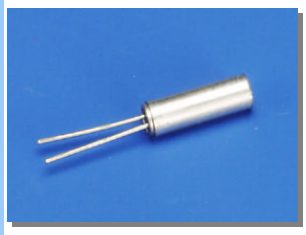
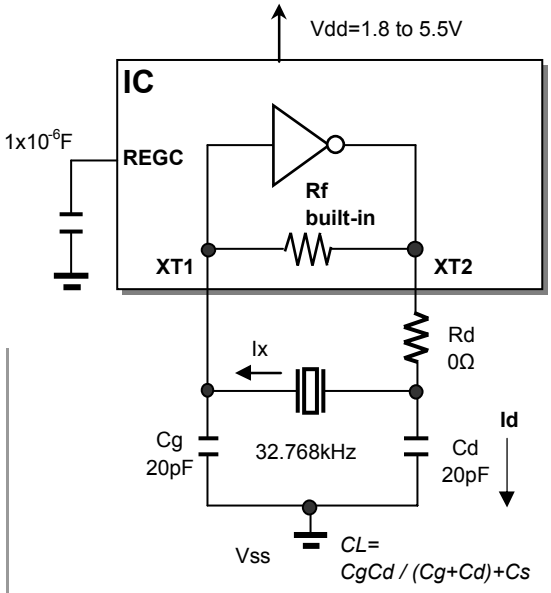
Evaluation of a Low Frequency Clock Oscillation Circuit

VT-200 12.5pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

Measurement conditions : 3.0V



Model	:VT-200
Frequency	:Fo=32.768kHz
Frequency tolerance	:dF/Fo= +/-20x10^{-6}
Load capacitance	:CL=12.5pF
Equivalent series resistance	:R1=50kΩ max
Max. drive level	:DL=1μW max
Level of drive	:DL=0.1μW typ

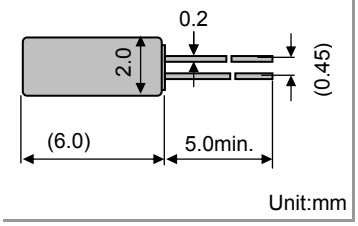


Remark) Ix : current through crystal

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	**Normal** (*1)
Mode 2	1.8V	

***1 ; Normal current consumption mode**

MODEL:VT-200 12.5pF 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)	20	20	Optimal capacitance in response to CL
Capacitance at drain : Cd (pF)	20	20	(CL = Cd // Cg + stray capacitance)

Circuit characteristics (at 25°C)	Mode 2	Mode 1	Remarks
Matching Accuracy : df / f (x10^{-6})	1.9	2.1	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)	0.05	0.05	DL=Ix^2 Re < 1x10^{-6}W,Re=R1(1 + Co / CL)^2
Negative resistance : | - RL | (kΩ)	251	251	5 times larger than R_{1MAX}
Oscillation allowance : M (times)	5	5	Judgmental standard of oscillation stability
Current consumption : Id (nA)	634	632	Cd charge current, Id = ωCd*Vd <1μA
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)	2.12	2.12	Time to reach 90% of output level, Ts < 5.0sec

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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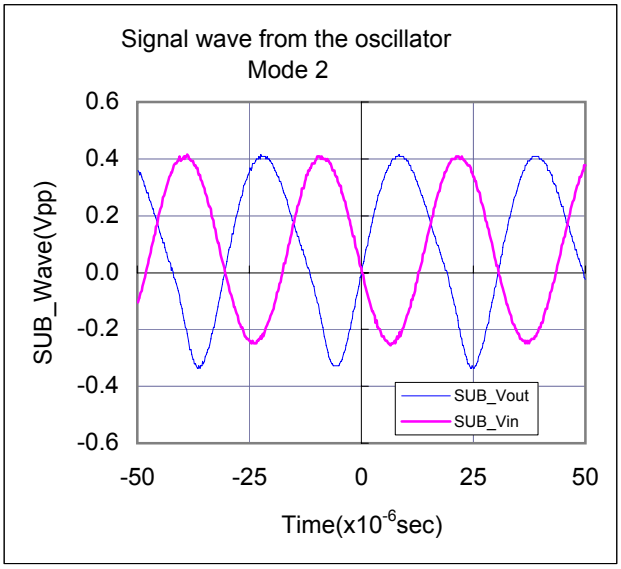
Evaluation of a Low Frequency Clock Oscillation Circuit

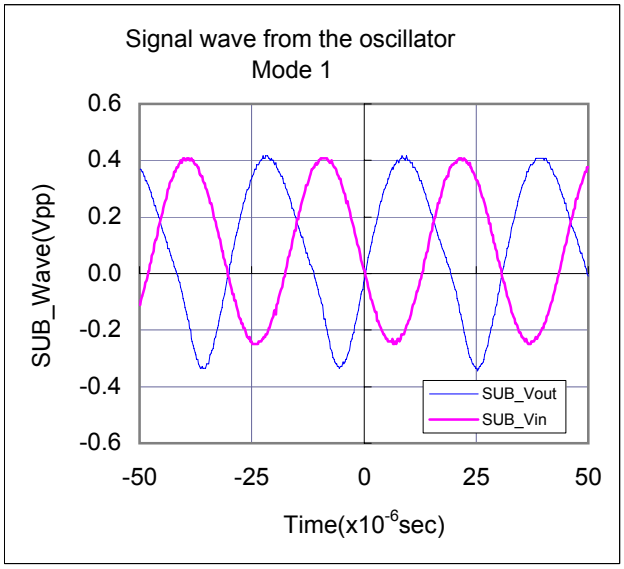
VT-200 12.5pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

