

Evaluation of Subsystem Clock Oscillation Circuit**SSP-T7-FL 6.0pF ATMEGA164PA-44P [TQFP(10x10) 0.8mm pitch]**

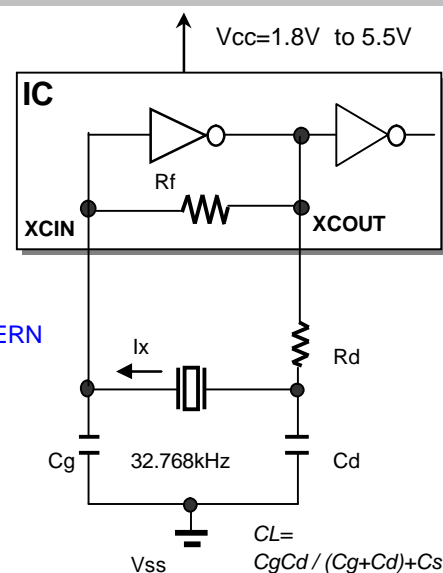
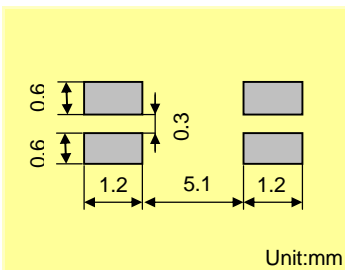
Measurement conditions : 3.0V, 5.0V

**SSP-T7-FL****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=65kohm max
Max. drive level	:DL=1x10 ⁻⁶ W max
Level of drive	:DL=0.1x10 ⁻⁶ W typ

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 PATTERNRemark) I_x : current through crystal

MODEL:SSP-T7-FL 6.0pF with ATMEGA164PA at 25°C

Key specifications	Vcc=3.0V	Vcc=5.0V	Remarks
Current control resistance : Rd (k ohm)	0	0	Control drive level & secure phase margin
Capacitance at gate : Cg (pF)	3	3	Optimal capacitance in response to CL
Capacitance at drain : Cd (pF)	3	4	(CL = Cd // Cg + stray capacitance)

Circuit characteristics (at 25°C)	Vcc=3.0V	Vcc=5.0V	Remarks
Matching Accuracy : df/f ($\times 10^{-6}$)	3.6	3.4	Frequency offset volume at specified Vcc
Voltage Fluctuation : $\pm df/V$ ($\times 10^{-6}$)	1.2	1.0	Vcc +/-10% (Standard operating voltage range)
Drive Level : DL ($\times 10^{-6}$ W)	0.01	0.01	$DL = I_x^2 R_e < 1 \times 10^{-6}$ W, $R_e = R_1 / (1 + C_o / CL)^2$
Negative resistance : $ -R_L $ (kohm)	566	566	5 times larger than R_{1MAX}
Oscillation allowance : M (times)	9	9	Judgemental standard of oscillation stability
Low consumption current : Id (nA)	226	241	Cd charge current, $I_d = f \cdot C_d \cdot V_d$
Voltage of oscillation start : Vstrat (V)	1.44	1.43	
Voltage of oscillation stop : Vstop (V)	1.36	1.35	
Oscillation start up time : Ts (sec)	0.93	0.93	Time to reach 90% of output level

Temperature characteristics of circuit	Vcc=3.0V	Vcc=5.0V	Remarks
at -40°C	Variation : df/T ($\times 10^{-6}$)	-116	Typ.Tp=25°C (K = $-3.5 \times 10^{-8} / ^\circ C^2$)
at +85°C	Variation : df/T ($\times 10^{-6}$)	-141	Typ.Tp=25°C (K = $-3.5 \times 10^{-8} / ^\circ C^2$)

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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We value the "takumi" spirit.

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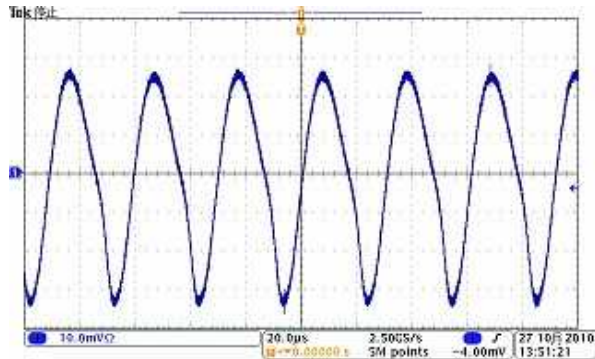
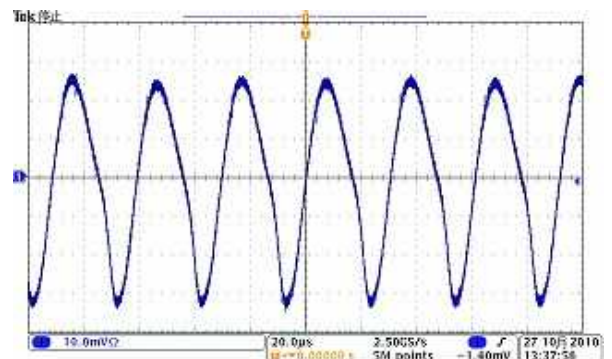
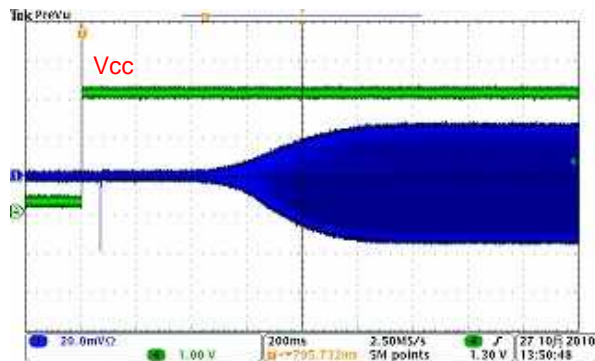
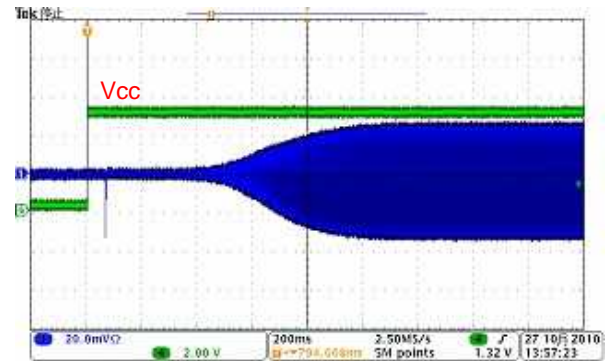
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SSP-T7-FL 6.0pF ATMEGA164PA-44P [TQFP(10x10) 0.8mm pitch]

