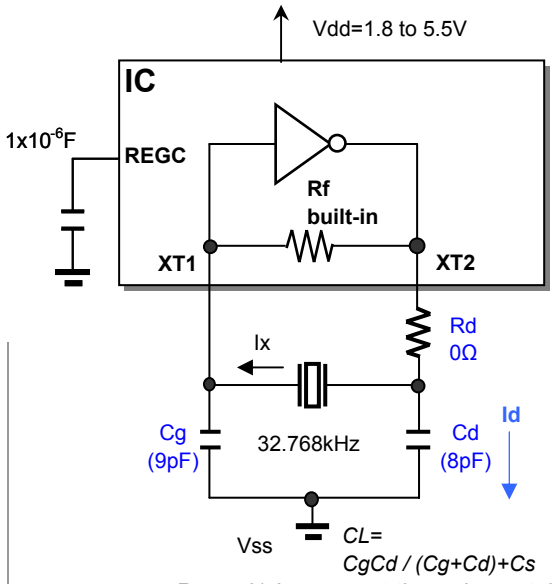
Evaluation of a Low Frequency Clock Oscillation Circuit

VT-200-FL 6.0pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

Measurement conditions : 3.0V

New

Model	:VT-200-FL
Frequency	:Fo=32.768kHz
Frequency tolerance	:dF/Fo= +/-20x10^{-6}
Load capacitance	:CL=6.0pF
Equivalent series resistance	:R1=50kΩ max
Max. drive level	:DL=1μW max
Level of drive	:DL=0.01μW typ

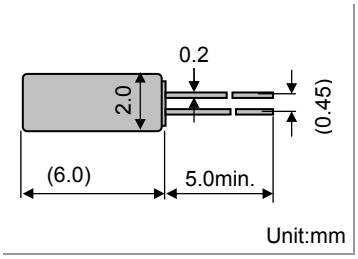


Remark) Ix : current through crystal

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)



	REGVDD	Oscillation mode
Mode 1	2.4V	Low (*1)
Mode 2	1.8V	

Low power cnsumption 78K0R/Kx3-L and VT-200-FL 6.0pF

***1 ; Low current consumption mode**

MODEL:VT-200-FL 6.0pF with uPD78F1014GC at 25°C

Key specifications	mode 2	mode 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)	mode 2	mode 1	Remarks
Matching Accuracy : df / f (x10^{-6})	0.9	1.1	Frequency offset volume at specified Vdd
Voltage Fluctuation : +/-df / V (x10^{-6})	0.0	0.0	Vdd +/-10% (Standard operating voltage range)
Drive Level : DL (μW)	0.01	0.01	DL=Ix^2 Re < 1x10^{-6}W,Re=R1(1 + Co / CL)^2
Negative resistance : | - RL | (kΩ)	516	516	5 times larger than R_{1MAX}
Oscillation allowance : M (times)	10	10	Judgmental standard of oscillation stability
Low current consumption : Id (nA)	**213**	**213**	**Cd charge current, Id = ωCd*Vd < 250nA**
Voltage of oscillation start : Vstrat (V)	1.72	1.61	
Voltage of oscillation stop : Vstop (V)	1.59	1.59	
Oscillation start up time : Ts (sec)	1.05	1.05	Time to reach 90% of output level, Ts < 2.0sec

Temperature characteristics of circuit		mode 2	mode 1	Remarks
at -40°C	Variation : df / T (x10^{-6})	-142	-142	Typ.Tp=25°C (K = -3.5×10^{-8} / °C^2)
at +85°C	Variation : df / T (x10^{-6})	-124	-124	Typ.Tp=25°C (K = -3.5×10^{-8} / °C^2)

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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78K0R/Kx3-L

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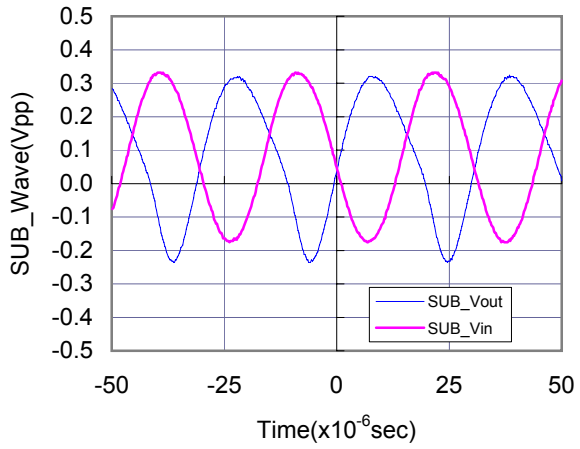
VT-200-FL 6.0pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

