Evaluation of a Low Frequency Clock Oscillation Circuit

SSP-T7-FL 6.0pF with uPD78F1505GC-16BT [LQFP(14x14) 0.5mm pitch]

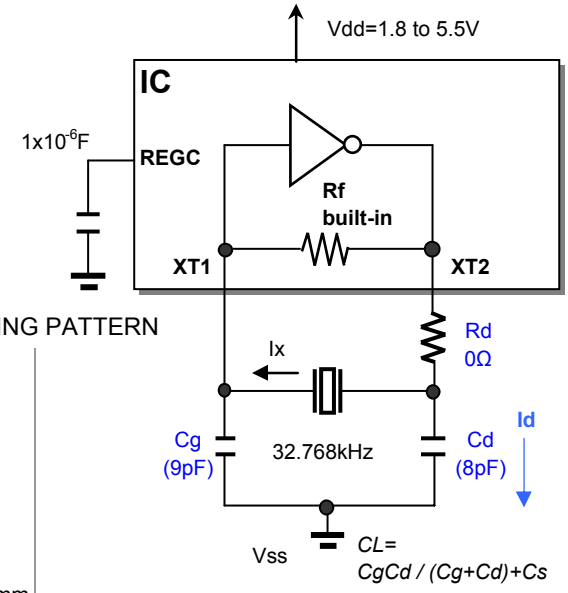
Measurement conditions : 3.0V

New

SSP-T7-FL

CL=6.0pF

Model	:SSP-T7-FL
Frequency	:Fo=32.768kHz
Frequency tolerance	:dF/Fo= +/-20x10^{-6}
Load capacitance	:CL=6.0pF
Equivalent series resistance	:R1=65kΩ max
Max. drive level	:DL=1μW max
Level of drive	:DL=0.01μW typ

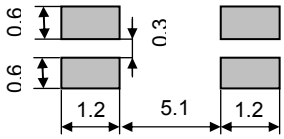


Remark) Ix : current through crystal

FEATURES

1.Ultra thin type with 1.4mm Max.
2.SMD type suitable for automatic & high density surface mounting.
3.Plastic mold package containing highly reliable tubular type quartz crystal.
4.Excellent shock and heat resistance.
5.Cellular phones,PDA,Radio communication equipment, Portable applications etc.

RECOMMENDED SOLDERING PATTERN



Unit:mm

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

Low power Consumption 78K0R/Lx3 and SSP-T7-FL 6.0pF

***1 ; Low current consumption mode**

MODEL:SSP-T7-FL 6.0pF with uPD78F1505GC 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})	2.4	2.6	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)	611	611	5 times larger than R_{1MAX}
Oscillation allowance : M (times)	9	9	Judgmental standard of oscillation stability
Low current consumption : Id (nA)	**228**	**228**	**Cd charge current, Id = ωCd*Vd < 250nA**
Voltage of oscillation start : Vstrat (V)	1.63	1.61	
Voltage of oscillation stop : Vstop (V)	1.59	1.59	
Oscillation start up time : Ts (sec)	0.98	0.98	Time to reach 90% of output level, Ts < 1.5sec

Temperature characteristics of circuit		mode 2	mode 1	Remarks
at -40°C	Variation : df / T (x10^{-6})	-138	-138	Typ.Tp=25°C (K = -3.5×10^{-8} / °C^2)
at +85°C	Variation : df / T (x10^{-6})	-129	-129	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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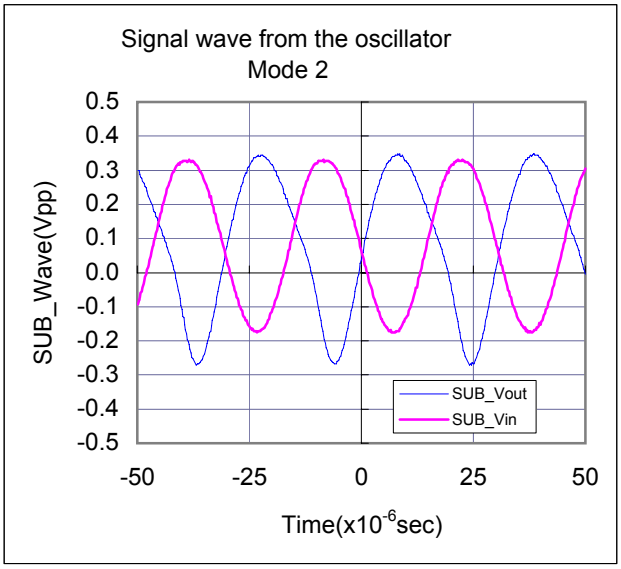
Evaluation of a Low Frequency Clock Oscillation Circuit

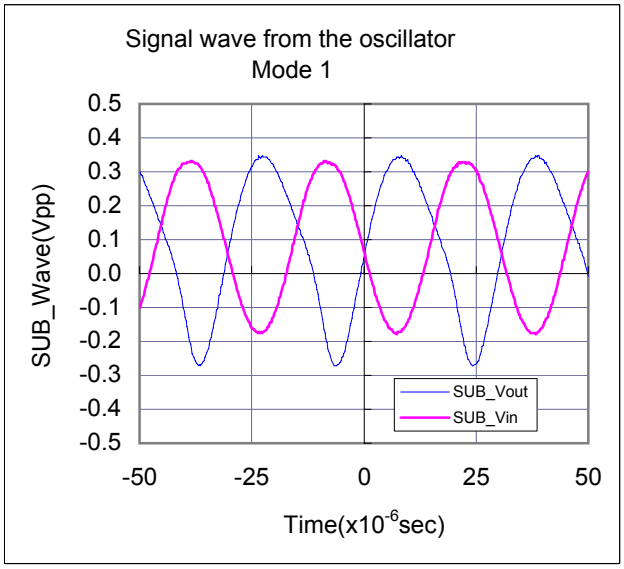
SSP-T7-FL 6.0pF with uPD78F1505GC-16BT [LQFP(14x14) 0.5mm pitch]