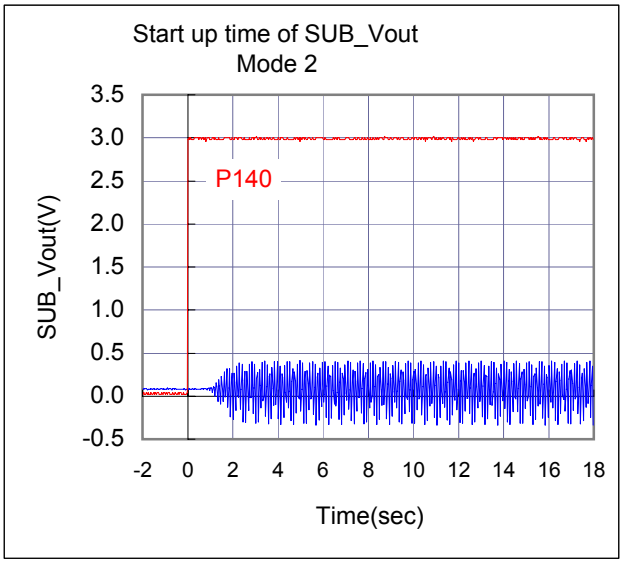
Measurement conditions : 3.0V

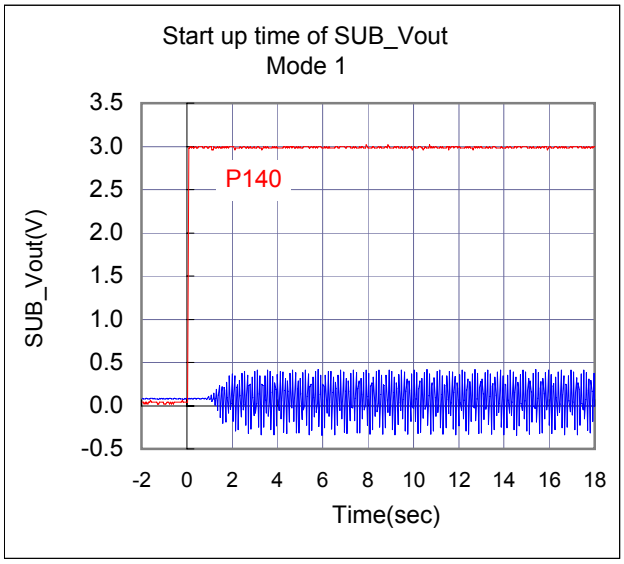
Normal current consumption mode

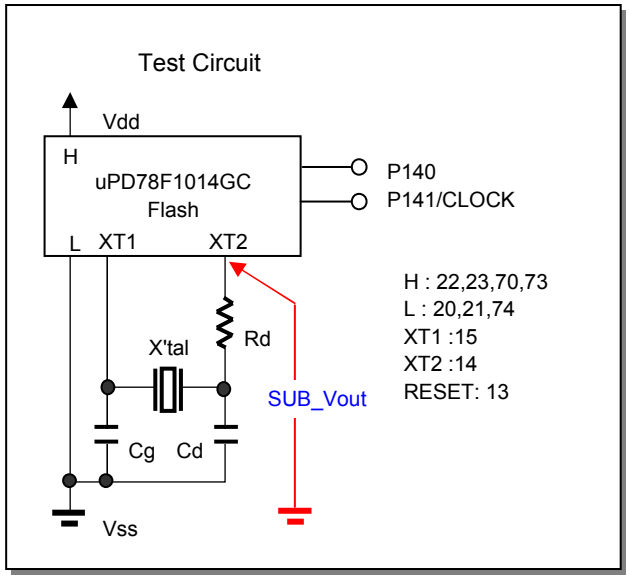
Test Data at 25°C

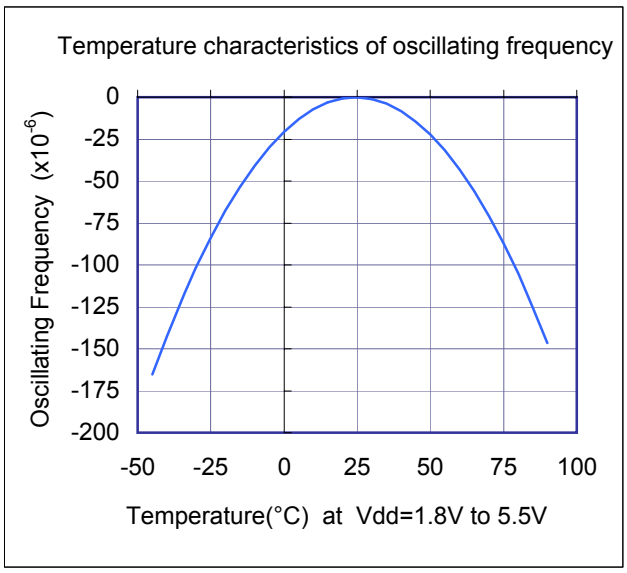












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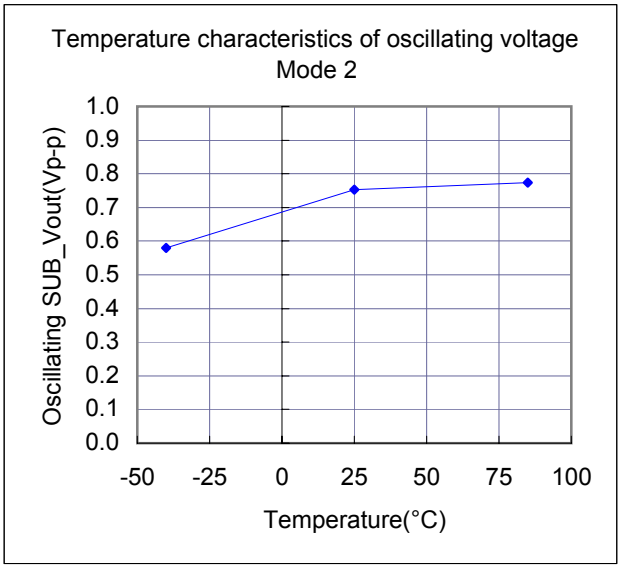
Evaluation of a Low Frequency Clock Oscillation Circuit