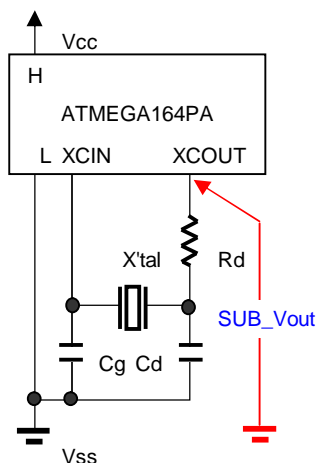
Measurement conditions : 3.0V, 5.0V



Test Data at 25°C

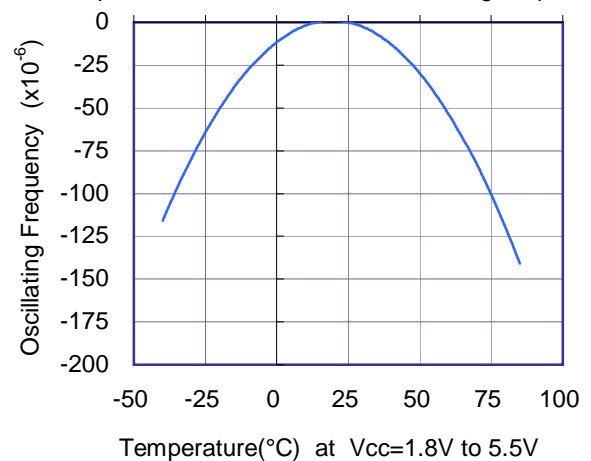
Signal wave from the oscillator
3.0VSignal wave from the oscillator
5.0VStart up time of SUB_Vout
3.0VStart up time of SUB_Vout
5.0V