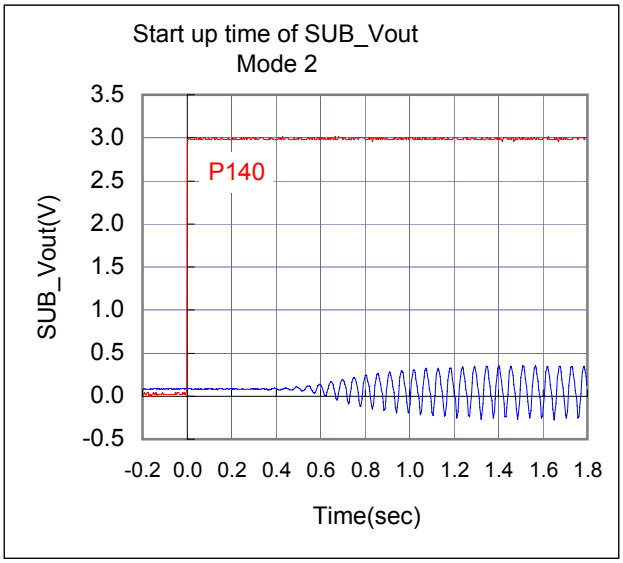
Measurement conditions : 3.0V

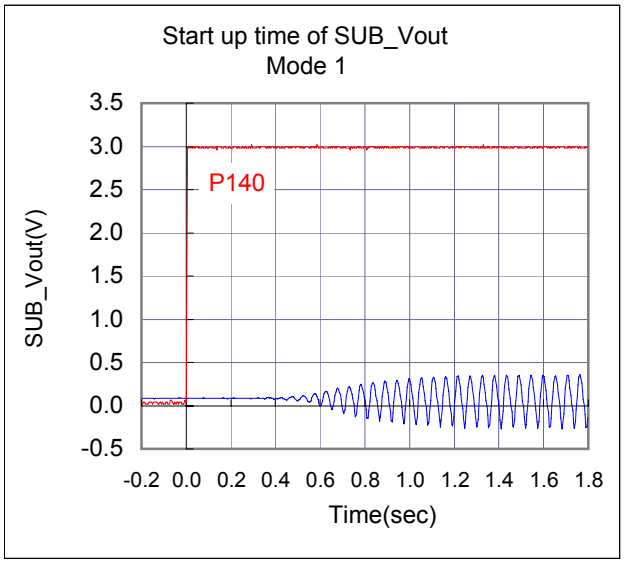
Low current consumption mode

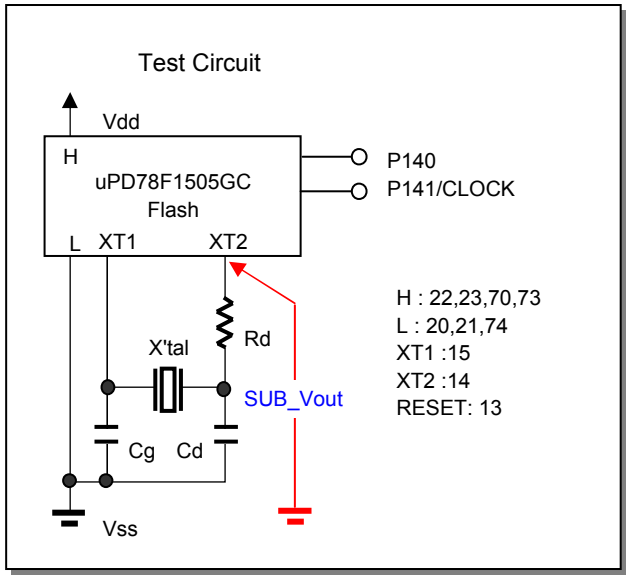
Test Data at 25°C

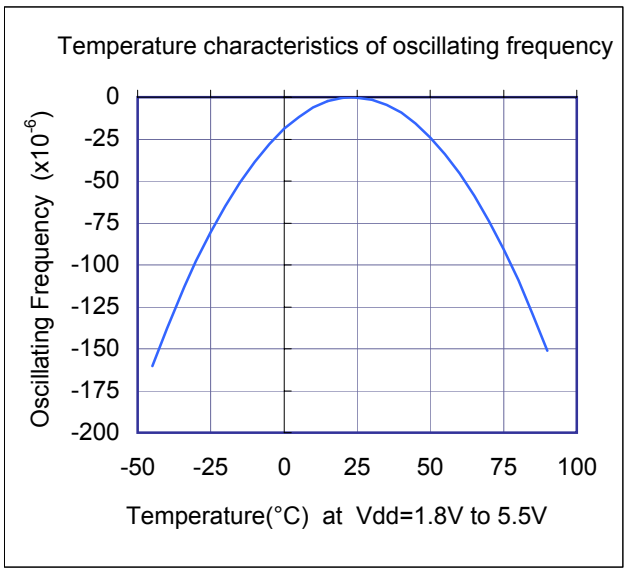












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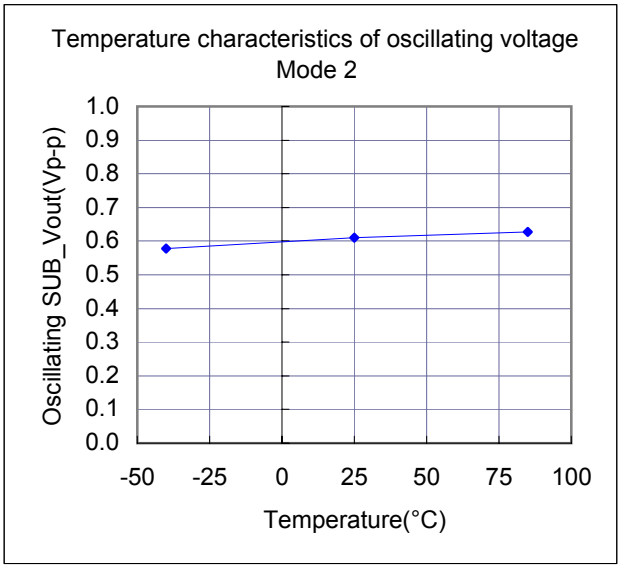
Evaluation of a Low Frequency Clock Oscillation Circuit

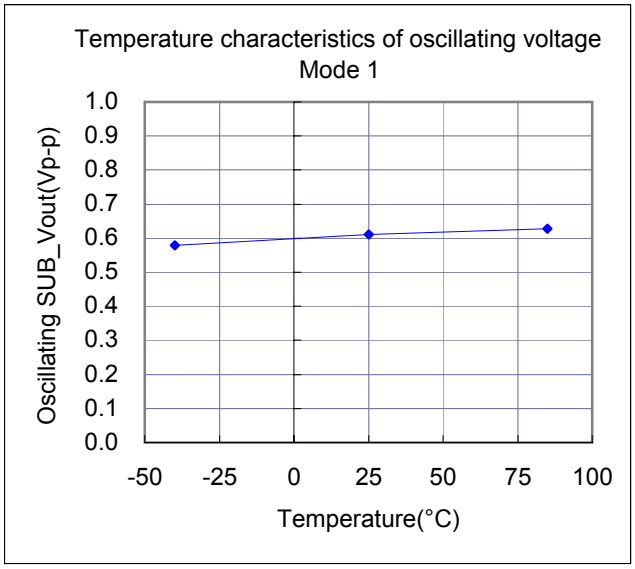
SSP-T7-FL 6.0pF with uPD78F1505GC-16BT [LQFP(14x14) 0.5mm pitch]