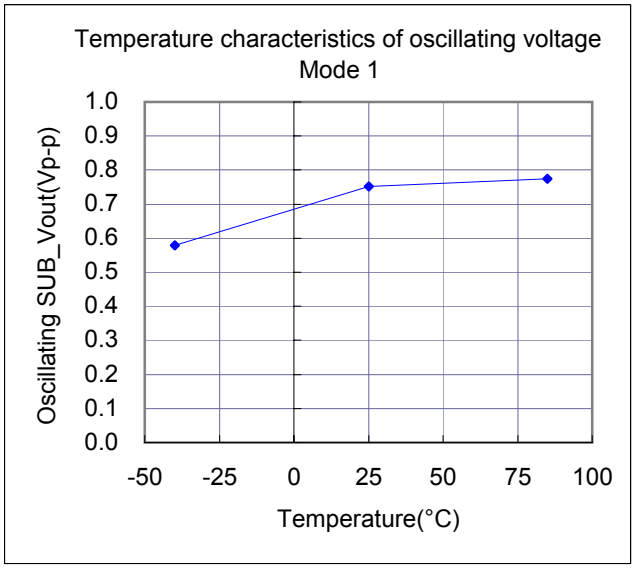
VT-200 12.5pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

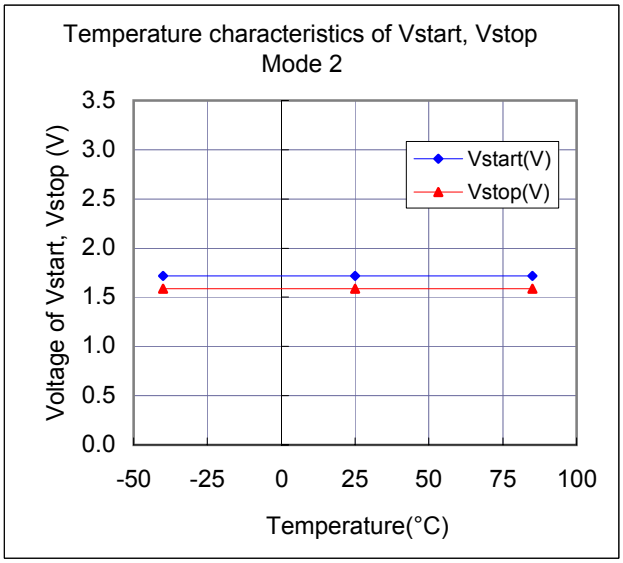
Measurement conditions : 3.0V

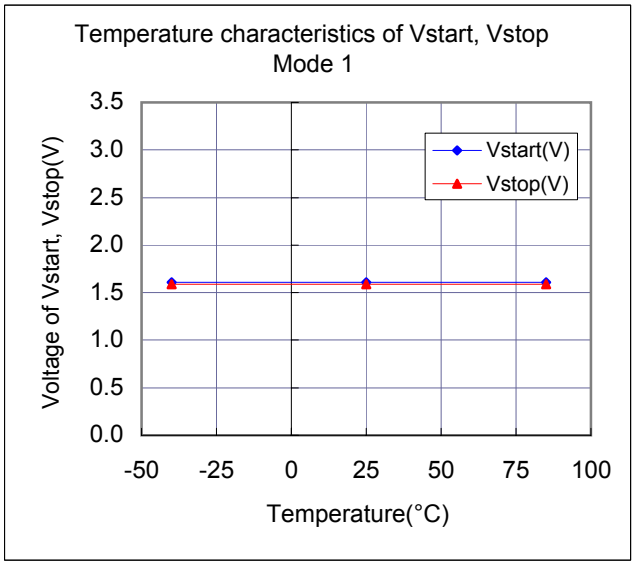
Normal current consumption mode

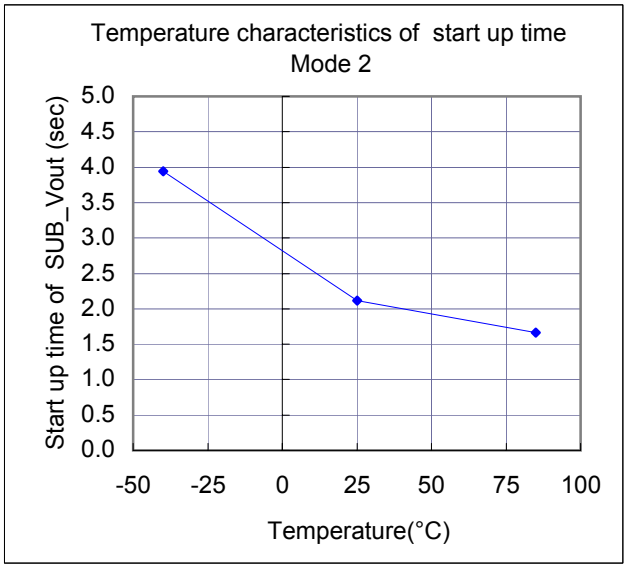
Test Data : Temperature characteristics

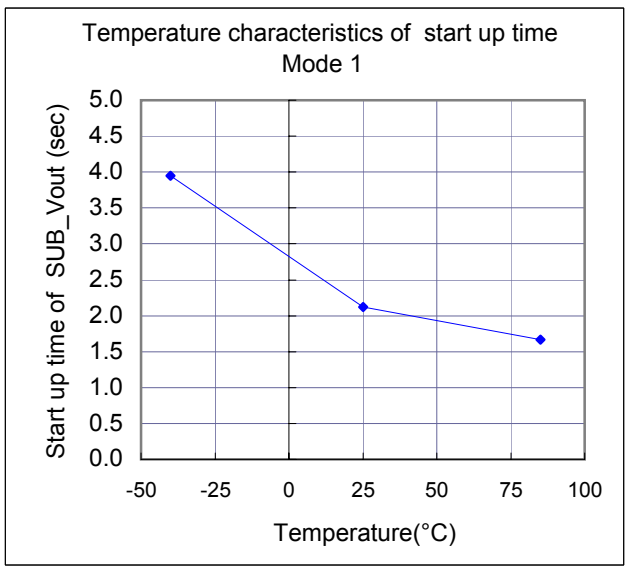












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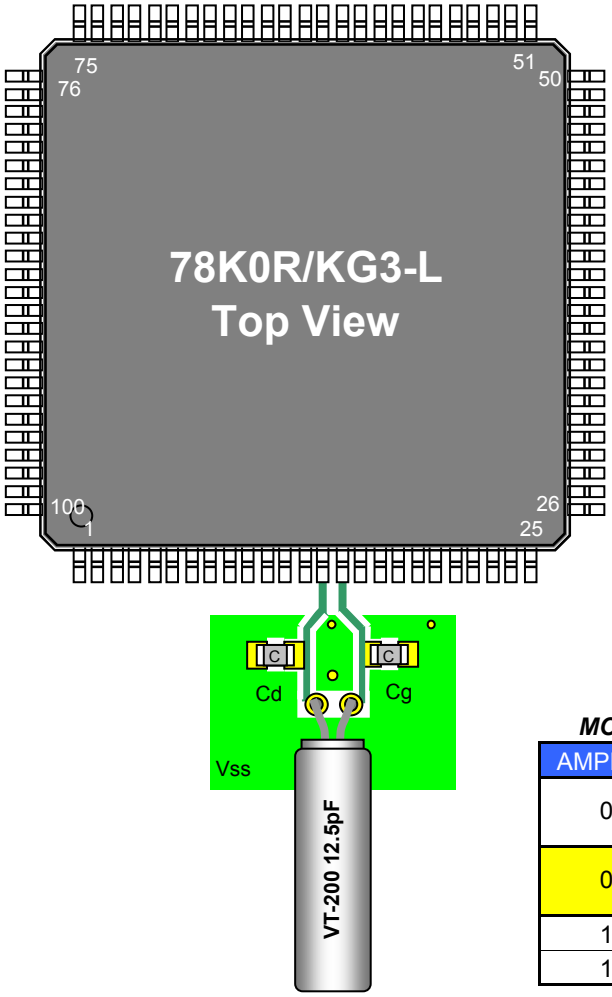
Evaluation of a Low Frequency Clock Oscillation Circuit

VT-200 12.5pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

Measurement conditions : 3.0V

Normal 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 12.5pF with uPD78F1014GC at 25°C

AMPHS1	AMPHS0	Oscillation mode selection
0	0	Low consumption oscillation mode.(default) *N/R
0	1	Normal consumption oscillation mode. Id=630nA typ.
1	0	Extremely low consumption oscillation mode. *N/R
1	1	

***N/R: Not recommended.(underestimated gain at 12.5pF)**

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).

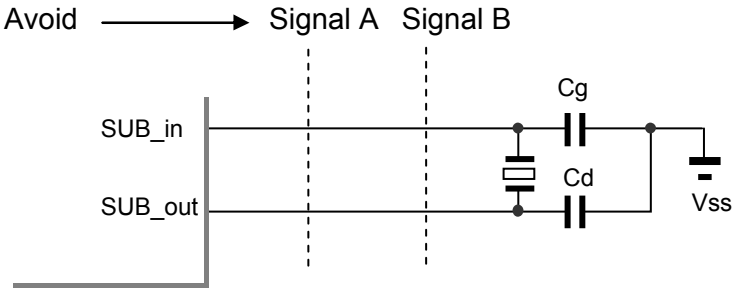


