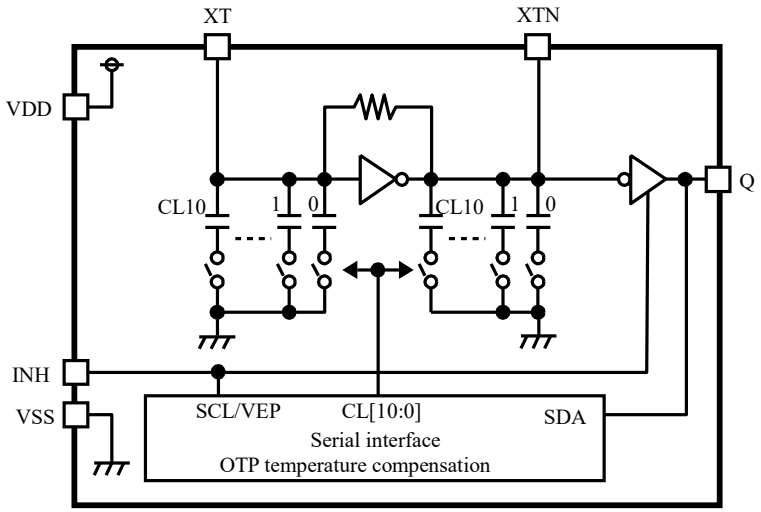
1. OVERVIEW

The WF7290A is 32.768kHz output crystal oscillator module IC that has a digital temperature compensation function. The WF7290A has a Non-volatile memory (OTP) and can be adjusted the oscillation frequency after the modules implementation.

2. FEATURES

- Oscillation and output frequency : 32.768kHz
- Operation voltage range : 1.3V to 3.63V（Oscillation output）
  : 1.5 V to 3.63 V（Temperature compensation ）
- Operating temperature of oscillation and output operation : -40°C to +105°C
- Operating temperature compensation : -40°C to +105°C
- Frequency accuracy : ±5.0 ppm
- Temperature compensation interval : select 2s / 0.5s / 0.25s / 0.125s / 0.0625s
- Low power current consumption : 1.0μA typ.
  (V_{DD}=1.8V, C_{LOUT}=0pF, temperature compensation interval 2s.)
- CMOS input/output
- Output drive capability : ±0.1mA (V_{DD}=1.5V)
- Output disable function
- 2-wire type serial interface