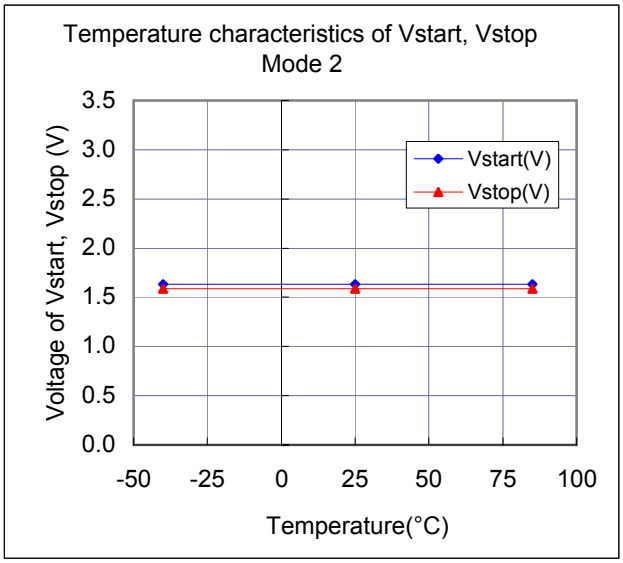
Measurement conditions : 3.0V

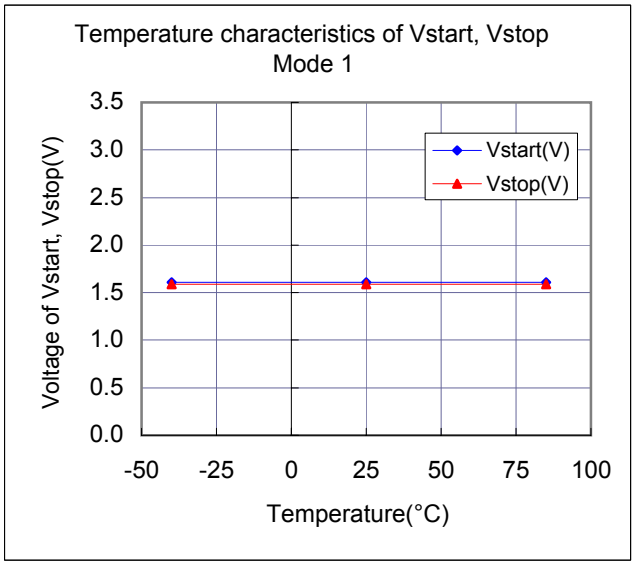
Low current consumption mode

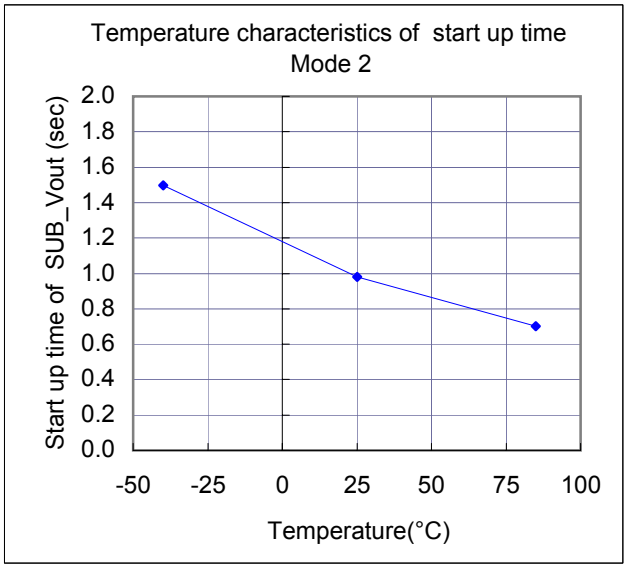
Test Data : Temperature characteristics

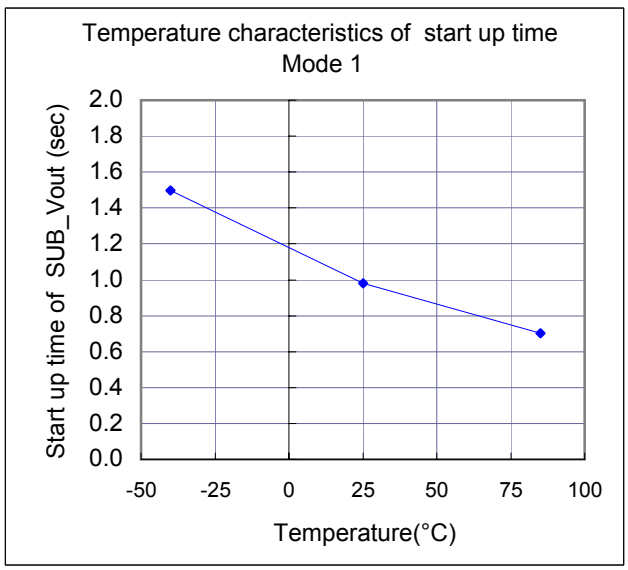












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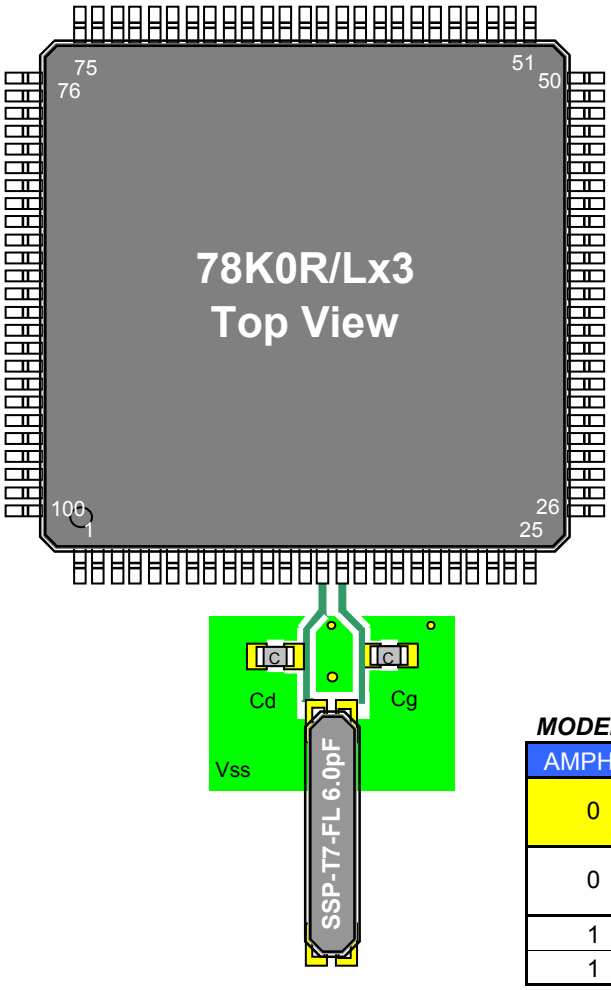
Measurement conditions : 3.0V

Low current consumption mode

Referential components layout(see Figure 1)



78K0R/Lx3 series

uPD78F1500
uPD78F1501
uPD78F1502
uPD78F1503
uPD78F1504
uPD78F1505
uPD78F1506
uPD78F1507
uPD78F1508

MODEL:SSP-T7-FL 6.0pF with uPD78F1505GC at 25°C

AMPHS1	AMPHS0	Oscillation mode selection
0	0	Low consumption oscillation mode. (default) ; Id=220nA 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).