Measurement conditions : 3.0V

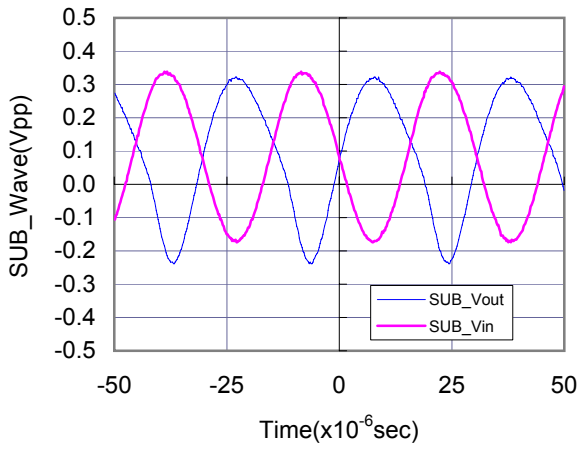
Low current consumption mode

Test Data at 25°C

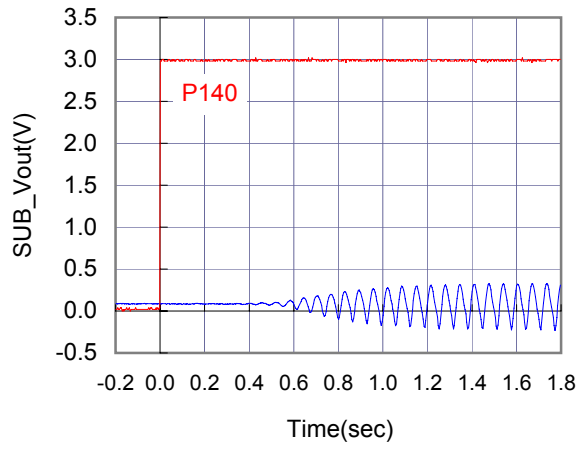
Signal wave from the oscillator
Mode 2



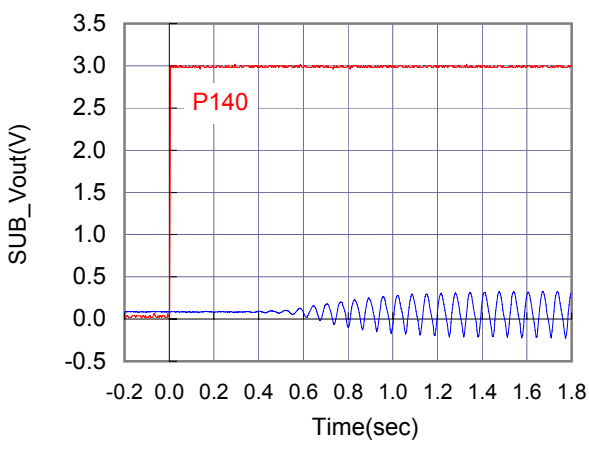
Signal wave from the oscillator
Mode 1



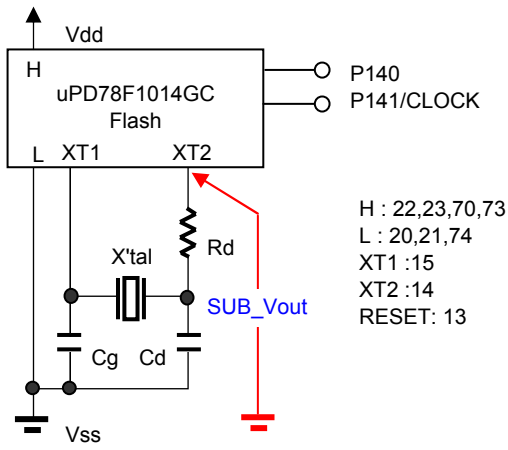
Start up time of SUB_Vout
Mode 2



Start up time of SUB_Vout
Mode 1

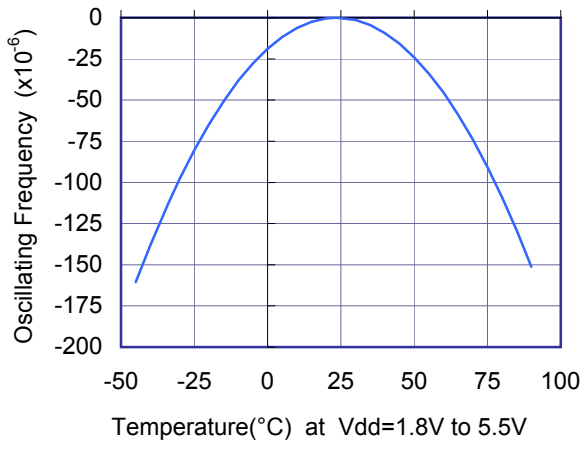


Test Circuit



H : 22,23,70,73
L : 20,21,74
XT1 :15
XT2 :14
RESET: 13

Temperature characteristics of oscillating frequency



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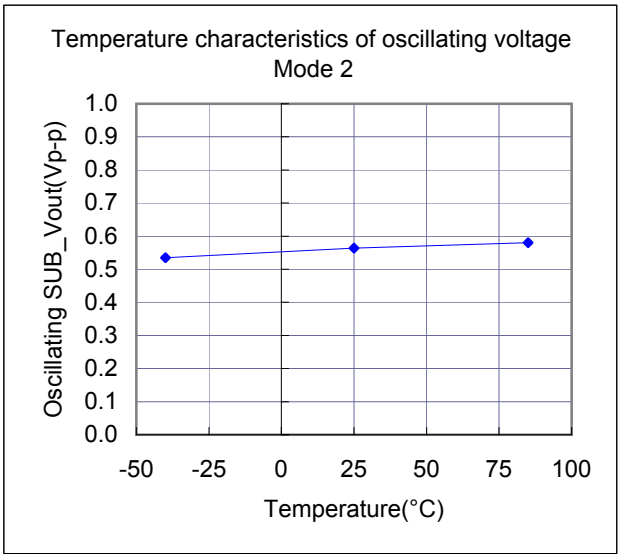
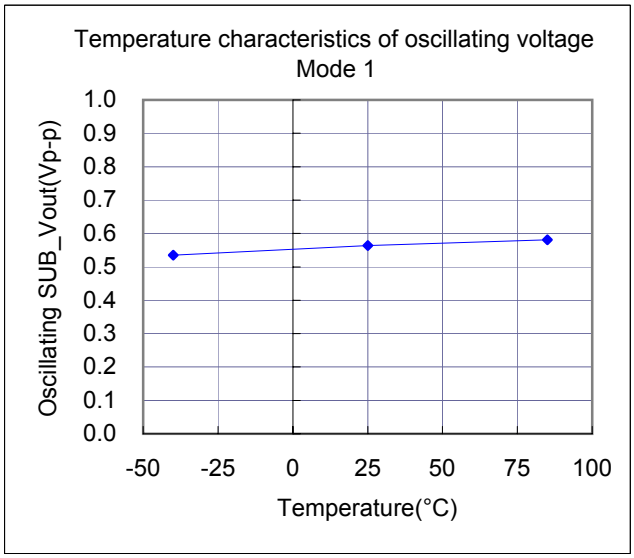
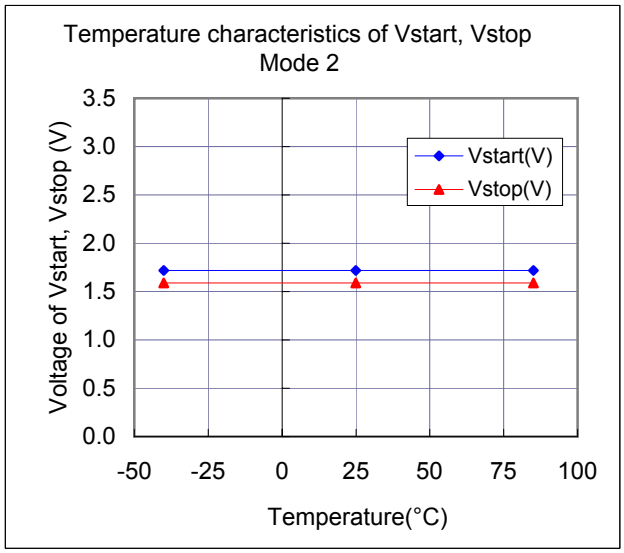
Measurement conditions : 3.0V