Figure 2 Example of Incorrect Board Design

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

Normal 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	1	12.5	32767.96	32765.38	26.8	0.89	2.109	86.0
	2	12.5	32767.57	32764.92	27.6	0.88	2.164	81.4
	3	12.5	32768.07	32765.42	27.2	0.88	2.164	82.5

[IC Test Data : IC sample Rd=0Ω,Cg=20pF,Cd=20pF at 25°C]

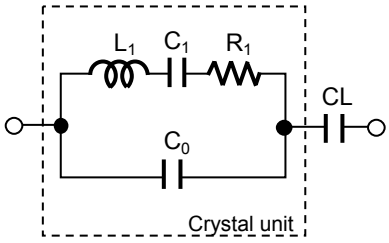
MODE	IC sample	Fosc(Hz)	df / f(x10^{-6})	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1	Sample 1	32768.02	1.8	0.06	5	0.76	641	1.58	2.29
	Sample 2	32768.03	2.0	0.06	5	0.77	646	1.58	2.16
	Sample 3	32768.03	2.1	0.05	5	0.75	632	1.61	2.12
	Sample 4	32768.03	2.1	0.04	5	0.74	625	1.59	2.11
	Sample 5	32768.03	2.0	0.04	5	0.72	606	1.59	2.08

[IC Test Data : IC sample Rd=0Ω,Cg=20pF,Cd=20pF 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	32768.01	1.6	0.06	5	0.76	643	1.67	2.29
	Sample 2	32768.02	1.8	0.06	5	0.77	648	1.68	2.16
	Sample 3	32768.02	1.9	0.05	5	0.75	634	1.72	2.12
	Sample 4	32768.02	1.9	0.05	5	0.74	627	1.69	2.11
	Sample 5	32768.02	1.8	0.04	5	0.72	607	1.70	2.08