Test Circuit



H : 5, 27
L : 6, 28
XCIN : 25
XCOU : 26
Fosc : 16
RESET : 4

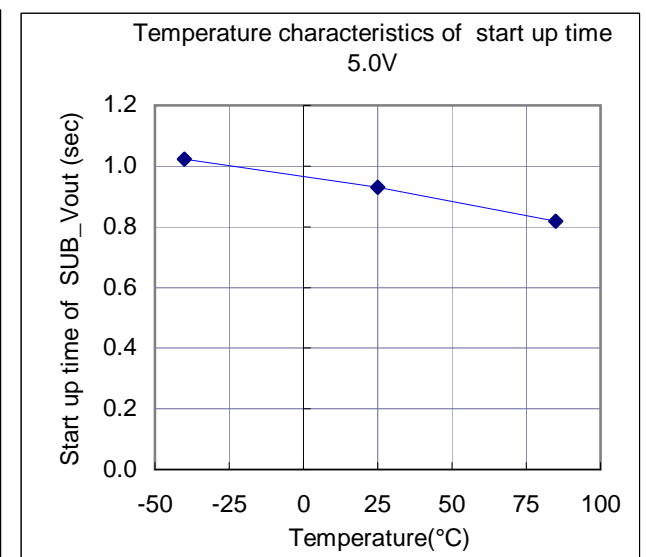
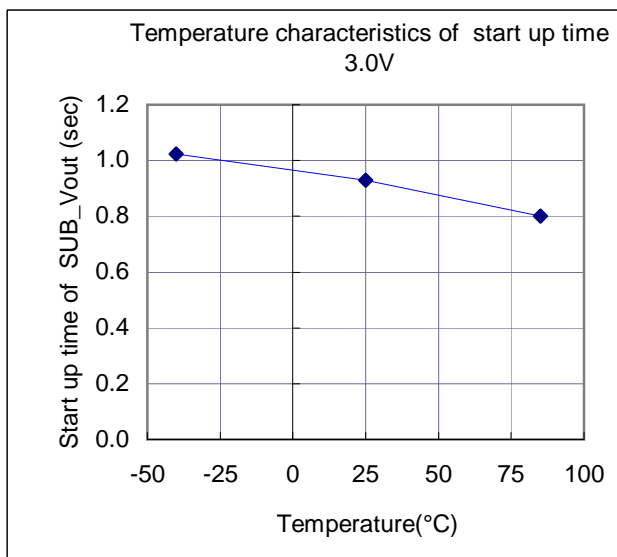
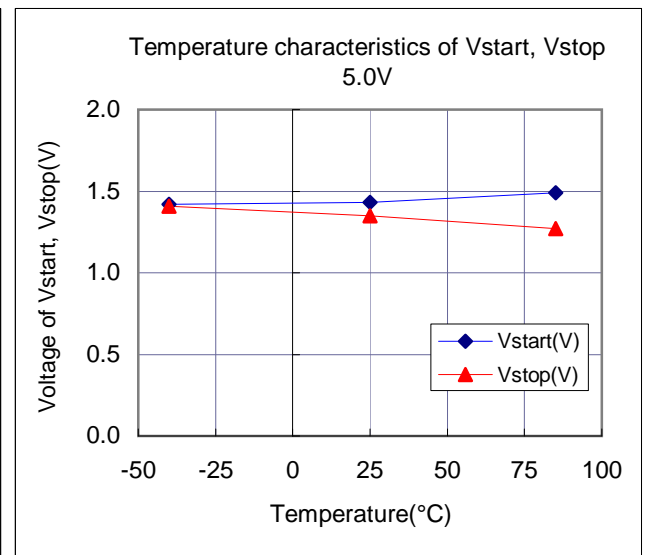
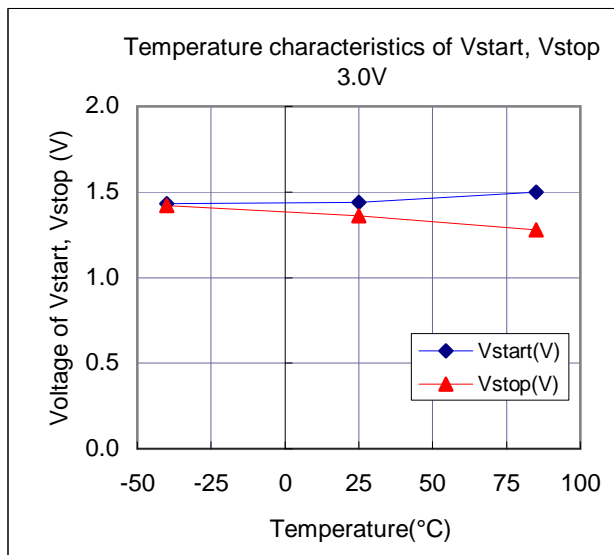
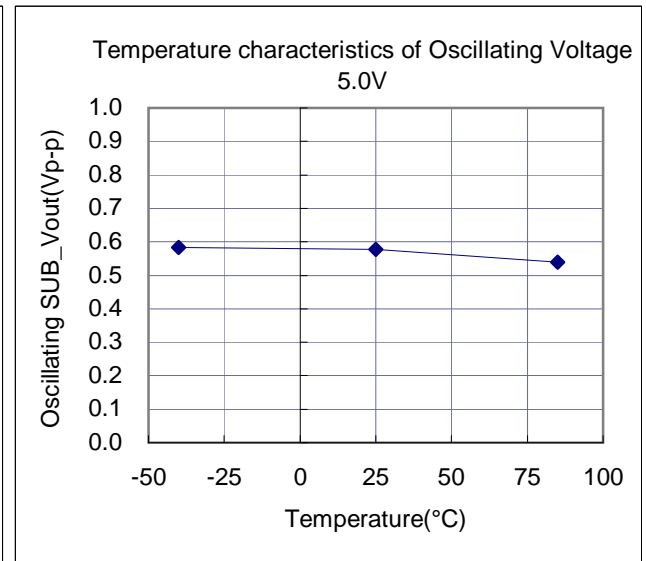
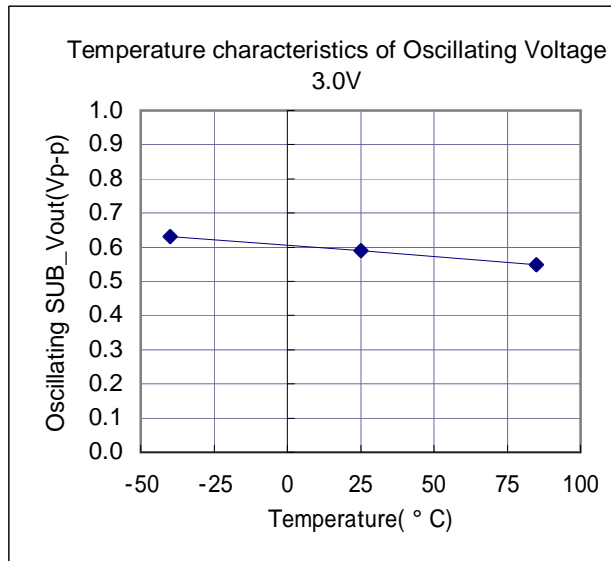
Temperature characteristics of oscillating frequency