3. BLOCK DIAGRAM

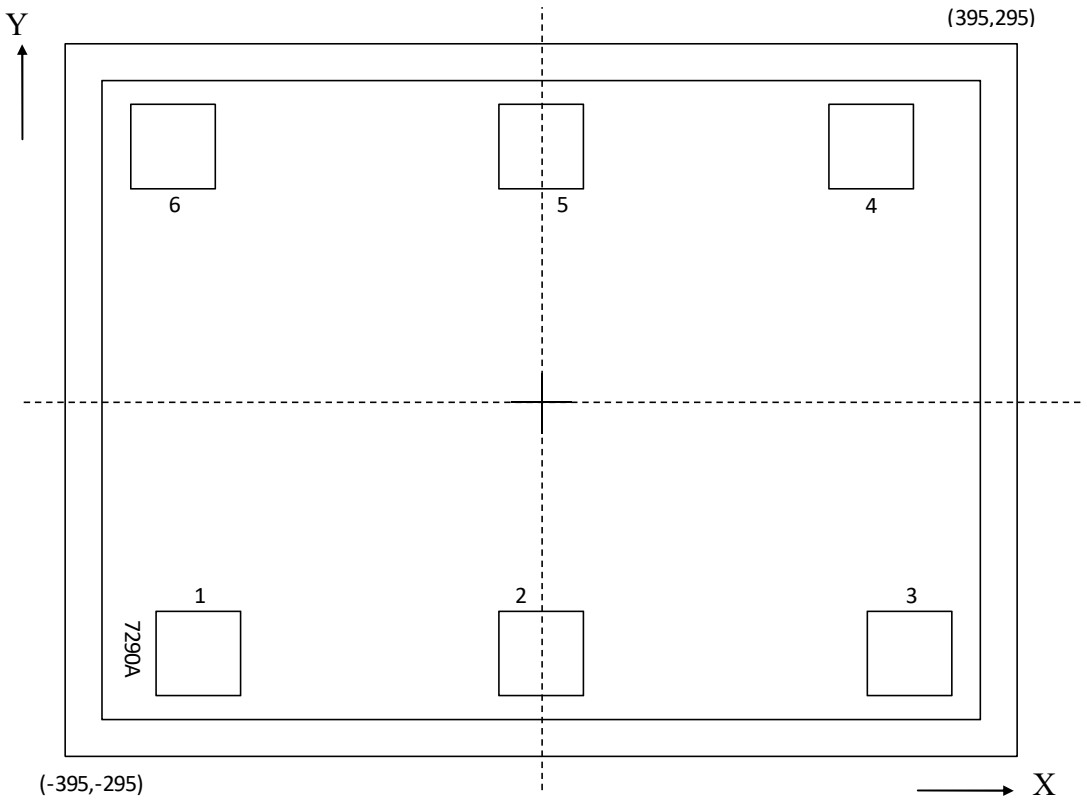


3.1 block diagram

4. PAD DIMENSIONS

(1) Chip size [*1] : X = 0.79mm, Y = 0.59 mm
(2) Wafer thickness : 100 ± 10μm
(2) Rear surface : V_{SS} potential
(3) Wafer size : φ200 mm ± 0.5 mm
(4) Pad aperture size : 70 μm × 70 μm
(5) Chip form and Pad dimensions

*1 : Chip size is the value between the scribe line centers.



Unit: μm

PAD No.	Pad Name	X	Y
1	VDD	-285	-210
2	XT	0	-210
3	VSS	306	-210
4	INH	274	210
5	XTN	0	210
6	Q	-306	210

5. PAD DESCRIPTION

Pad No.	Pad name	I/O*1	Description
1	VDD	—	(+) supply voltage
2	XT	I	Crystal input pin, C_G built-in
3	VSS	—	(-) ground
4	INH (SCL)	I	Use in Open or "Low" usually. (in PUDN=0, QS[1:0]=00) It becomes serial interface mode if the high voltage is inputted. SCL (Clock input) pin in serial interface mode. Pull-up or pull-down resistors are selectable with built-in One Time Programmable memory (OTP). The polarity of INH is selectable with built-in One Time Programmable memory (OTP).
5	XTN	O	Crystal output connection pin, C_D built-in
6	Q (SDA)	I/O	Oscillation output (32.768kHz), High-impedance output in standby mode (INH="L" level), SDA(Data input/output) pin in serial interface mode

*1: I : Input pin, O : Output pin, I/O : Input / Output pin

6. ABSOLUTE MAXIMUM RATINGS

V_{SS}=0V unless otherwise noted

Parameter	Symbol	Conditions	Rating	Unit
Supply voltage range *1	V_{DD}	Between VDD and VSS	-0.3 to +4.5	V
Program input voltage range *1	V_{PP}	Between INH and VSS	-0.3 to +6.75	V
Input voltage range *1,*2	V_{IN1}	Input pins INH *3	-0.3 to V_{DD}+0.3 *5	V
	V_{IN2}	Input pins XT	-0.3 to 2.5	V
Output voltage range *1,*2	V_{OUT1}	Output pins Q	-0.3 to V_{DD}+0.3 *5	V
	V_{OUT2}	Output pins XTN	-0.3 to 2.5	V
Output current *2	I_{OUT}	Q pin	±10	mA
Junction temperature *2	T_j	—	+150	°C
Storage temperature range *4	T_{STG}	Exclude EEPROM data retention	-55 to +150	°C

∗1 : Absolute maximum ratings are the values that must never exceed even for a moment. This product may suffer breakdown if any one of these parameter ratings is exceeded. Operation and characteristics are guaranteed only when the product is operated at recommended supply voltage range.

∗2 : Do not exceed these values. If a rating is exceeded, there is a risk of decrease in reliability.

∗3 : The value is in normal operation except program read/write operation.

*4 : When stored in nitrogen or vacuum atmosphere applied to IC itself only.

*5 : V_{DD} is a V_{DD} value of recommended operating conditions.

7. RECOMMENDED OPERATING CONDITIONS

V_{SS}=0V unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Operating supply voltage *1	V_{DD}	Oscillation output	1.3	1.8	3.63	V
		Temperature compensation operation	1.5	1.8	3.63	V
Input voltage	V_{IN}	INH	V_{SS}	-	V_{DD}	V
		XT	V_{SS}	-	2.0	V
Operating temperature	T_a	Oscillation operation	-40	-	+105	°C
Program supply voltage	V_{pp}	INH pin V_{DD}=1.5V to 3.63V	6.35	6.5	6.75	V
OTP data retention	—	Ta=-40°C to +105°C	10	-	-	years
Output load capacitance	C_{LOUT}	Q pin	-	-	30	pF

*1: For stable operation of this product, mount a ceramic chip capacitor that is more than 0.1 μF between VDD and VSS in close proximity to IC.

* Since it may influence the reliability if it is used out of the recommended operating conditions range, this product should be used within this range.