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

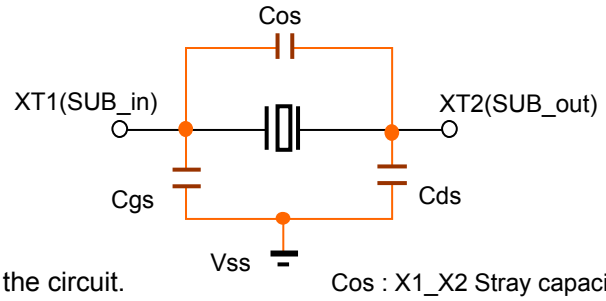
Figure 3 Equivalent circuit of crystal unit, and CL

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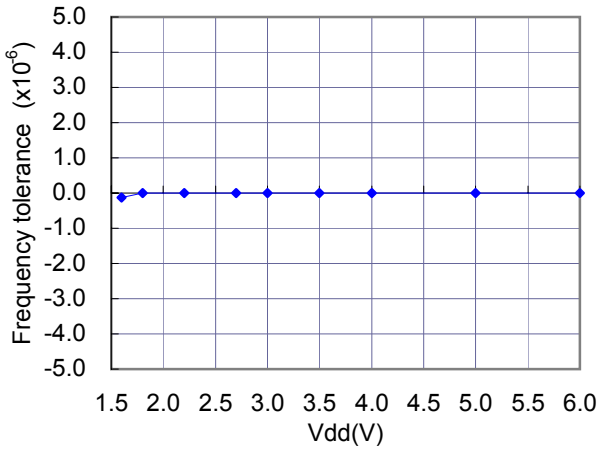
Measurement conditions : Vdd=(1.6V) to (6.0V) at 25°C

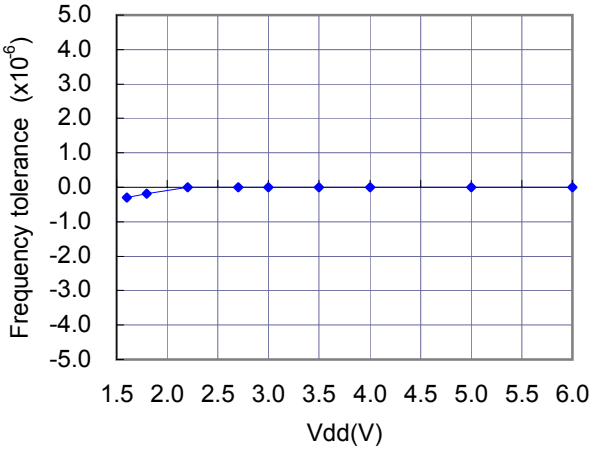
Normal current consumption mode

Referential Data(1) : Voltage characteristics

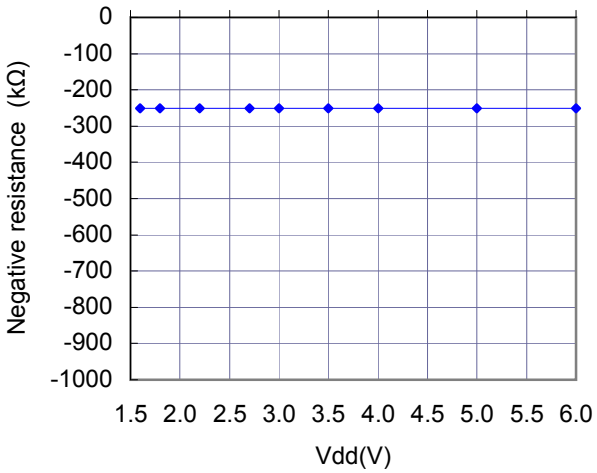
Frequency / voltage coefficient
Mode 2



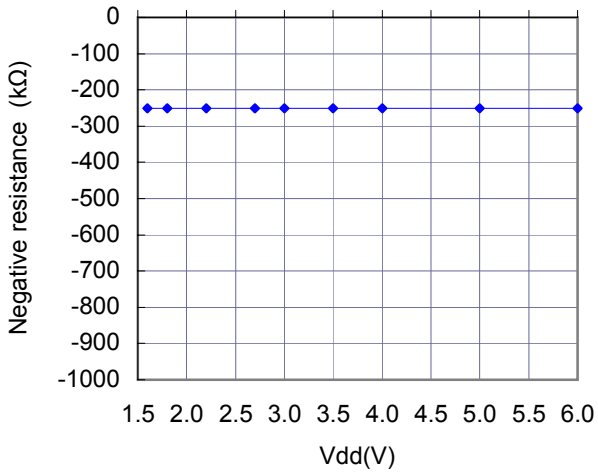
Frequency / voltage coefficient
Mode 1



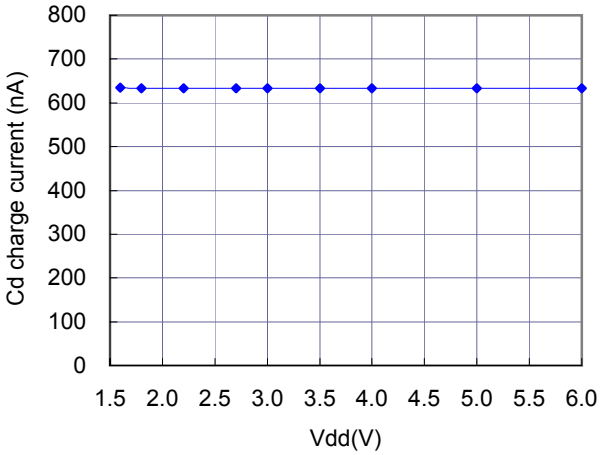
Negative resistance / voltage coefficient
Mode 2