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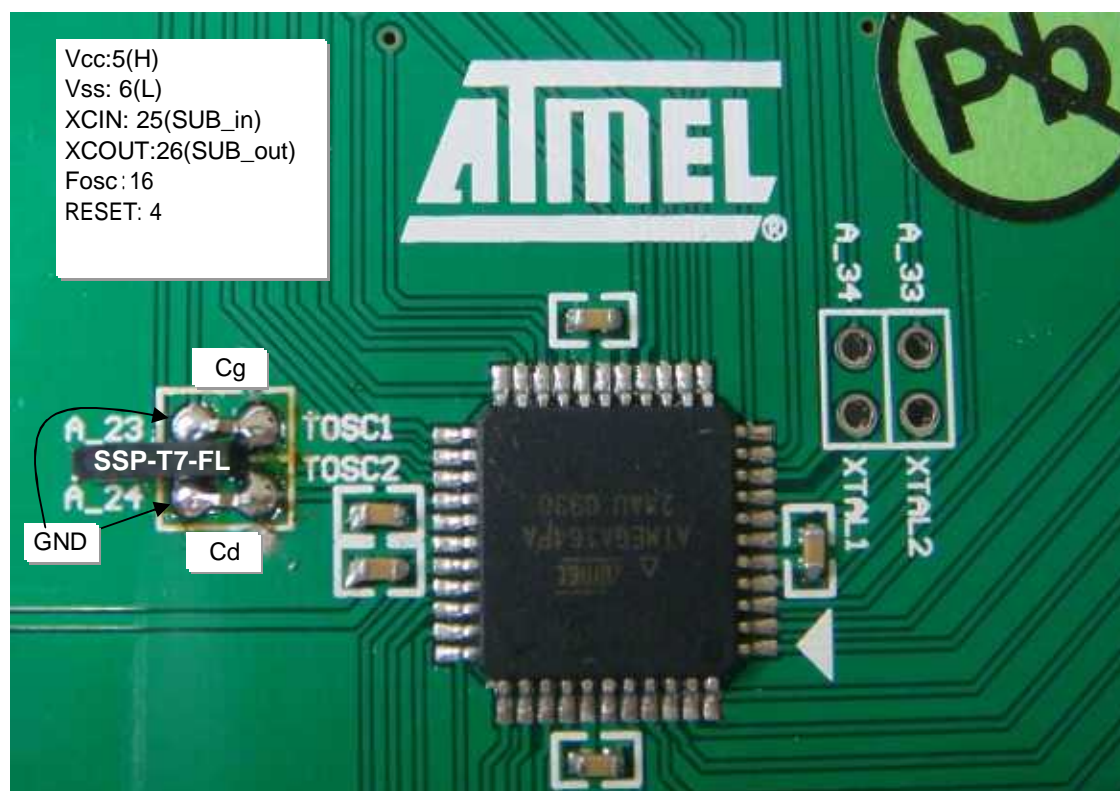
Measurement conditions : 3.0V, 5.0V

**Test Data : Temperature characteristics**

Evaluation of Subsystem Clock Oscillation Circuit

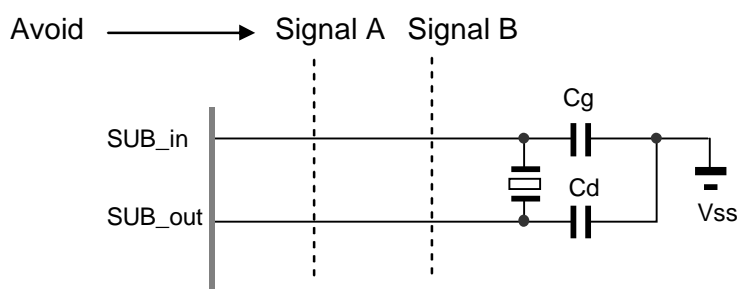
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Measurement conditions : 3.0V, 5.0V

Referential components layout(see Figure 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 resistors R_d in series on the SUB_out side.

Evaluation of Subsystem Clock Oscillation Circuit

SSP-T7-FL 6.0pF ATMEGA164PA-44P [TQFP(10x10) 0.8mm pitch]

Measurement conditions : 3.0V, 5.0V

[Evaluation Sample at 25°C]

SAMPLE	No.	CL(pF)	Fo(Hz)	fr(Hz)	R1(kohm)	Co(pF)	C1(fF)	Q(k)
SSP-T7	1	6.0	32767.73	32762.70	44.5	0.92	2.125	51.4
	2	6.0	32767.79	32762.79	42.3	0.91	2.109	54.5
	3	6.0	32767.92	32762.98	40.4	0.88	2.075	58.0

[IC Test Data : IC sample Rd=0k ohm,Cg=3pF,Cd=3pF at 25°C]

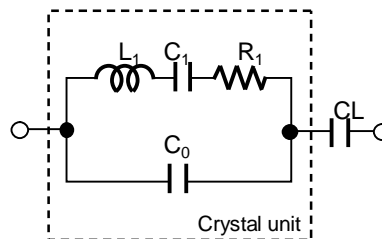
Vcc (V)	IC sample	Fosc(Hz)	df / f(x10 ⁻⁶)	DL(x10 ⁻⁶ W)	-RL (kohm)	Vstart(V)	Ts(sec)
3.0	1	16383.954	3.60	0.01	566	1.44	0.93
	2	16383.908	0.79	0.01	466	1.44	1.05

[IC Test Data : IC sample Rd=0k ohm,Cg=3pF,Cd=4pF at 25°C]

Vcc (V)	IC sample	Fosc(Hz)	df / f(x10 ⁻⁶)	DL(x10 ⁻⁶ W)	-RL (kohm)	Vstart(V)	Ts(sec)
5.0	1	16383.950	3.36	0.01	566	1.43	0.93
	2	16383.930	2.14	0.01	466	1.43	1.05

Remark (see figure 3)