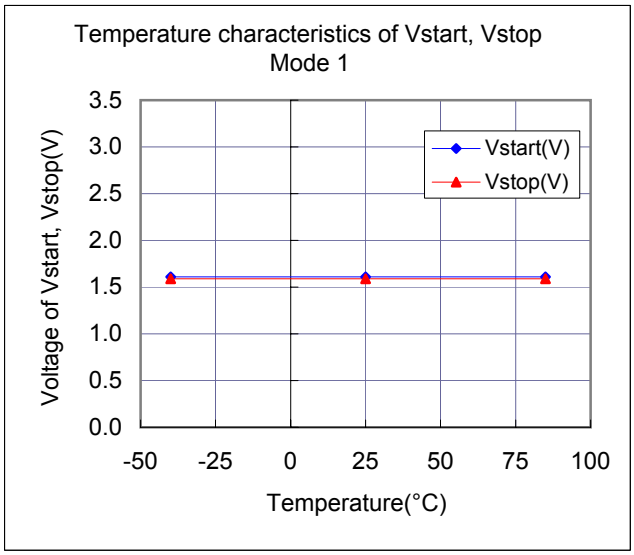
Low current consumption mode

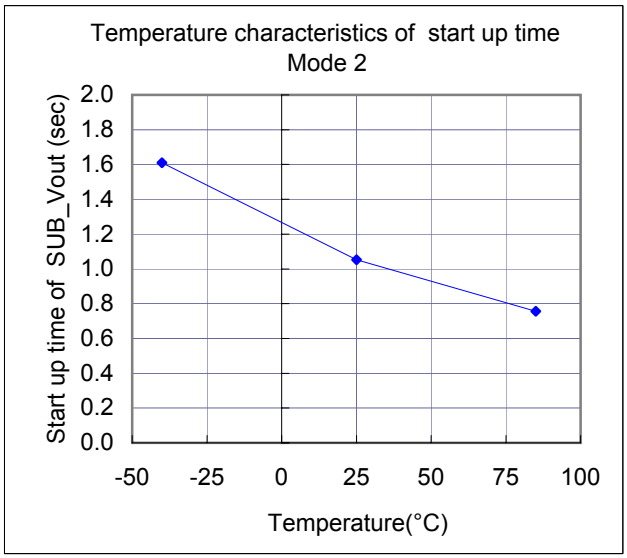
Test Data : Temperature characteristics

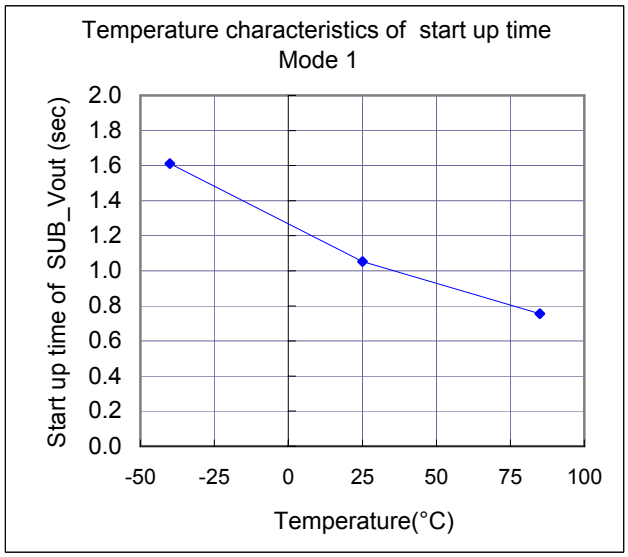












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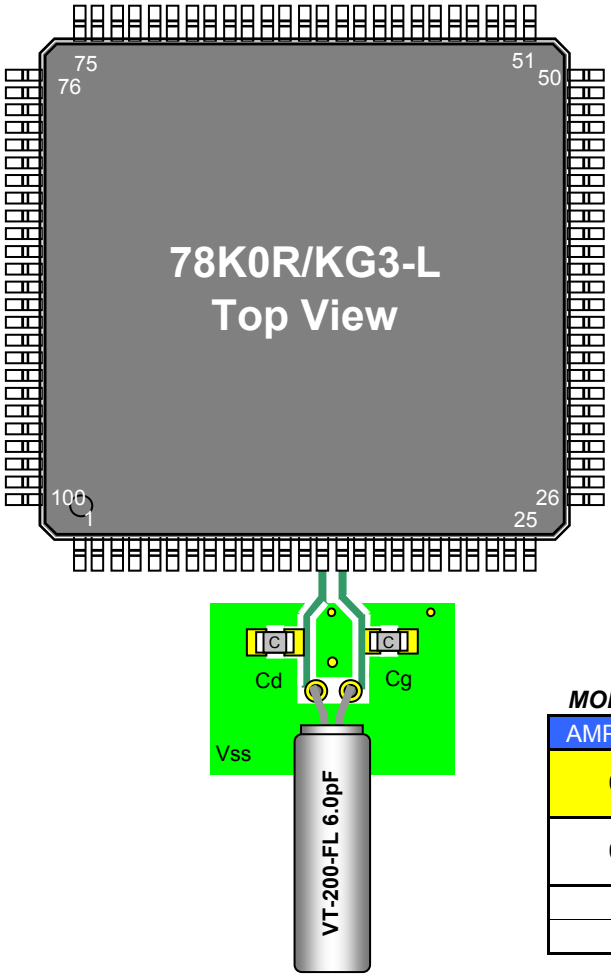
Measurement conditions : 3.0V

Low current consumption mode

Referential components layout(see Figure 1)



78K0R/Kx3-L series
**78K0R/KF3-L*
uPD78F1010
uPD78F1011
uPD78F1012
**78K0R/KG3-L*
uPD78F1013
uPD78F1014

MODEL:VT-200-FL 6.0pF with uPD78F1014GC at 25°C

AMPHS1	AMPHS0	Oscillation mode selection
0	0	Low consumption oscillation mode. (default) ; Id=210nA typ.
0	1	Normal consumption oscillation mode. Id=380nA typ.
1	0	Extremely low consumption oscillation mode. Id=120nA typ.
1	1	

Figure 1 Referential components layout

Notes for 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).

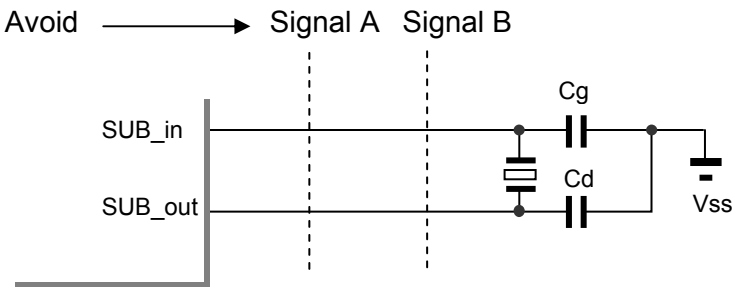


Figure 2 Example of Incorrect Board Design

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

Low current consumption mode

[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	35.4	0.86	2.065	66.5
	2	6.0	32768.05	32763.10	34.8	0.85	2.068	67.5
	3	6.0	32768.11	32763.13	34.6	0.87	2.088	67.3

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

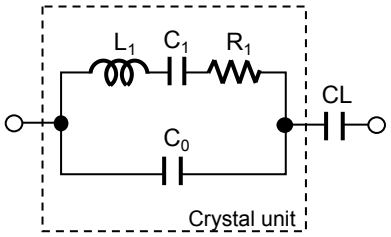
MODE	IC sample	Fosc(Hz)	df / f(x10^{-6})	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1	Sample 1	32768.07	1.4	0.02	9	0.58	220	1.58	1.19
	Sample 2	32768.06	1.1	0.01	10	0.54	204	1.58	1.17
	Sample 3	32768.06	1.1	0.01	10	0.56	213	1.61	1.05
	Sample 4	32768.06	1.2	0.01	11	0.59	223	1.59	0.93
	Sample 5	32768.05	0.9	0.01	10	0.54	205	1.59	0.94

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

MODE	IC sample	Fosc(Hz)	df / f(x10^{-6})	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 2	Sample 1	32768.06	1.2	0.02	9	0.58	220	1.67	1.19
	Sample 2	32768.05	0.8	0.01	10	0.54	204	1.68	1.17
	Sample 3	32768.05	0.9	0.01	10	0.56	213	1.72	1.05
	Sample 4	32768.05	1.0	0.01	11	0.59	223	1.69	0.93
	Sample 5	32768.04	0.7	0.01	10	0.54	206	1.70	0.94