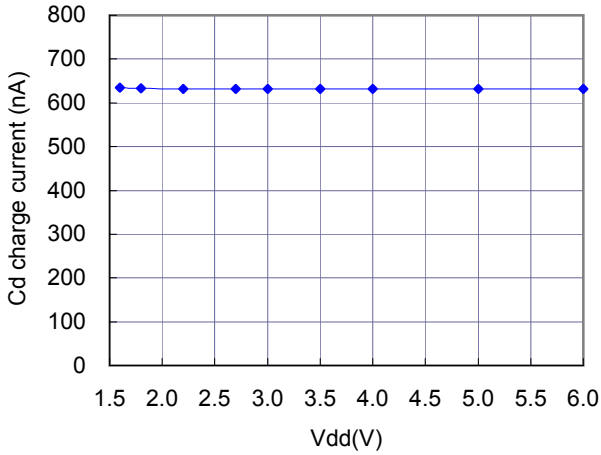
Negative resistance / voltage coefficient
Mode 1



Cd charge current / voltage coefficient
Mode 2



Cd charge current / voltage coefficient
Mode 1



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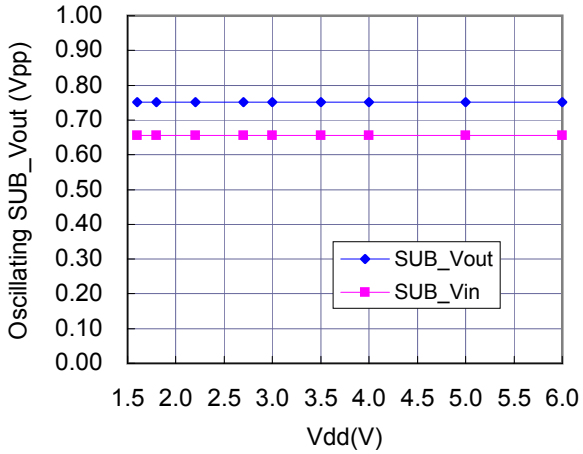
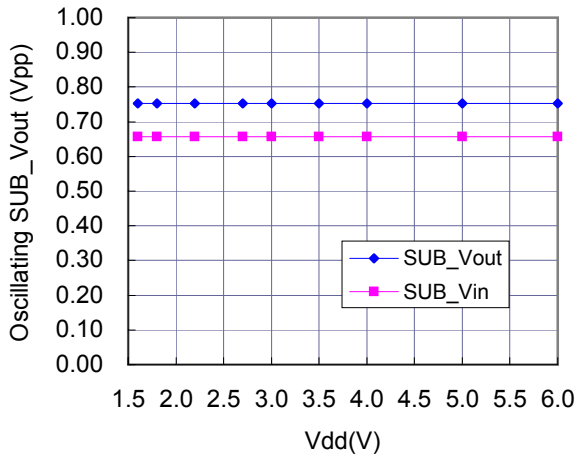
Normal current consumption mode

Referential Data(2) : Voltage characteristics

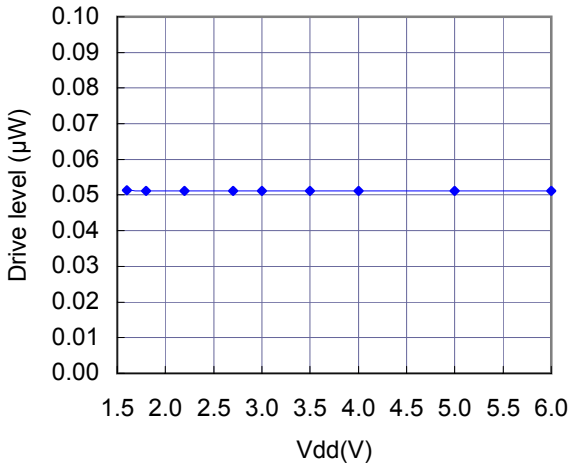
Output signal Wave / voltage coefficient
Mode 2



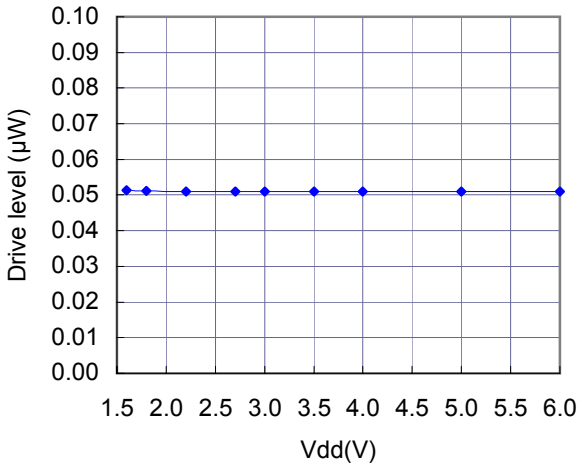
Output signal Wave / voltage coefficient
Mode 1



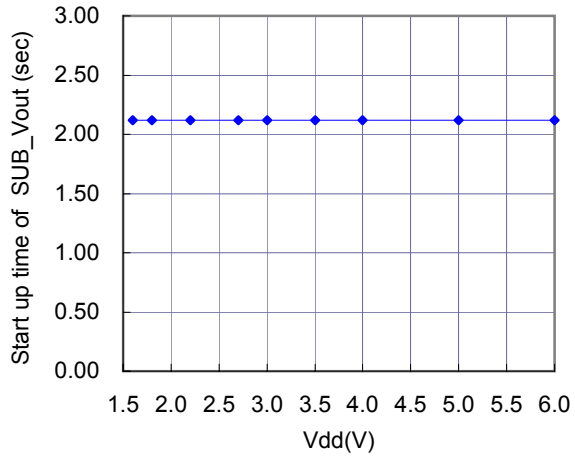
Drive level / voltage coefficient
Mode 2