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



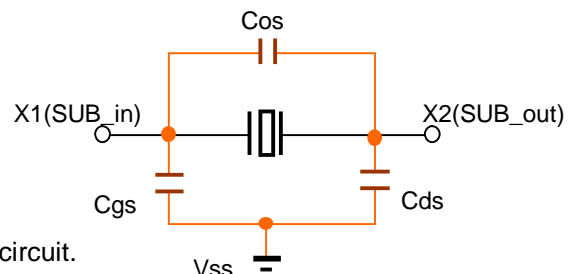
Fo : Load resonance frequency
 fr : Resonance frequency
 R1 : Motional resistance
 C1 : Motional capacitance
 Co : Shunt capacitance
 CL : Load Capacitance

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

Approximate formula of the load capacitance of the circuit CL.

$$CL = Cg \times Cd / (Cg + Cd) + Cs \text{ (pF)}$$

Where Cs(=2 to 3pF) Stands for stray capacitance of the circuit.



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

ATMEGA164PA

IC sample	Cs (pF)
1	3.9 ~ 4.5
2	4.1 ~ 4.6

Vcc=5.5~1.8V

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

Resonator circuit constants will 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.

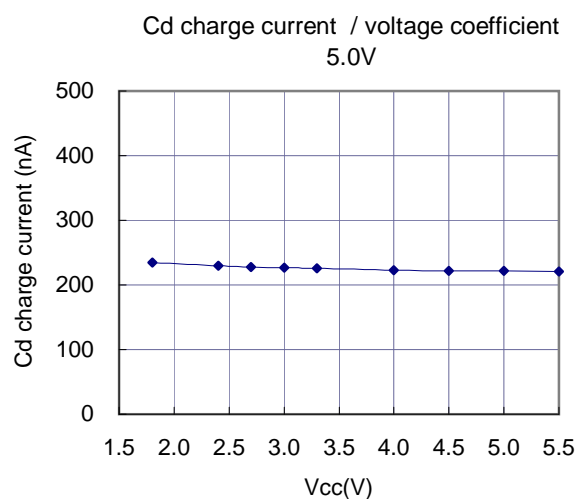
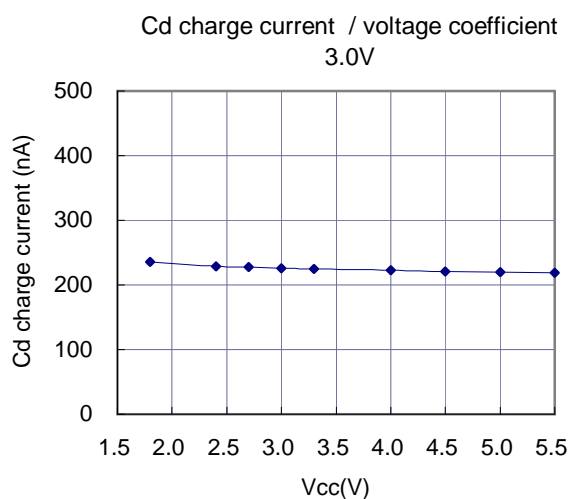
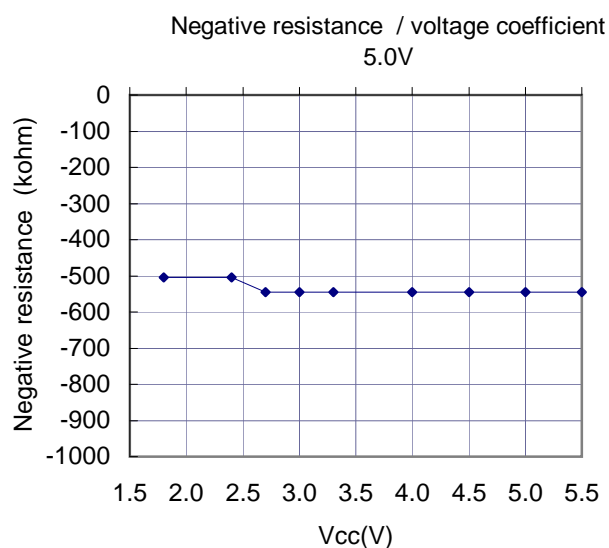
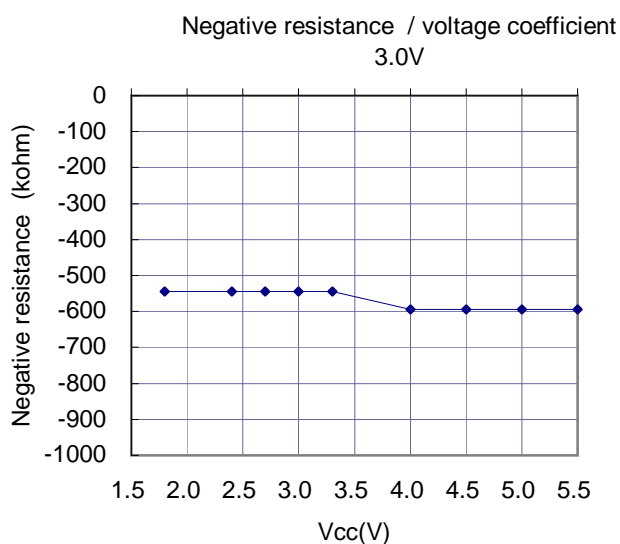
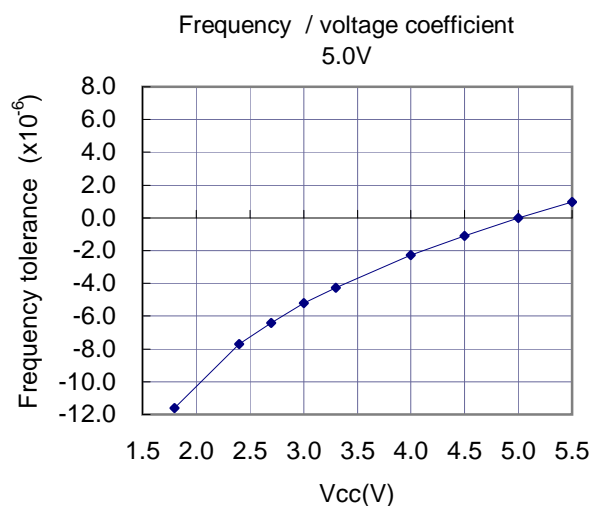
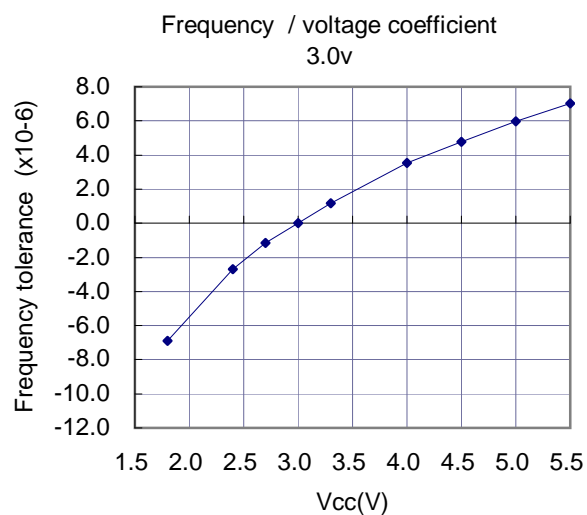
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Measurement conditions : Vcc=1.8V to 5.5V at 25°C