Remark (see figure 3)

$$Fo = fr \times \{ C1/ (2\times(Co + CL)) + 1 \} \quad (Hz)$$



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

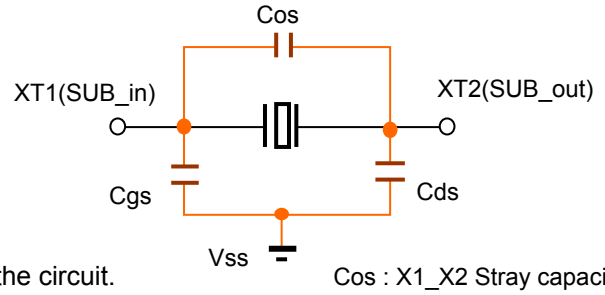
Remark (see figure 4)

Approximate formula of the load capacitance of the circuit CL,

$$CL = Cg\times Cd / (Cg + Cd) + Cs \quad (pF)$$

$$Cs = Cgs\times Cds / (Cgs + Cds) + Cos \quad (pF)$$

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



Cos : X1_X2 Stray capacitance
Cgs : X1_Vss Stray capacitance
Cds : X2_Vss Stray capacitance

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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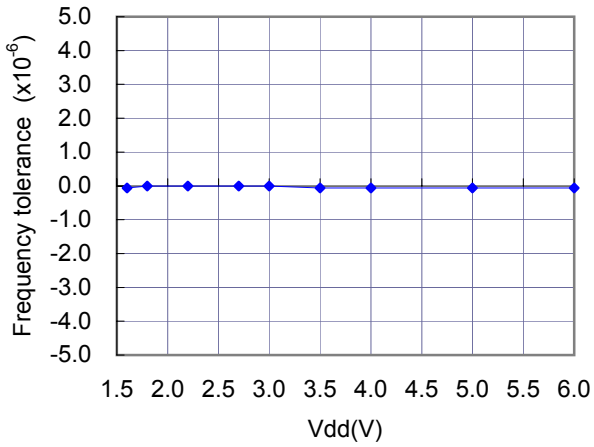
Measurement conditions : Vcc=(1.6V) to (6.0V) at 25°C

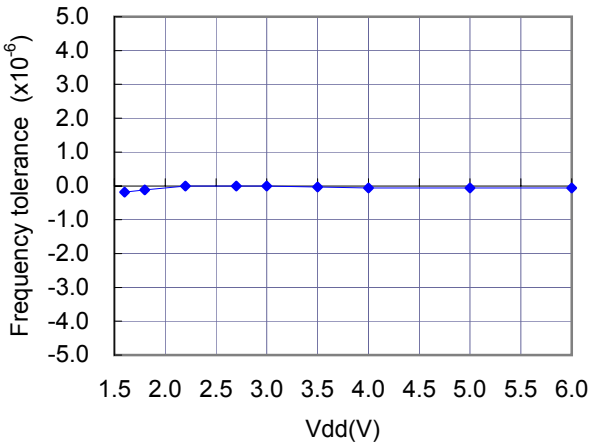
Low current consumption mode

Referential Data(1) : Voltage characteristics

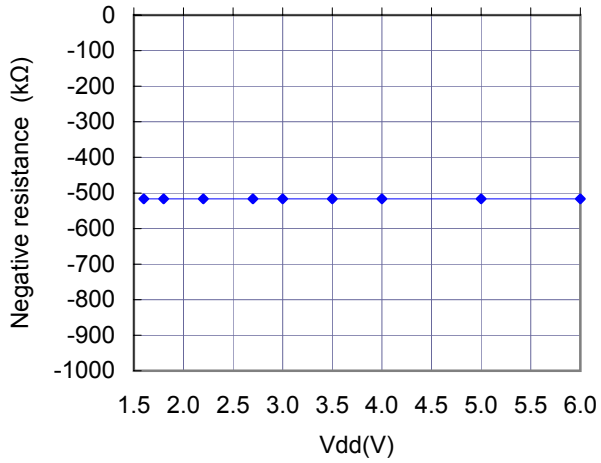
Frequency / voltage coefficient
Mode 2



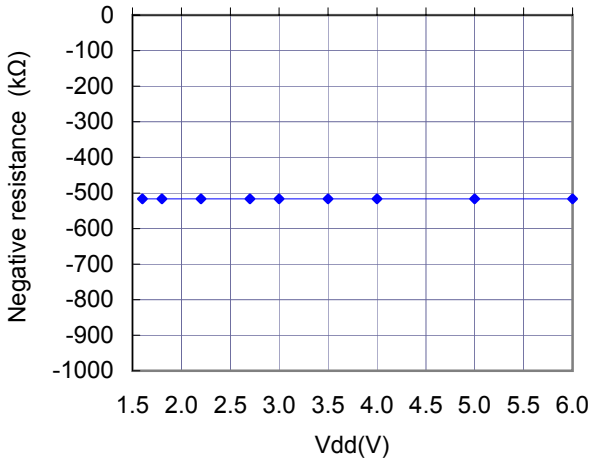
Frequency / voltage coefficient
Mode 1



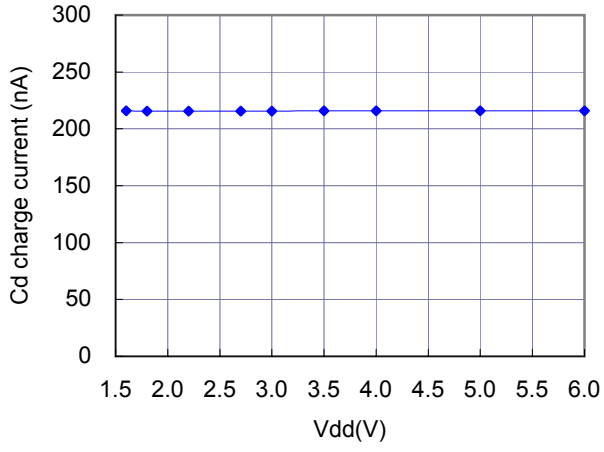
Negative resistance / voltage coefficient
Mode 2



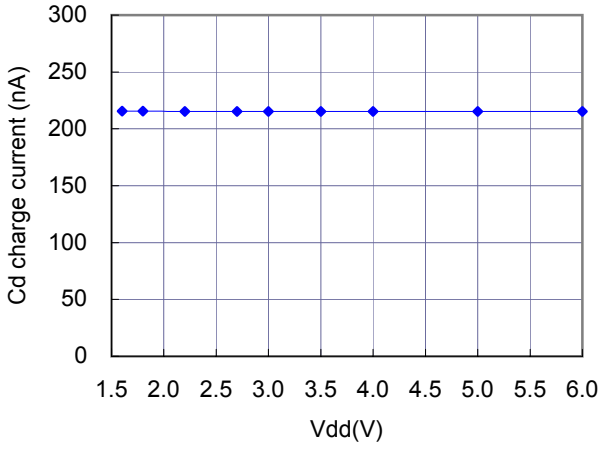
Negative resistance / voltage coefficient
Mode 1