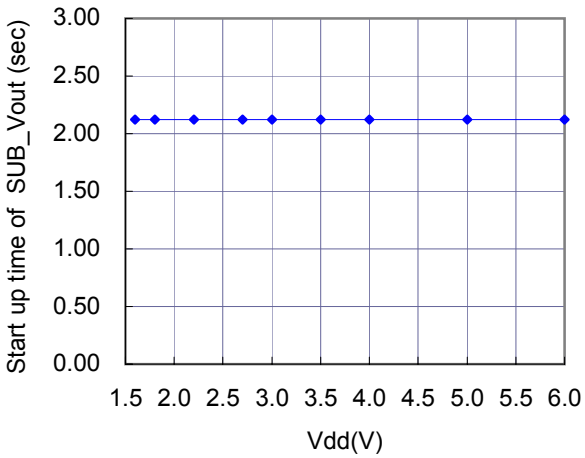
Drive level / voltage coefficient
Mode 1



Start up time / voltage coefficient
Mode 2



Start up time / voltage coefficient
Mode 1



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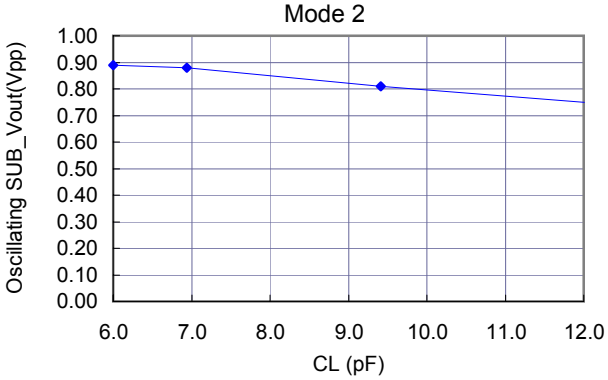
Measurement conditions : Vdd=3.0V at 25°C

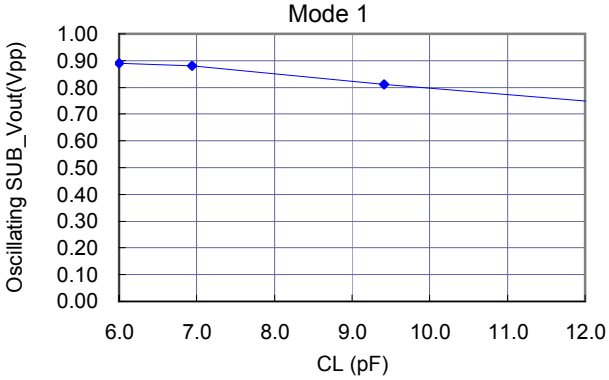
Normal current consumption mode

Referential Data(4) : Load capacitance characteristics

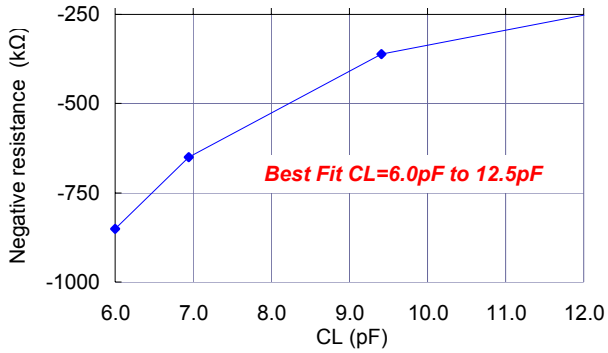
Output signal wave / load capacitance coefficient
Mode 2



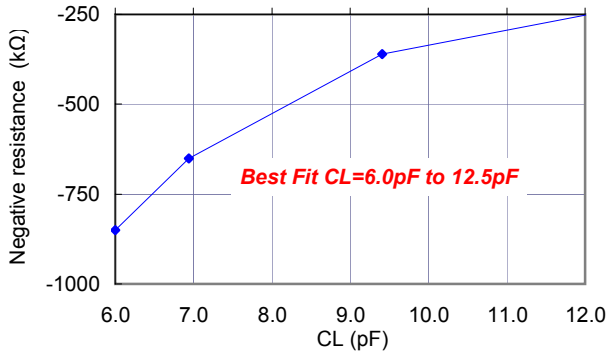
Output signal wave / load capacitance coefficient
Mode 1



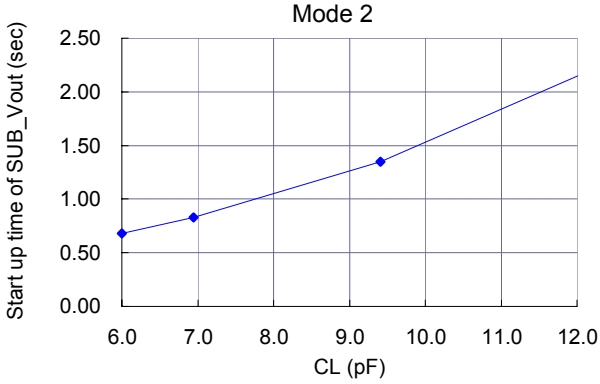
Negative resistance / load capacitance coefficient
Mode 2



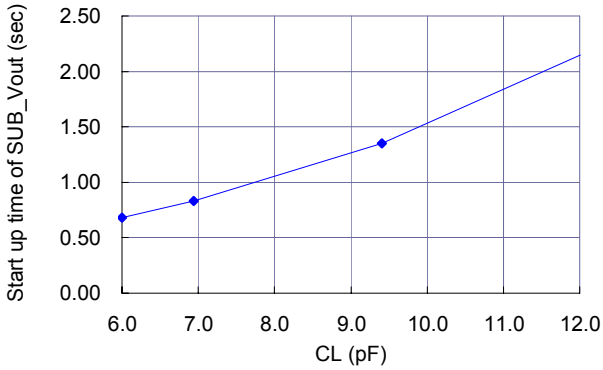
Negative resistance / load capacitance coefficient
Mode 1