Referential Data(1) : Voltage characteristics



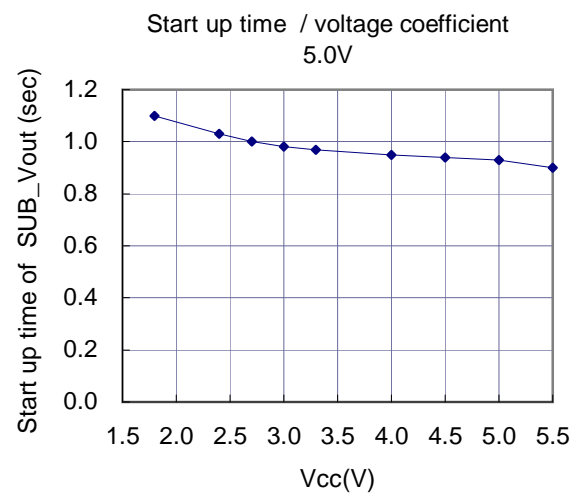
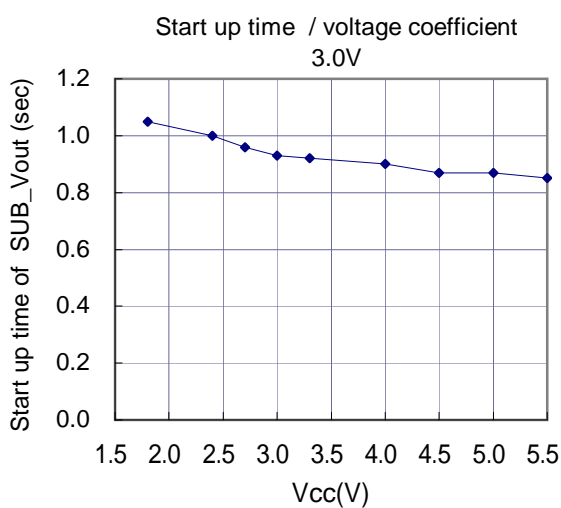
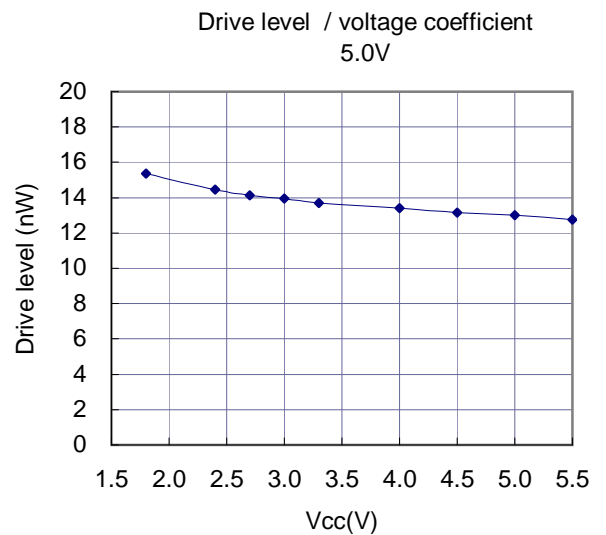
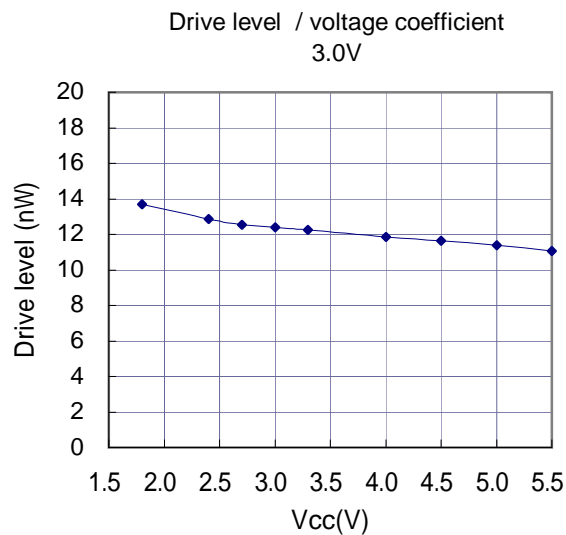
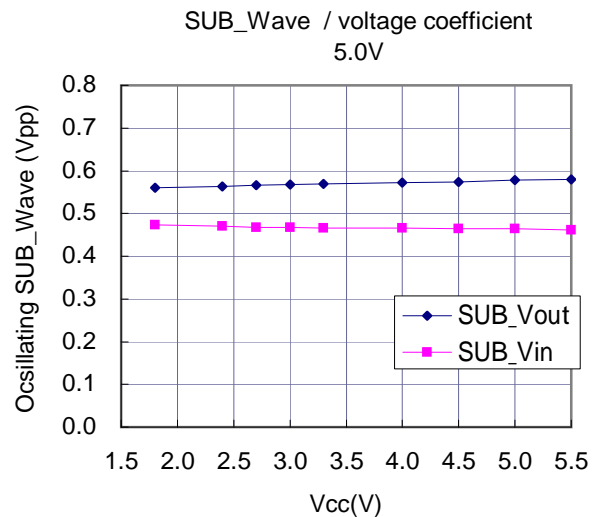
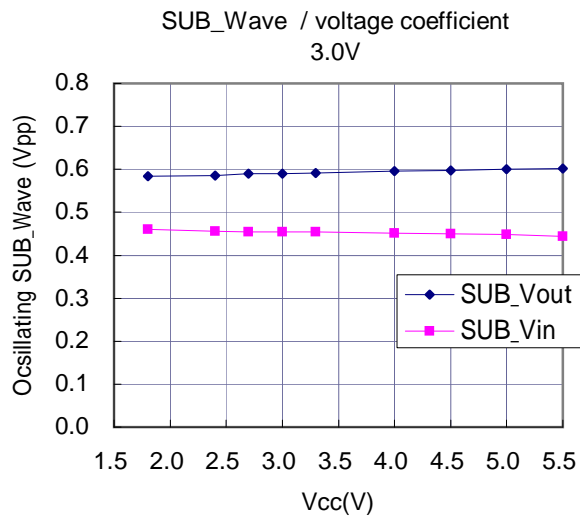
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Measurement conditions : Vcc=1.8V to 5.5V at 25°C