Cd charge current / voltage coefficient
Mode 2



Cd charge current / voltage coefficient
Mode 1



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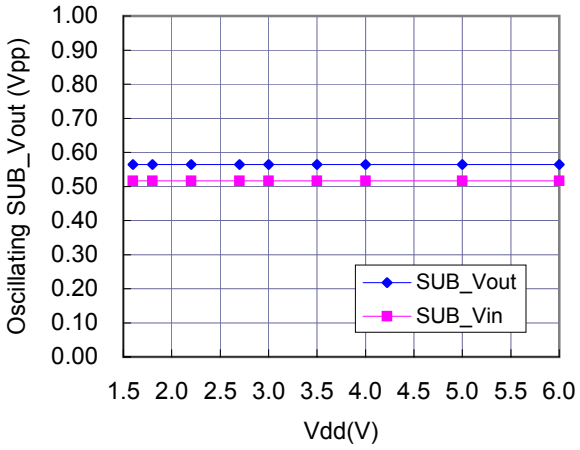
Measurement conditions : Vcc=(1.6V) to (6.0V) at 25°C

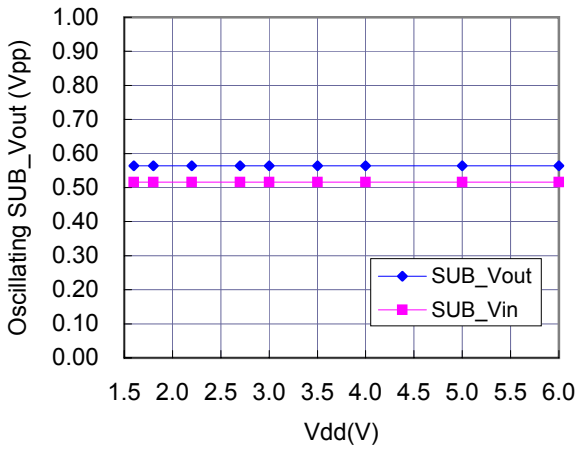
Low current consumption mode

Referential Data(2) : Voltage characteristics

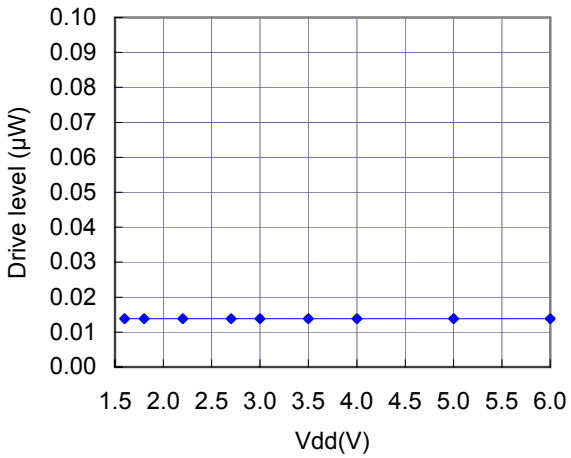
Output signal Wave / voltage coefficient
Mode 2



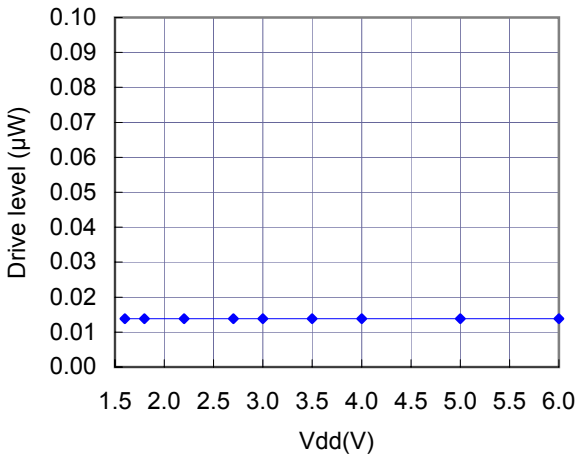
Output signal Wave / voltage coefficient
Mode 1



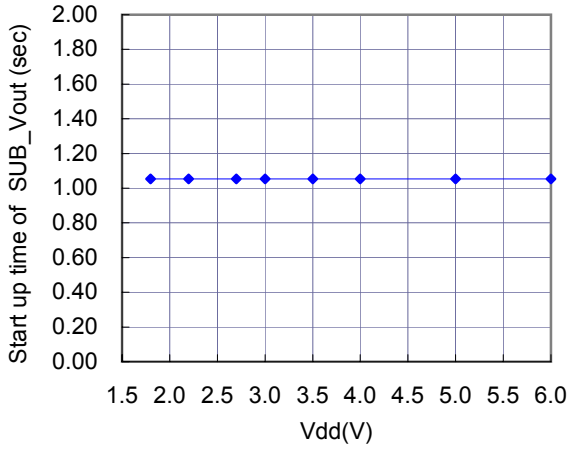
Drive level / voltage coefficient
Mode 2



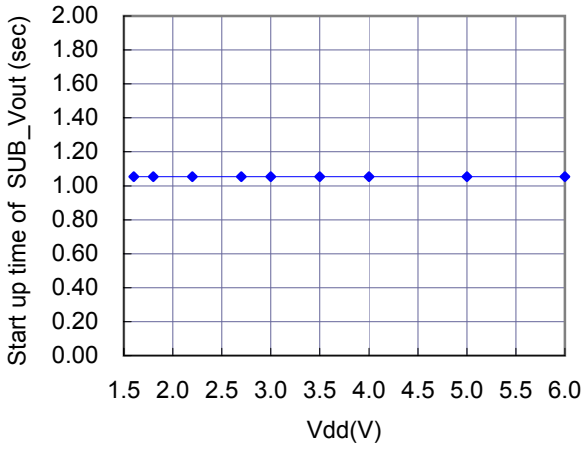
Drive level / voltage coefficient
Mode 1



Start up time / voltage coefficient
Mode 2



Start up time / voltage coefficient
Mode 1



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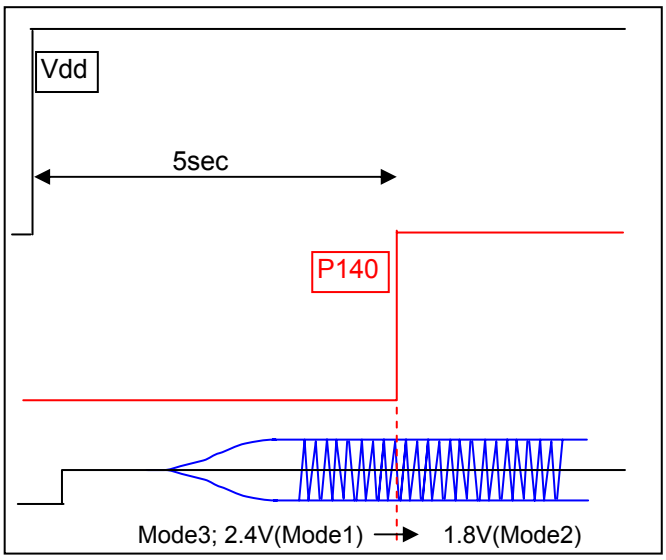
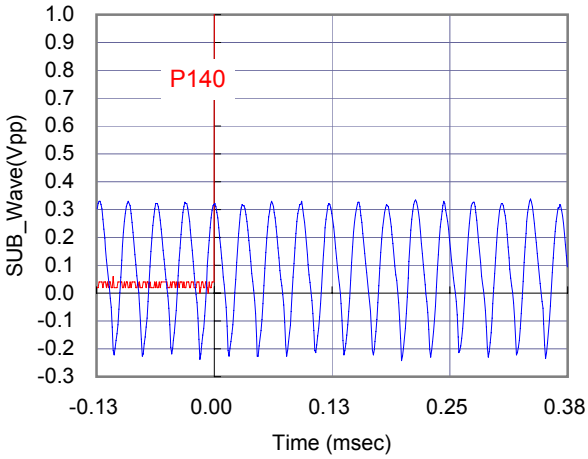
Measurement conditions : Vdd=3.0V at 25°C