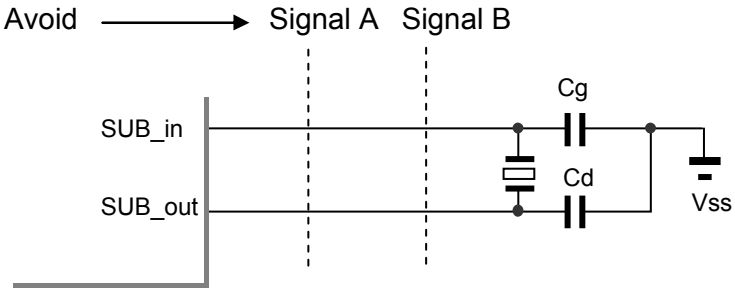


Figure 2 Example of Incorrect Board Design

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)
SSP-T7-FL	1	6.0	32768.01	32763.04	41.1	0.91	2.096	56.4
	2	6.0	32768.05	32763.07	38.8	0.90	2.097	59.7
	3	6.0	32768.00	32763.05	40.6	0.90	2.085	57.4

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

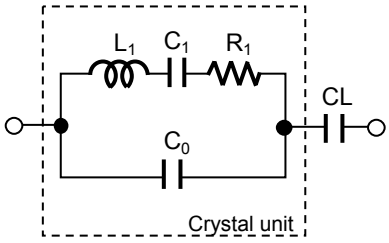
MODE	IC sample	Fosc(Hz)	df / f(x10^{-6})	DL(μW)	M(times)	XT2(Vpp)	Id(nA)	Vstart(V)	Ts(sec)
Mode 1	Sample 1	32768.14	2.7	0.02	9	0.62	232	1.61	0.99
	Sample 2	32768.13	2.6	0.02	9	0.57	211	1.59	1.03
	Sample 3	32768.14	2.6	0.01	9	0.61	228	1.61	0.98
	Sample 4	32768.13	2.3	0.01	9	0.56	211	1.60	0.98
	Sample 5	32768.12	2.0	0.01	10	0.58	216	1.59	0.88

[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	32768.13	2.5	0.02	9	0.62	232	1.63	0.99
	Sample 2	32768.13	2.3	0.02	9	0.57	212	1.61	1.03
	Sample 3	32768.13	2.4	0.01	9	0.61	228	1.63	0.98
	Sample 4	32768.12	2.2	0.01	9	0.56	211	1.61	0.98
	Sample 5	32768.11	1.8	0.01	10	0.58	216	1.62	0.88

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

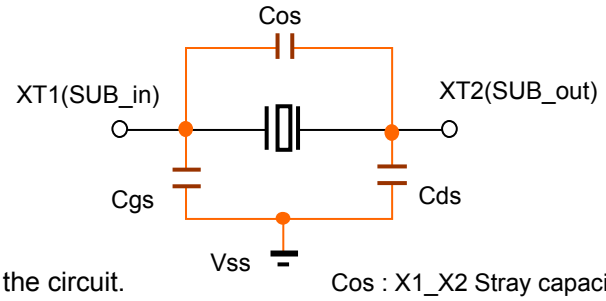
Remark (see figure 4)

Approximate formula of the load capacitance of the circuit CL,

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

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

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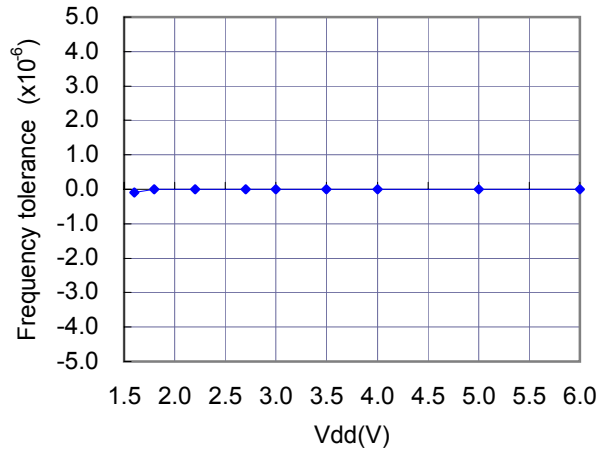
Measurement conditions : Vcc=(1.6V) to (6.0V) at 25°C

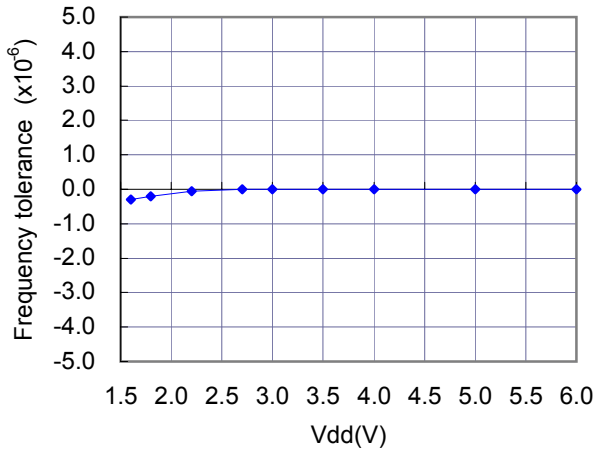
Low current consumption mode

Referential Data(1) : Voltage characteristics

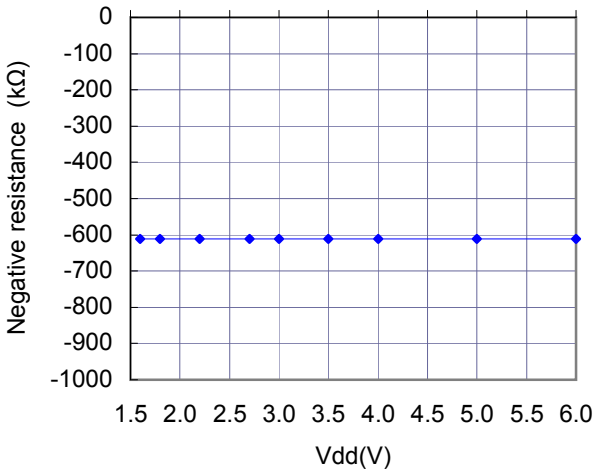
Frequency / voltage coefficient
Mode 2



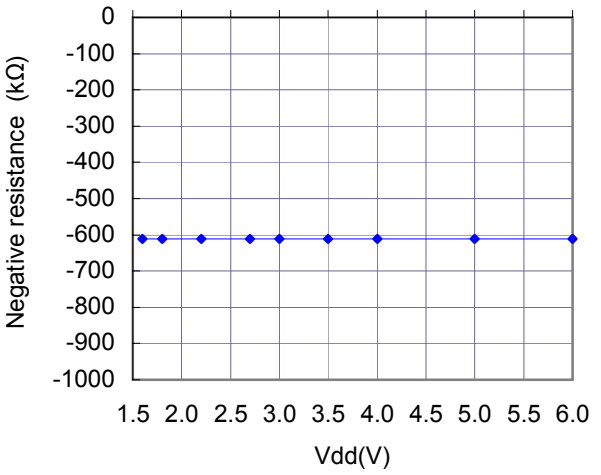
Frequency / voltage coefficient
Mode 1



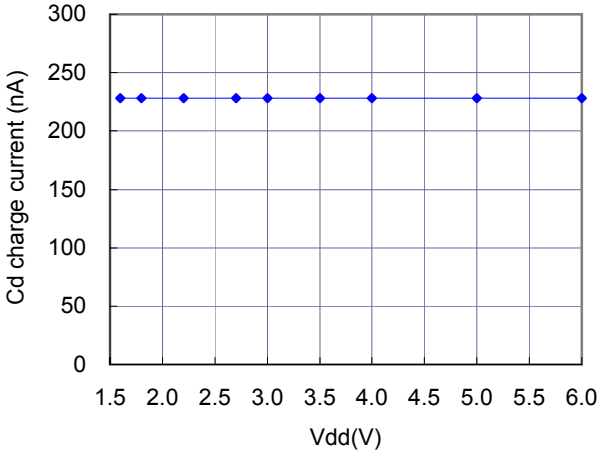
Negative resistance / voltage coefficient
Mode 2



