	13	21	5.8
5	15	21	31	4.4
2	25	35	53	2.9
0	28	31	0	1.7

\* R<sub>1max</sub>=50kΩ

**Evaluation of a Low Frequency Clock Oscillation Circuit**

VT-200-FL 6.0pF with uPD78F1009GB-16BT [LQFP(10x10) 0.50mm pitch]

Measurement conditions : Vdd=1.8V to 5.5V



Referential Data(6) : Circuit characteristics (TYP,HH,LL) at -40°C / +85°C

at -40°C

Circuit characteristics (TYP)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	322	482
Oscillation allowance: M( times )	6	10
Oscillation start up time: Ts( sec )	2.11	1.15

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

at 85°C

Circuit characteristics (TYP)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	522	802
Oscillation allowance: M( times )	10	16
Oscillation start up time: Ts( sec )	1.15	0.61

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

at -40°C

Circuit characteristics (HH)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	292	482
Oscillation allowance: M( times )	6	10
Oscillation start up time: Ts( sec )	2.24	1.65

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

at 85°C

Circuit characteristics (HH)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	522	802
Oscillation allowance: M( times )	10	16
Oscillation start up time: Ts( sec )	1.03	0.64

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

at -40°C

Circuit characteristics (LL)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	322	482
Oscillation allowance: M( times )	6	10
Oscillation start up time: Ts( sec )	2.38	1.41

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

at 85°C

Circuit characteristics (LL)	Low(*2)	Low(*1)
Negative resistance :   - RL   ( kΩ )	522	672
Oscillation allowance: M( times )	10	13
Oscillation start up time: Ts( sec )	1.29	0.78

\*1; Low current consumption mode (M=12 at 25°C)

\*2; Extremely low current consumption mode (M=8 at 25°C)

**Extremely low power consumption of 1/10 : 78K0R/Kx3-L & Low CL Sseries**

*\* It is achieved by the technical collaboration to make low AMP and low CL Tuning Fork.*

**NEC MPU 78K0R/Kx3-L series**  
 78K0R/KC3-L;uPD78F1000MC/1001MC/1002MC/1003MC  
 uPD78F1000GA/1001GA/1002GA/1003GA  
 uPD78F1000GB/1001GB/1002GB/1003GB  
 78K0R/KD3-L;uPDF1004GB/1005GB/1006GB  
 78K0R/KE3-L;uPD78F1007GA/1008GA/1009GA  
 uPD78F1007GB/1008GB/1009GB  
 uPD78F1007GK/1008GK/1009GK

Normal current consumption <500nA