Low current consumption mode

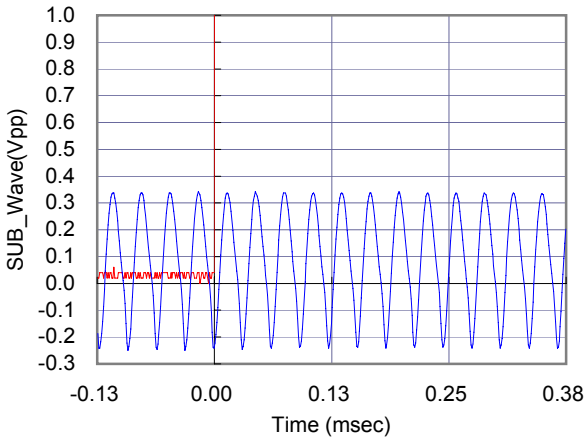
Referential Data(3) : Mode 3 characteristics



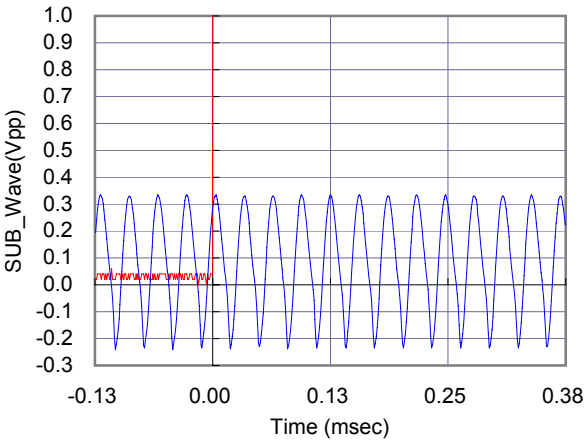
Signal wave from the oscillator
Mode 3; Sample 1



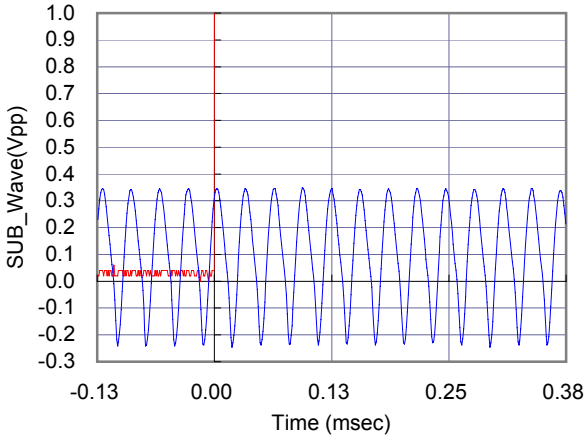
Signal wave from the oscillator
Mode 3; Sample 2



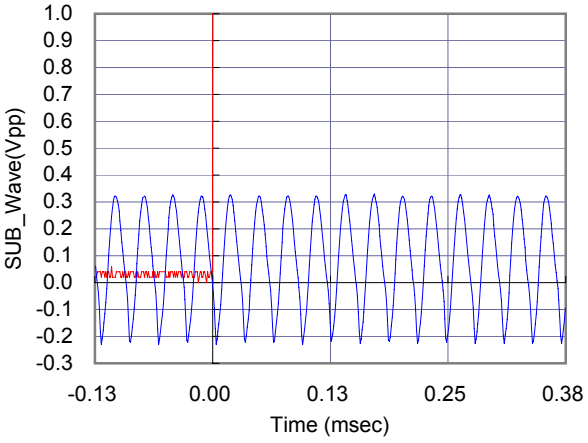
Signal wave from the oscillator
Mode 3; Sample 3



Signal wave from the oscillator
Mode 3; Sample 4



Signal wave from the oscillator
Mode 3; Sample 5



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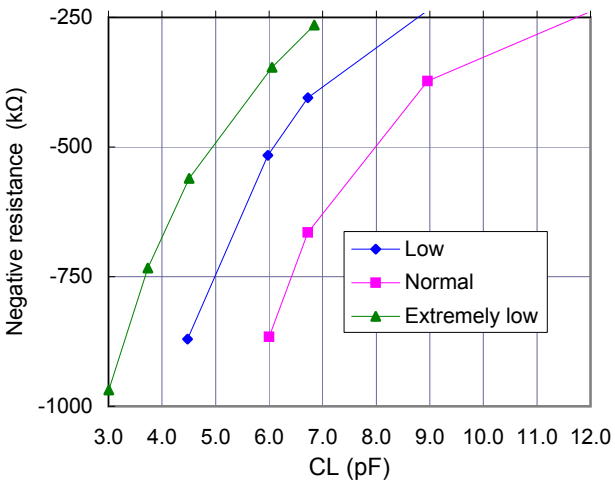
Measurement conditions : Vdd=3.0V at 25°C

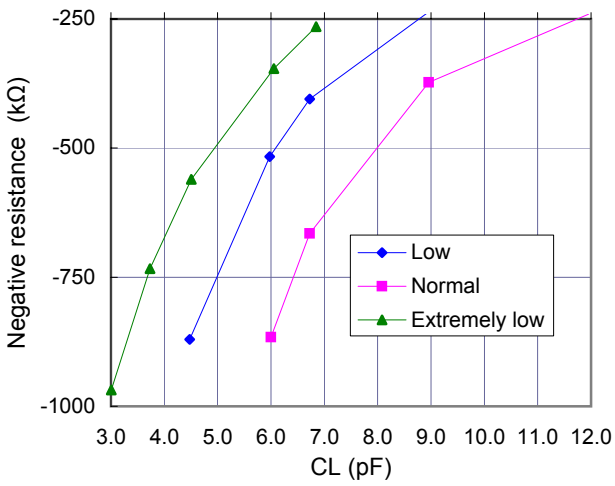
Low current consumption mode

Referential Data(4) : Load capacitance characteristics(Low,Normal,Extremely low)