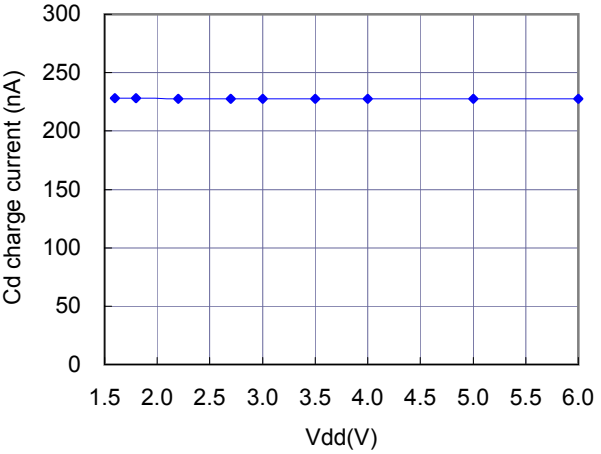
Negative resistance / voltage coefficient
Mode 1



Cd charge current / voltage coefficient
Mode 2



Cd charge current / voltage coefficient
Mode 1



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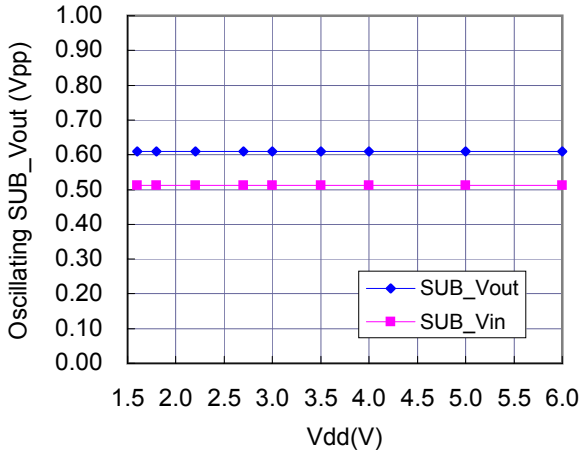
Measurement conditions : Vcc=(1.6V) to (6.0V) at 25°C

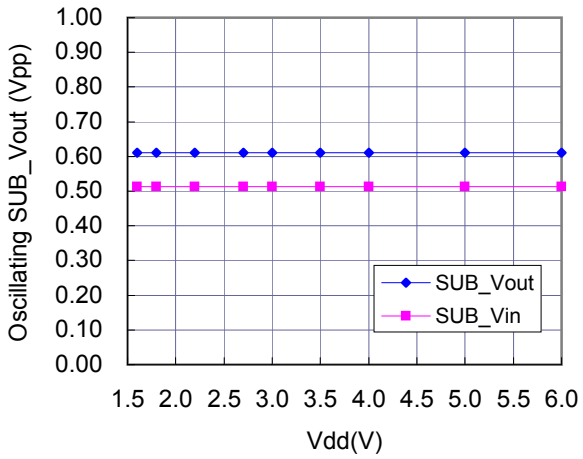
Low current consumption mode

Referential Data(2) : Voltage characteristics

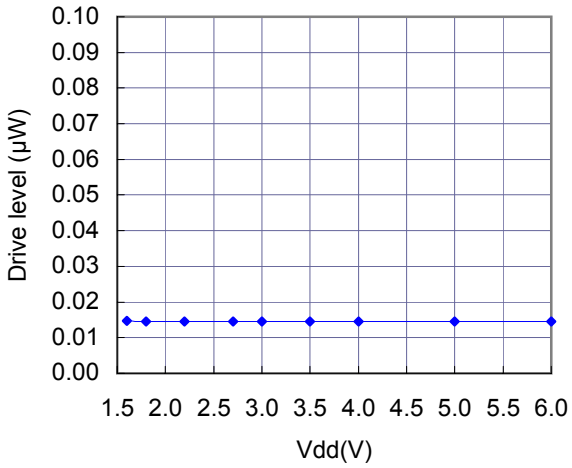
Output signal Wave / voltage coefficient
Mode 2



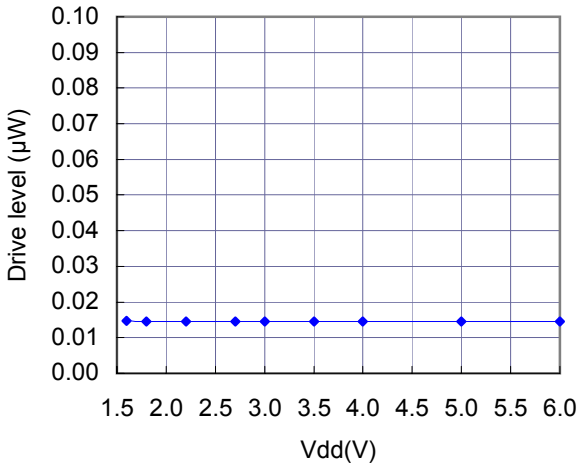
Output signal Wave / voltage coefficient
Mode 1



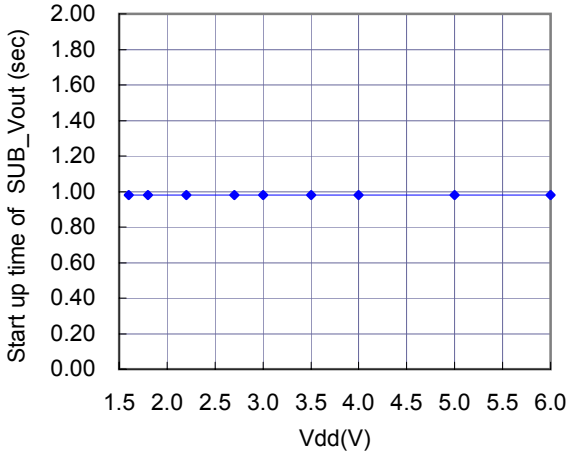
Drive level / voltage coefficient
Mode 2



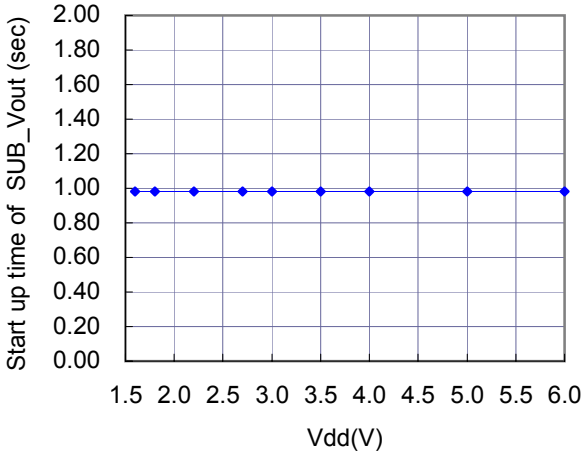
Drive level / voltage coefficient
Mode 1