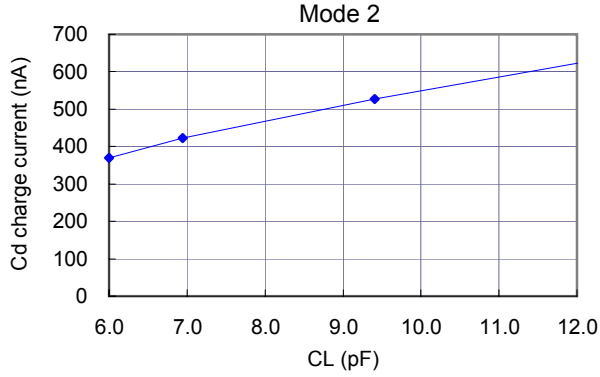
Start up time / load capacitance coefficient
Mode 2



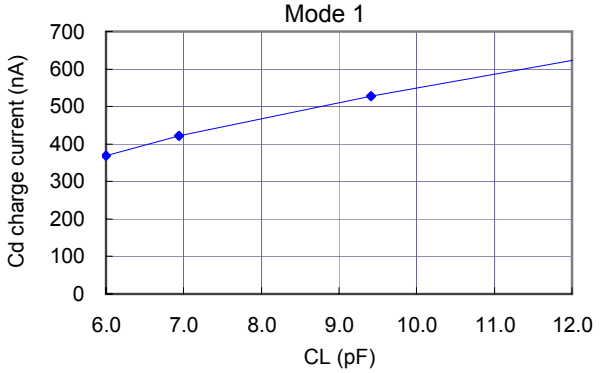
Start up time / load capacitance coefficient
Mode 1



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 12.5pF with uPD78F1014GC-16BT [LQFP(14x14) 0.5mm pitch]

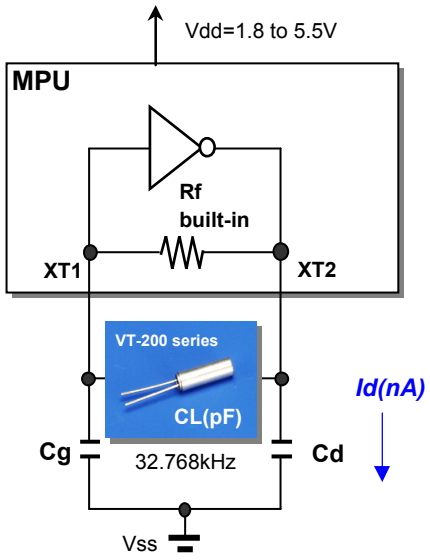
Measurement conditions : Vdd=3.0V at 25°C — **Normal current consumption mode**

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).

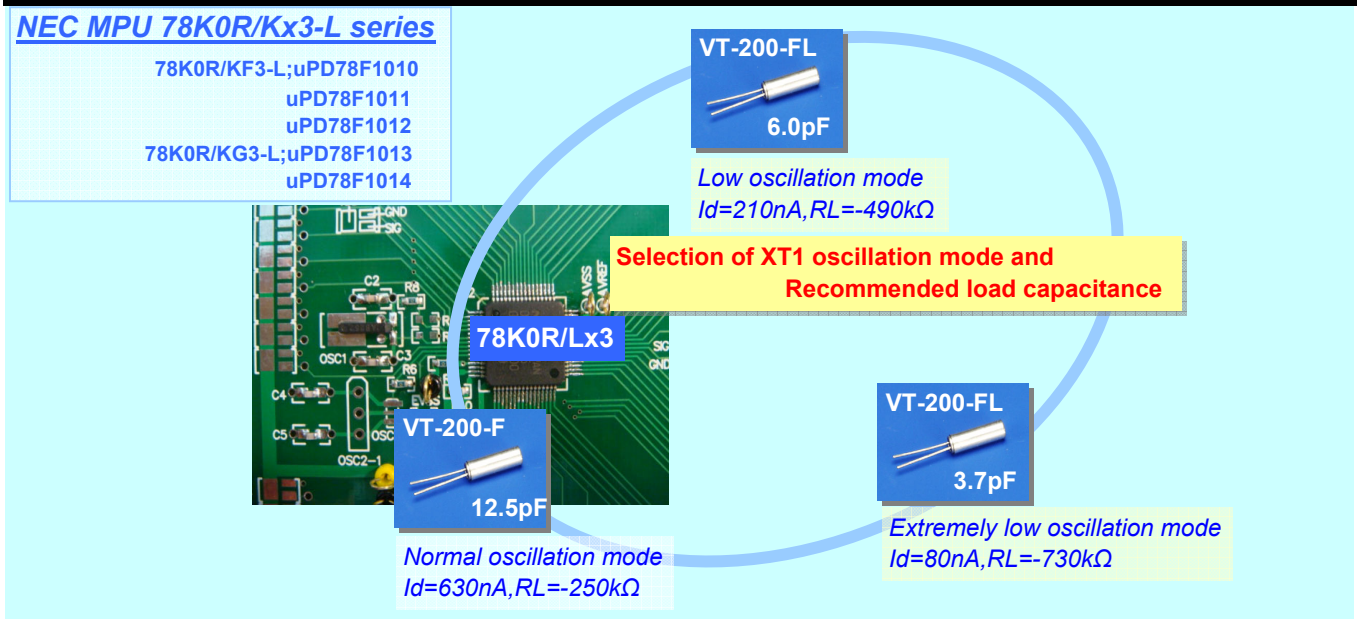
Correlations between the oscillation mode selection of XT1 oscillation circuit and the recommended load capacitance for a resonator are shown in Table 1 for safety use.



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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