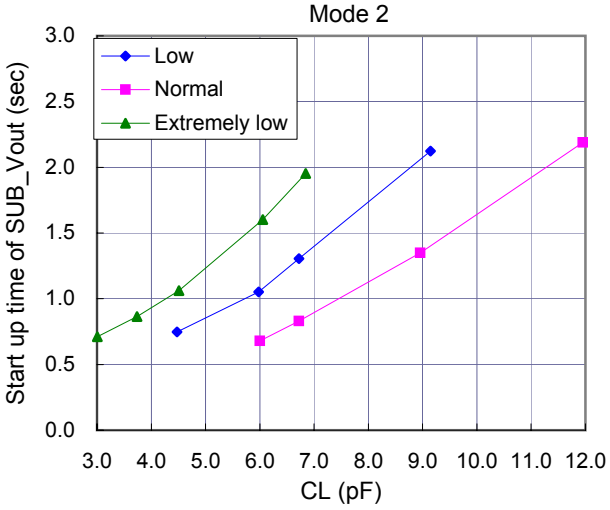
Negative resistance / load capacitance coefficient
Mode 2



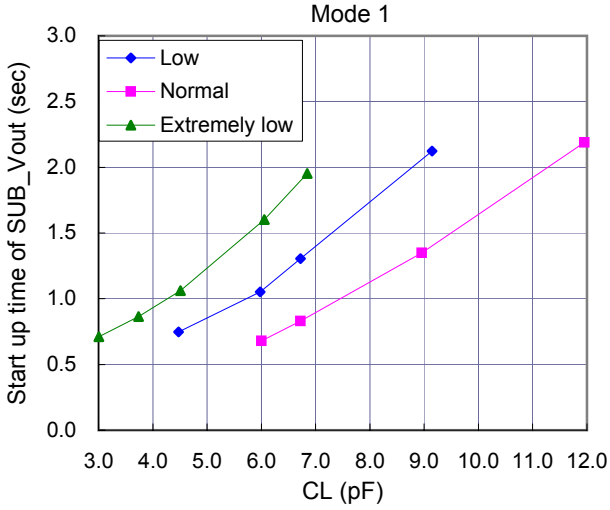
Negative resistance / load capacitance coefficient
Mode 1



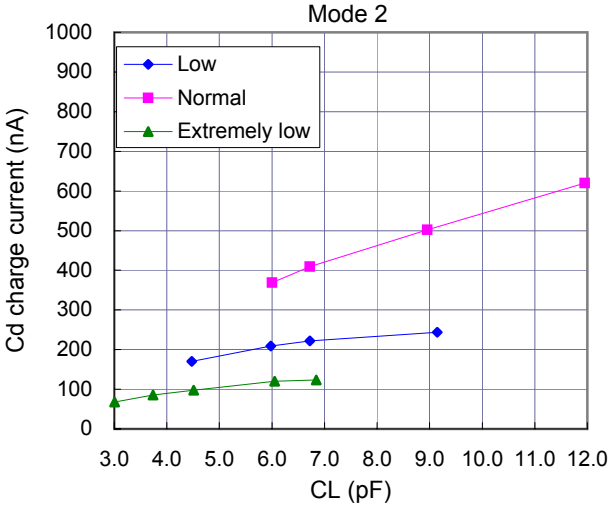
Start up time / load capacitance coefficient
Mode 2



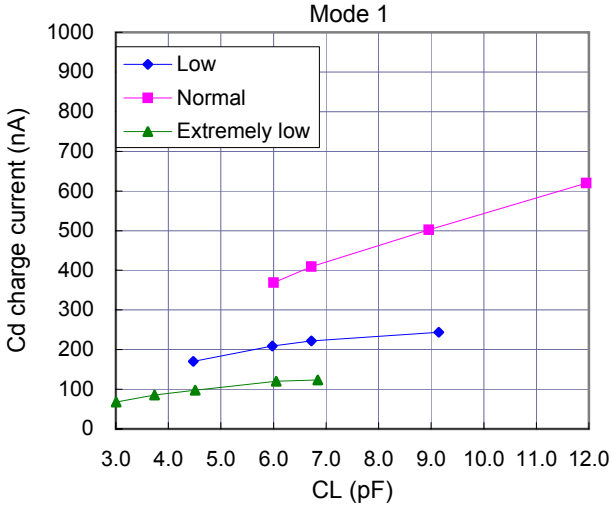
Start up time / load capacitance coefficient
Mode 1



Cd charge current / load capacitance coefficient
Mode 2



Cd charge current / load capacitance coefficient
Mode 1



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Evaluation of a Low Frequency Clock Oscillation Circuit

VT-200-FL 6.0pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

Measurement conditions : Vdd=3.0V at 25°C

Low current consumption mode

Referential Data(5) : IC sample characteristics(Low,Normal,Extremely low)

Table 1 Oscillation mode selection of XT1 oscillation circuit and load capacitance for a resonator

AMPHS1	AMPHS0	Oscillation mode selection *	Recommended load capacitance (Cd charge current)
0	0	Low consumption oscillation mode.(default)	6.0pF (210nA typ)
0	1	Normal consumption oscillation mode.	6.0pF (380nA typ),12.5pF (630nAtyp)
1	0	Extremely low consumption oscillation mode.	6.0pF (120nA typ),3.7pF (80nA typ)
1	1	(DC bias current; 200nA max. at 25°C)	3.0pF (65pF typ)

**78K0R/Kx3-L series; μPD78F1010 to μPD78F1014 & VT-200 series*

Low current consumption mode; IC sample Rd=0Ω,Cg=9pF,Cd=8pF,CL=6.0pF

MODE	IC sample	Fosc(Hz)	df / f(x10-6)	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1 (2.4V)	Sample 1	32768.07	1.4	0.015	9	0.58	220	1.58	1.19
	Sample 2	32768.06	1.1	0.014	10	0.54	204	1.58	1.17
	Sample 3	32768.06	1.1	0.014	10	0.56	213	1.61	1.05
	Sample 4	32768.06	1.2	0.010	11	0.59	223	1.59	0.93
	Sample 5	32768.05	0.9	0.011	10	0.54	205	1.59	0.94
Mode 2 (1.8V)	Sample 1	32768.06	1.2	0.015	9	0.58	220	1.67	1.19
	Sample 2	32768.05	0.8	0.014	10	0.54	204	1.68	1.17
	Sample 3	32768.05	0.9	0.014	10	0.56	213	1.72	1.05
	Sample 4	32768.05	1.0	0.010	11	0.59	223	1.69	0.93
	Sample 5	32768.04	0.7	0.011	10	0.54	206	1.70	0.94

Normal current consumption mode; IC sample Rd=0Ω,Cg=9pF,Cd=8pF,CL=6.0pF

MODE	IC sample	Fosc(Hz)	df / f(x10-6)	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1 (2.4V)	Sample 1	32768.04	0.7	0.019	15	1.00	412	1.58	0.77
	Sample 2	32768.04	0.7	0.019	16	0.96	394	1.58	0.77
	Sample 3	32768.03	0.2	0.016	17	0.92	381	1.61	0.68
	Sample 4	32768.02	0.0	0.013	19	0.84	350	1.59	0.71
	Sample 5	32768.01	-0.4	0.012	16	0.83	344	1.59	0.70
Mode 2 (1.8V)	Sample 1	32768.04	0.5	0.019	15	1.00	412	1.67	0.77
	Sample 2	32768.04	0.6	0.019	16	0.96	395	1.68	0.77
	Sample 3	32768.02	0.1	0.016	17	0.92	381	1.72	0.68
	Sample 4	32768.02	-0.2	0.013	19	0.84	351	1.69	0.71
	Sample 5	32768.00	-0.5	0.013	16	0.83	345	1.70	0.70