Start up time / voltage coefficient
Mode 2



Start up time / voltage coefficient
Mode 1



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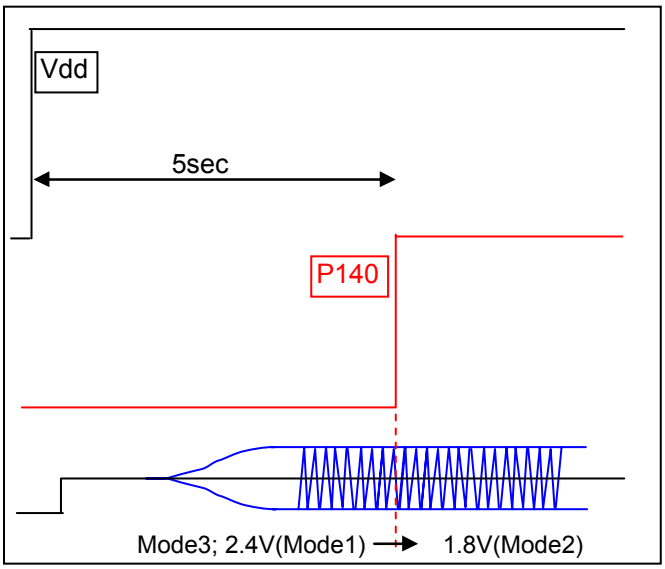
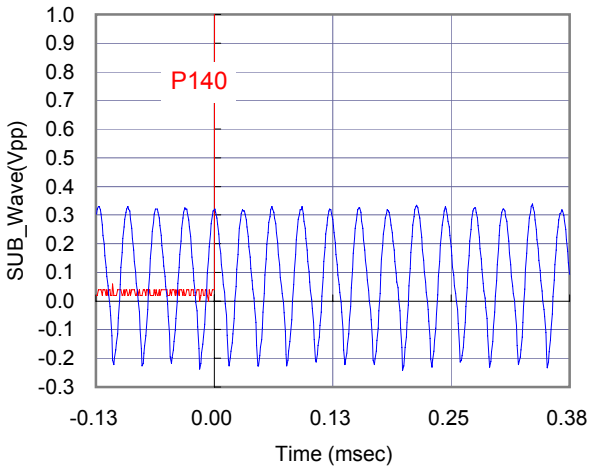
Measurement conditions : Vdd=3.0V at 25°C

Low current consumption mode

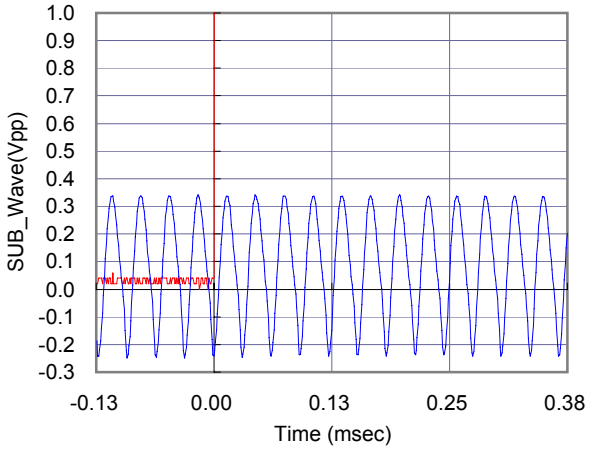
Referential Data(3) : Mode 3 characteristics



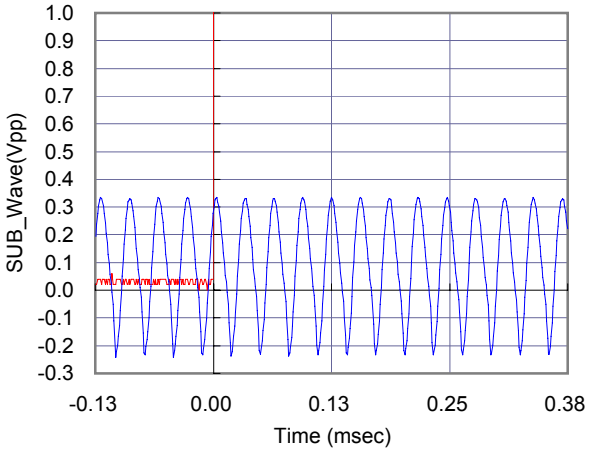
Signal wave from the oscillator
Mode 3; Sample 1



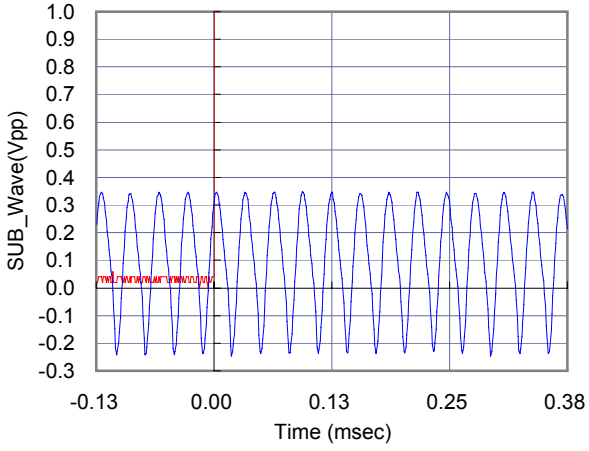
Signal wave from the oscillator
Mode 3; Sample 2



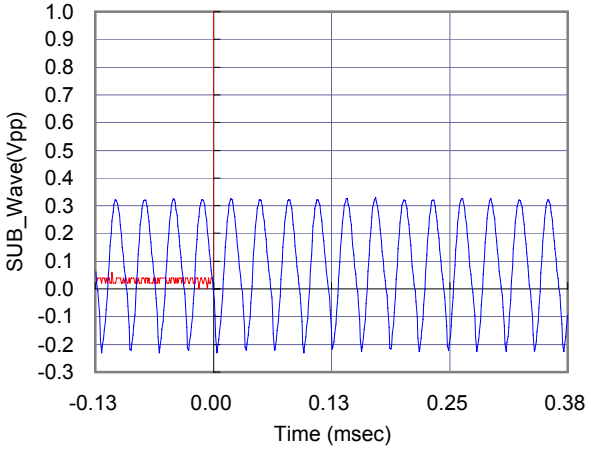
Signal wave from the oscillator
Mode 3; Sample 3



Signal wave from the oscillator
Mode 3; Sample 4



Signal wave from the oscillator
Mode 3; Sample 5



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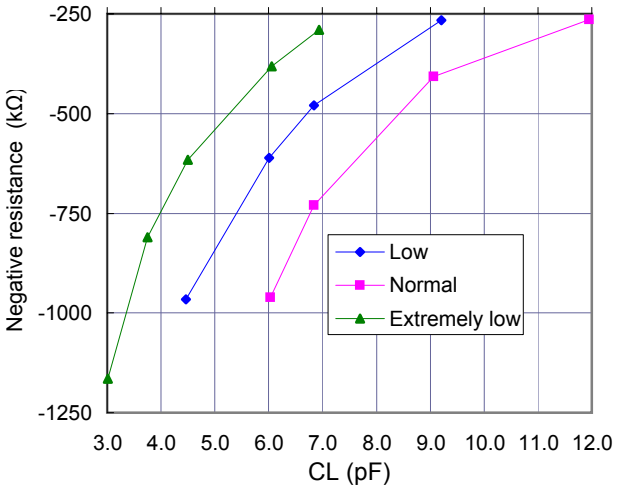
Measurement conditions : Vdd=3.0V at 25°C