Referential Data(2) : Voltage characteristics

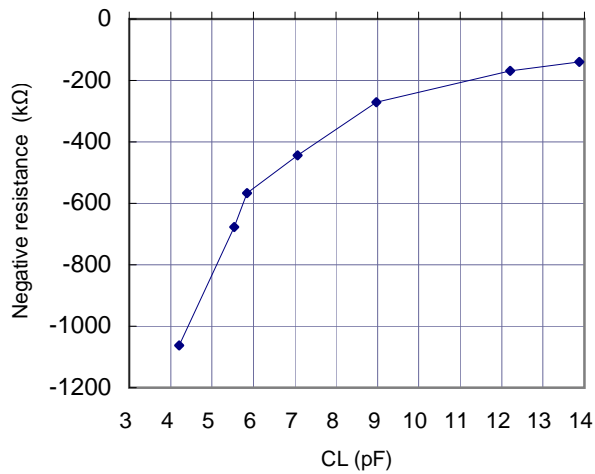
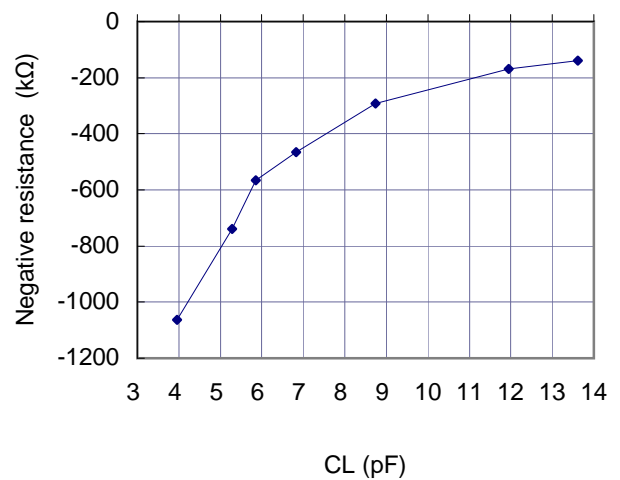
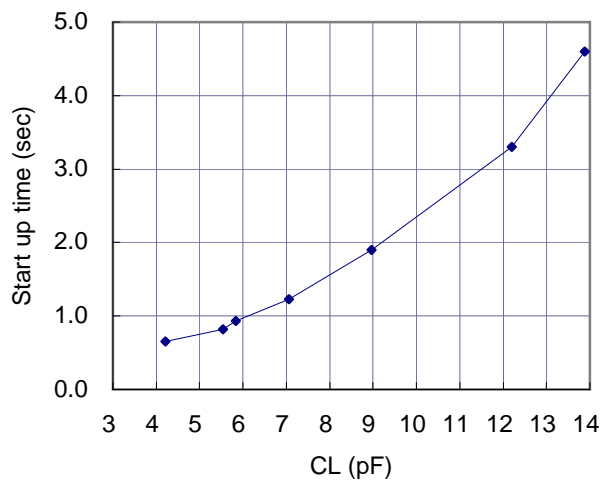
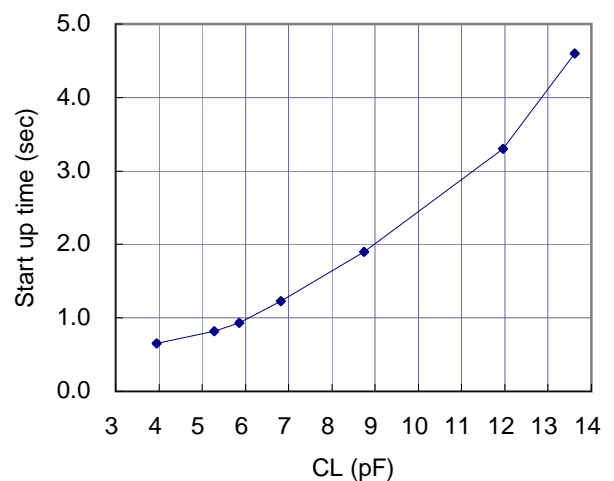
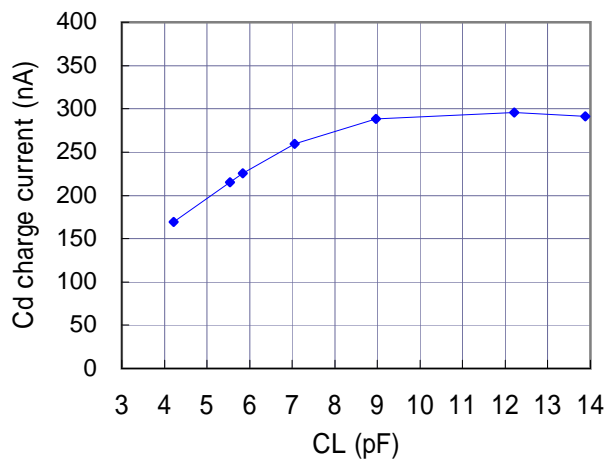
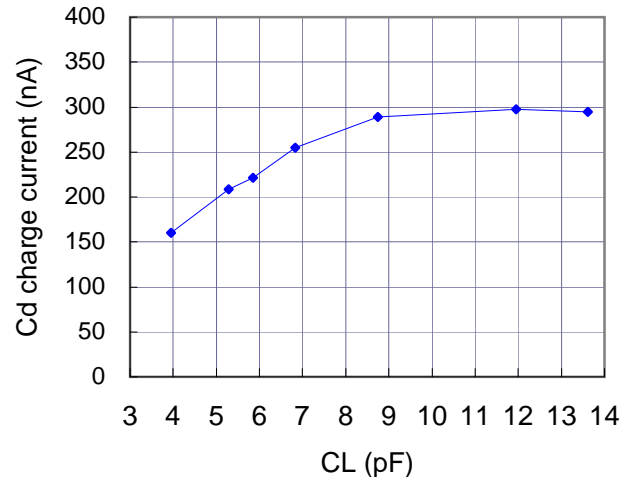


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SSP-T7-FL 6.0pF ATMEGA164PA-44P [TQFP(10x10) 0.8mm pitch]

Measurement conditions : $V_{CC}=3.0V, 5.0V$ at $25^{\circ}C$ 

Referential Data(3) : Load capacitance characteristics

Negative resistance / load capacitance coefficient
3.0VNegative resistance / load capacitance coefficient
5.0VStart up time / load capacitance coefficient
3.0VStart up time / load capacitance coefficient
5.0VCd charge current / load capacitance coefficient
3.0VCd charge current / load capacitance coefficient
5.0V

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SSP-T7-FL 6.0pF ATMEGA164PA-44P [TQFP(10x10) 0.8mm pitch]

Measurement conditions : Vcc=3.0V, 5.0V at 25°C

**[Comments from SII engineer]****1 12.5pF resonator**

According to the referential data (3): Load capacitance characteristics, 12.5pF resonator can not be used for Atmega 164PA due to insufficient negative resistance.

Our recommended negative resistance is 5 times larger than R1 max. and less than 1200kohm.

2 Performance improvement possibility

Fig 1 shows Atmega 164PA without external capacitance. Atmega 164PA has stray capacitance around 4pF.

If the stray capacitance were reduced to around 3pF, the low CL resonator(ex. CL=4.4pF) could be used which would improve the Ts, negative resistance and Id of CL=6pF close to values shown in Fig. 1.

3 Recommended CL resonator

As a result of our evaluation, our recommended resonators are CL=6pF as best, and CL=7pF as 2nd best for Atmega164PA.

Fig. 1: Cs and Osc. characteristics without external capacitance

ATMEGA 164PA	Vdd (V)	Cs (pF)	Ts (sec.)	RL (kΩ)	Id (nA)
No.1	5.0	3.9	0.55	1156	156
	3.0	4.2	0.65	1056	165
	1.8	4.5	0.75	876	177
No.2	5.0	4.1	0.70	876	144
	3.0	4.3	0.76	806	150
	1.8	4.6	0.90	776	158