Extremely low current consumption mode; IC sample Rd=0Ω,Cg=9pF,Cd=8pF,CL=6.0pF

MODE	IC sample	Fosc(Hz)	df / f(x10-6)	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1 (2.4V)	Sample 1	32768.02	0.1	0.007	6	0.35	122	1.58	1.79
	Sample 2	32767.99	-0.8	0.006	6	0.32	112	1.58	1.69
	Sample 3	32768.03	0.2	0.006	7	0.34	119	1.61	1.60
	Sample 4	32768.03	0.2	0.007	8	0.37	127	1.59	1.39
	Sample 5	32768.01	-0.3	0.006	6	0.33	114	1.59	1.39
Mode 2 (1.8V)	Sample 1	32768.02	-0.2	0.007	6	0.35	123	1.67	1.79
	Sample 2	32767.99	-1.1	0.006	6	0.32	113	1.68	1.69
	Sample 3	32768.02	0.0	0.006	7	0.34	119	1.72	1.60
	Sample 4	32768.02	0.1	0.007	8	0.37	128	1.69	1.39
	Sample 5	32768.00	-0.5	0.006	6	0.33	115	1.70	1.39

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Evaluation of a Low Frequency Clock Oscillation Circuit

VT-200-FL 6.0pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

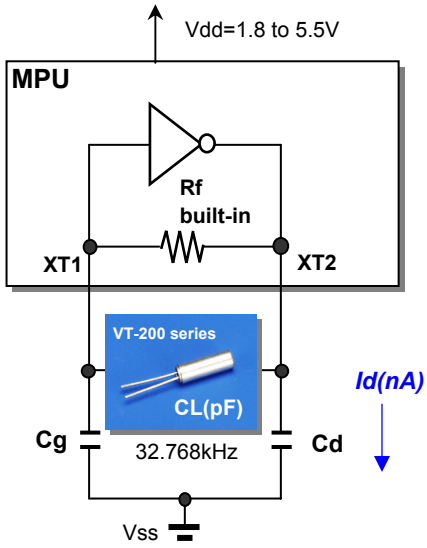
Measurement conditions : Vdd=3.0V at 25°C — **Low current consumption mode**

Referential Data(5) : Selection of XT1 oscillation mode and recommended load capacitance

For 78K0R/Kx3-L series

XT1 oscillation circuit has the function (via software) to select the XT1 oscillation mode.
The XT1 oscillation mode can be switched over just one time among normal oscillation (Normal), low consumption oscillation (Low), and "extremely low consumption oscillation" mode (E-Low).

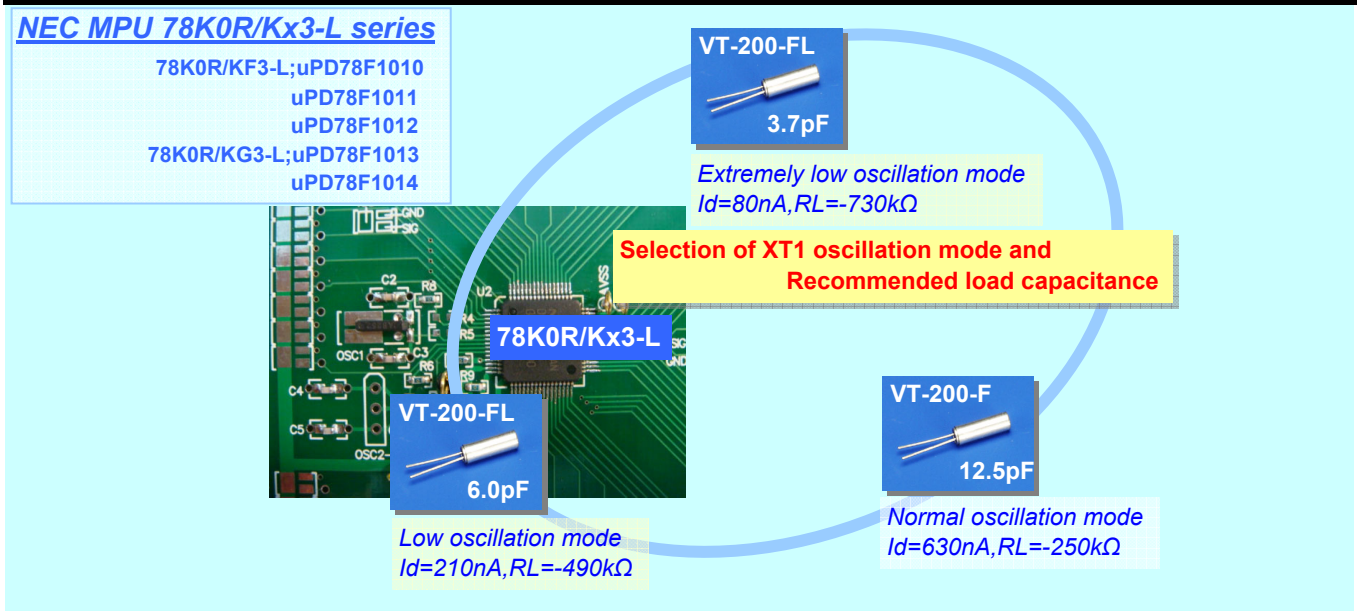
Correlations between the oscillation mode selection of XT1 oscillation circuit and the recommended load capacitance for a resonator are shown in Table 1 for safety use.



VT-200 series
VT-200-FL CL=3.0pF,3.7pF,4.4pF,6.0pF and VT-200-F CL=8.7pF,12.5pF

Table 1 Oscillation mode selection of XT1 oscillation circuit and load capacitance for a resonator

XT1 oscillation mode selection	Recommended circuit constant and load capacitance for a resonator				
	Cg=3pF,Cd=2pF	Cg=4pF,Cd=3pF	Cg=9pF,Cd=8pF	Cg=15pF,Cd=13pF	Cg=20pF,Cd=20pF
E-Low Extremely low consumption oscillation	**VT-200-FL 3.0pF** *Id=65nA typ* *RL=-990kΩ typ* *Ts=0.75sec typ*	**VT-200-FL 3.7pF** *Id=80nA typ* *RL=-730kΩ typ* *Ts=0.85sec typ*	**VT-200-FL 6.0pF** *Id=120nA typ* *RL=-335kΩ typ* *Ts=1.55sec typ*	*Not recommended.*	*Not recommended.*
Low Low consumption oscillation	*Not recommended.*	*Not recommended.*	**VT-200-FL 6.0pF** *Id=210nA typ* *RL=-490kΩ typ* *Ts=1.05sec typ*	*Not recommended.*	*Not recommended.*
Normal Normal oscillation	*Not recommended.*	*Not recommended.*	**VT-200-FL 6.0pF** *Id=380nA typ* *RL=-830kΩ typ* *Ts=0.75sec typ*	**VT-200-F 8.7pF** *Id=500nA typ* *RL=-420kΩ typ* *Ts=1.20sec typ*	**VT-200-F 12.5pF** *Id=630nA typ* *RL=-250kΩ typ* *Ts=2.15sec typ*



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