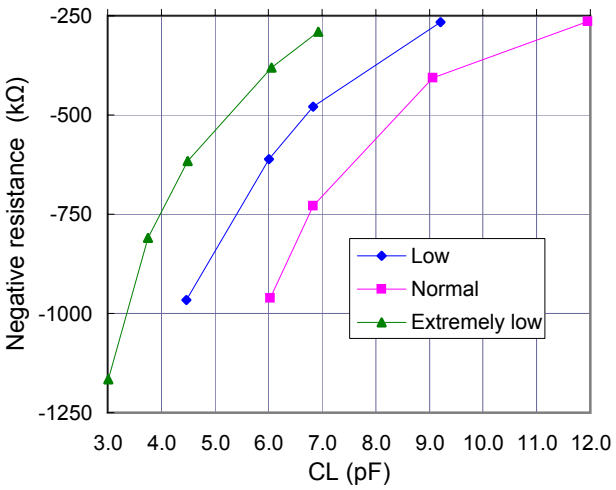
Low current consumption mode

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

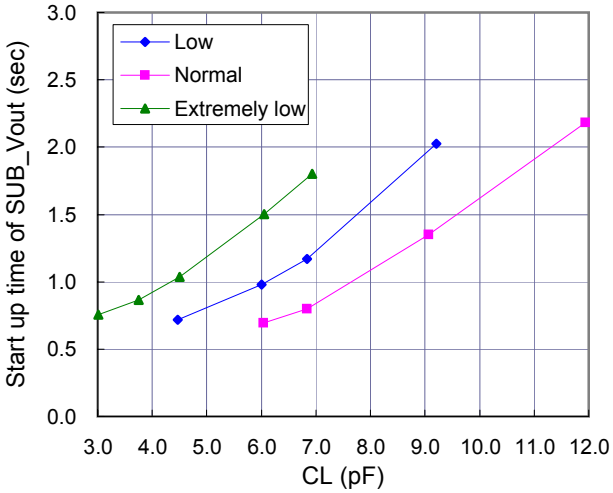
Negative resistance / load capacitance coefficient
Mode 2



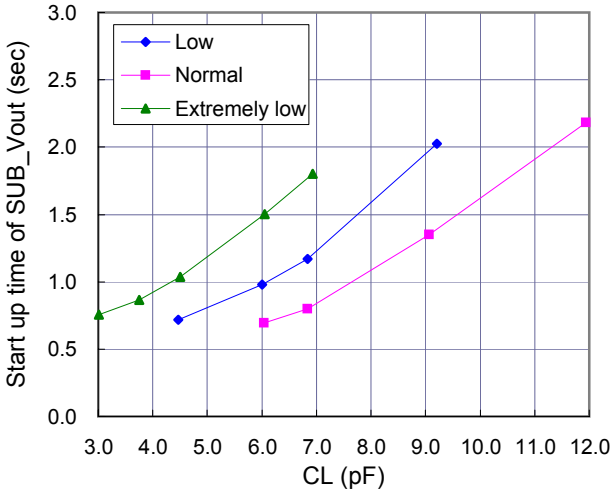
Negative resistance / load capacitance coefficient
Mode 1



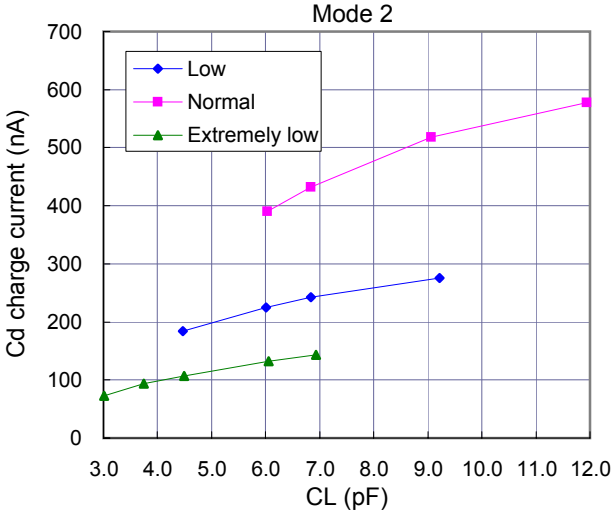
Start up time / load capacitance coefficient
Mode 2



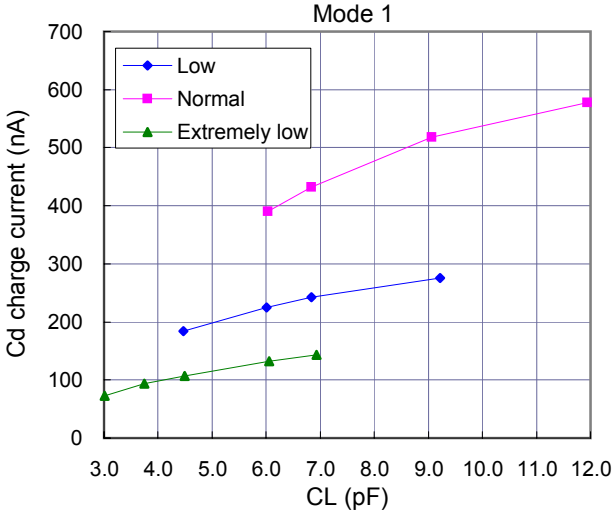
Start up time / load capacitance coefficient
Mode 1



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

SSP-T7-FL 6.0pF with uPD78F1505GC-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 (220nA typ)
0	1	Normal consumption oscillation mode.	6.0pF (380nA typ),7.0pF (420nA typ),9.0pF(530nAtyp)
1	0	Extremely low consumption oscillation mode.	6.0pF (120nA typ),4.4pF(100nA typ),3.7pF (85nA typ)
1	1	(DC bias current; 200nA max. at 25°C)	

**78K0R/Lx3 series; μPD78F1500 to μPD78F1508 & SSP-T7 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	32768.14	2.7	0.018	9	0.62	232	1.61	0.99
	Sample 2	32768.13	2.6	0.016	9	0.57	211	1.59	1.03
	Sample 3	32768.14	2.6	0.015	9	0.61	228	1.61	0.98
	Sample 4	32768.13	2.3	0.011	9	0.56	211	1.60	0.98
	Sample 5	32768.12	2.0	0.011	10	0.58	216	1.59	0.88
Mode 2 (1.8V)	Sample 1	32768.13	2.5	0.018	9	0.62	232	1.63	0.99
	Sample 2	32768.13	2.3	0.016	9	0.57	212	1.61	1.03
	Sample 3	32768.13	2.4	0.015	9	0.61	228	1.63	0.98
	Sample 4	32768.12	2.2	0.011	9	0.56	211	1.61	0.98
	Sample 5	32768.11	1.8	0.011	10	0.58	216	1.62	0.88

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	32768.13	2.6	0.020	16	1.00	407	1.61	0.68
	Sample 2	32768.13	2.4	0.020	15	0.98	399	1.59	0.63
	Sample 3	32768.11	1.8	0.017	15	0.94	385	1.61	0.69
	Sample 4	32768.10	1.5	0.013	18	0.84	343	1.60	0.62
	Sample 5	32768.09	1.1	0.013	18	0.84	346	1.59	0.56
Mode 2 (1.8V)	Sample 1	32768.13	2.4	0.020	16	1.00	407	1.63	0.68
	Sample 2	32768.12	2.2	0.020	15	0.98	400	1.61	0.63
	Sample 3	32768.10	1.6	0.017	15	0.94	385	1.63	0.69
	Sample 4	32768.09	1.3	0.013	18	0.84	343	1.61	0.62
	Sample 5	32768.08	0.9	0.013	18	0.84	347	1.62	0.56

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	32768.09	1.2	0.008	6	0.36	123	1.61	1.59
	Sample 2	32768.08	0.9	0.007	6	0.35	118	1.59	1.64
	Sample 3	32768.11	1.7	0.009	6	0.39	132	1.61	1.50
	Sample 4	32768.12	2.0	0.008	6	0.35	120	1.60	1.40
	Sample 5	32768.11	1.7	0.007	7	0.35	120	1.59	1.38
Mode 2 (1.8V)	Sample 1	32768.08	0.9	0.008	6	0.36	123	1.63	1.59
	Sample 2	32768.07	0.6	0.007	6	0.35	119	1.61	1.64
	Sample 3	32768.10	1.5	0.009	6	0.39	132	1.63	1.50
	Sample 4	32768.11	1.7	0.008	6	0.35	120	1.61	1.40
	Sample 5	32768.10	1.5	0.007	7	0.35	120	1.62	1.38

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Evaluation of a Low Frequency Clock Oscillation Circuit

SSP-T7-FL 6.0pF with uPD78F1505GC-16BT [LQFP(14x14) 0.5mm pitch]

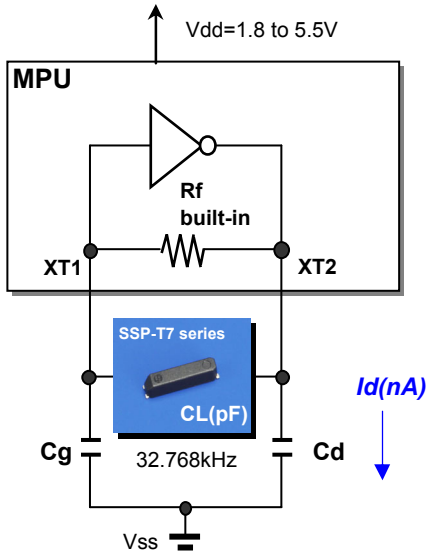
Measurement conditions : Vdd=3.0V at 25°C — **Low current consumption mode**

Referential Data(6) : Selection of XT1 oscillation mode and recommended load capacitance

For 78K0R/Lx3 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).

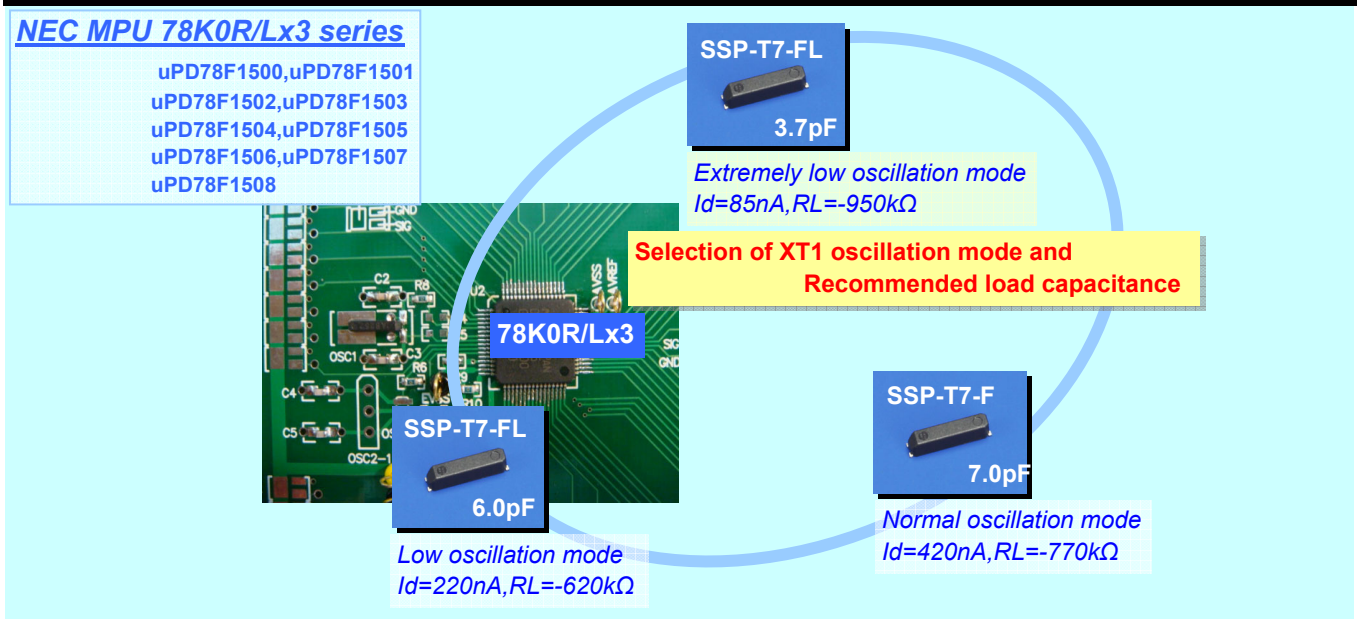
Correlations between the oscillation mode selection of XT1 oscillation circuit and the recommended load capacitance for a resonator are shown in Table 1 for safety use.



SSP-T7 series
SSP-T7-FL CL=3.7pF,4.4pF,6.0pF and SSP-T7-F CL=7.0pF,9.0pF

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=4pF,Cd=3pF	Cg=5pF,Cd=5pF	Cg=9pF,Cd=8pF	Cg=10pF,Cd=10pF	Cg=15pF,Cd=15pF
E-Low Extremely low consumption oscillation	**SSP-T7-FL 3.7pF** *Id=85nA typ* *RL=-950kΩ typ* *Ts=0.75sec typ*	**SSP-T7-FL 4.4pF** *Id=100nA typ* *RL=-700kΩ typ* *Ts=0.95sec typ*	**SSP-T7-FL 6.0pF** *Id=120nA typ* *RL=-395kΩ typ* *Ts=1.50sec typ*	*Not recommended.*	*Not recommended.*
Low Low consumption oscillation	*Not recommended.*	**SSP-T7-FL 4.4pF** *Id=185nA typ* *RL=-965kΩ typ* *Ts=0.70sec typ*	**SSP-T7-FL 6.0pF** *Id=220nA typ* *RL=-620kΩ typ* *Ts=0.95sec typ*	**SSP-T7-F 7.0pF** *Id=240nA typ* *RL=-480kΩ typ* *Ts=1.20sec typ*	*Not recommended.*
Normal Normal oscillation	*Not recommended.*	*Not recommended.*	**SSP-T7-FL 6.0pF** *Id=380nA typ* *RL=-1050kΩ typ* *Ts=0.65sec typ*	**SSP-T7-F 7.0pF** *Id=420nA typ* *RL=-770kΩ typ* *Ts=0.80sec typ*	**SSP-T7-F 9.0pF** *Id=530nA typ* *RL=-400kΩ typ* *Ts=1.35sec typ*



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