8. ELECTRICAL CHARACTERISTICS

8.1. DC Characteristics

V_{SS}=0V, V_{DD}=1.5V to 3.63V, Ta=-40°C to +105°C unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Current consumption in normal function (Select 2s for temperature compensation interval, SPXO=1)	I_{DD11}	V_{DD}=1.8V, C_{LOUT}=0pF*1, Measurement circuit 2 Ta=-40°C to +85°C	-	1.0	2.0	µA
	I_{DD12}	V_{DD}=1.8V, C_{LOUT}=0pF*1, Measurement circuit 2 Ta=-40°C to +105°C	-	1.0	3.0	µA
	I_{DD13}	V_{DD}=1.8V, C_{LOUT}=30pF*1, Measurement circuit 2 Ta=-40°C to +85°C	-	2.8	3.8	µA
	I_{DD14}	V_{DD}=1.8V, C_{LOUT}=30pF*1, Measurement circuit 2 Ta=-40°C to +105°C	-	2.8	4.8	µA
Current consumption in normal function (SPXO mode, SPXO=0)	I_{DD21}	V_{DD}=1.8V, C_{LOUT}=0pF*1, Measurement circuit 1 Ta=-40°C to +85°C	-	0.9	1.9	µA
	I_{DD22}	V_{DD}=1.8V, C_{LOUT}=0pF*1, Measurement circuit 1 Ta=-40°C to +105°C	-	0.9	2.9	µA
Current consumption in boot operation (SPXO mode, SPXO=0)	I_{BOOT}	Boot *1, V_{DD}=1.8V, C_{LOUT}=0pF*1, Measurement circuit 1	-	-	3.3	µA
Current consumption in disable function	I_{DIS}	Output disable, V_{DD} =1.8V, Measurement circuit 1,	-	-	2.0	µA

*1: C_{LOUT} is the load capacitor connected to Q pin outside.

*2: In order to shorten the oscillation start up time, the oscillation circuit has a boot circuit that increases the drive ability. Boot function operates from oscillation start to 0.5s (t_{sta}+ 0.5s) after applying power supply.

The contents of current consumption in normal function

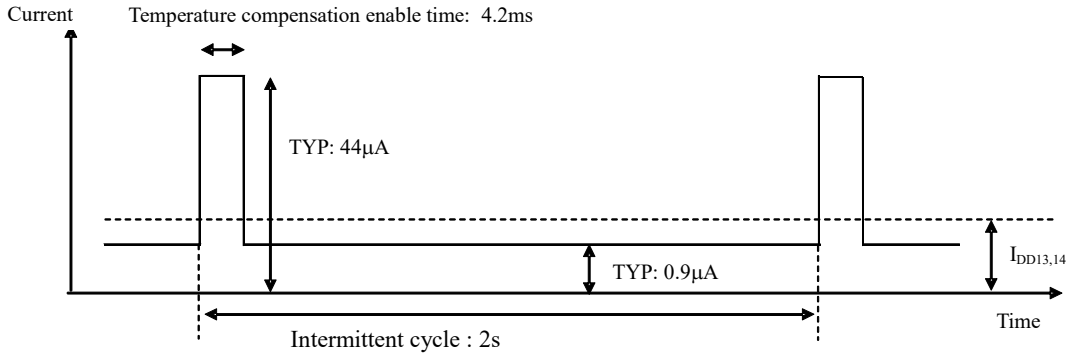
$I_{DD13,14}$ is the average value of the intermittent cycle (see below).

Example) temperature compensation interval =2s, V_{DD}=1.8V, C_{LOUT}=30pF

TYP :$I_{DD13,14}$ = 0.9µA × (2s – 4.2ms) / 2s + 44µA × 4.2ms / 2s + 30pF × 32.768kHz × 1.8V = 2.8µA

stop period — operate period — load current

Temperature compensation circuit



V_{SS}=0V, V_{DD}=1.5V to 3.63V, Ta=-40°C to +105°C, unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
High-level input voltage	V_{IH1}	INH*1, Measurement circuit 3	0.8V_{DD}	-	-	V
		Q*2, Measurement circuit 3,	0.8V_{DD}	-	-	V
Low-level input voltage	V_{IL1}	INH*1, Measurement circuit 3	-	-	0.2V_{DD}	V
		Q*2, Measurement circuit 3,	-	-	0.2V_{DD}	V
High-level output voltage	V_{OH1}	Q*1, I_{OH}=-0.1mA,V_{DD}=1.5V Measurement circuit 4	0.9V_{DD}	-	-	V
	V_{OH2}	Q*2, I_{OH} =-10μA,V_{DD}=1.5V Measurement circuit 5	0.9V_{DD}	-	-	V
Low-level output voltage	V_{OL1}	Q*1, I_{OL}=0.1mA,V_{DD}=1.5V Measurement circuit 4	-	-	0.1V_{DD}	V
	V_{OL2}	Q*2, I_{OL} =10μA,V_{DD}=1.5V Measurement circuit 5	-	-	0.1V_{DD}	V

*1 : It is the value in normal operation except temperature compensation control registers and OTP access.

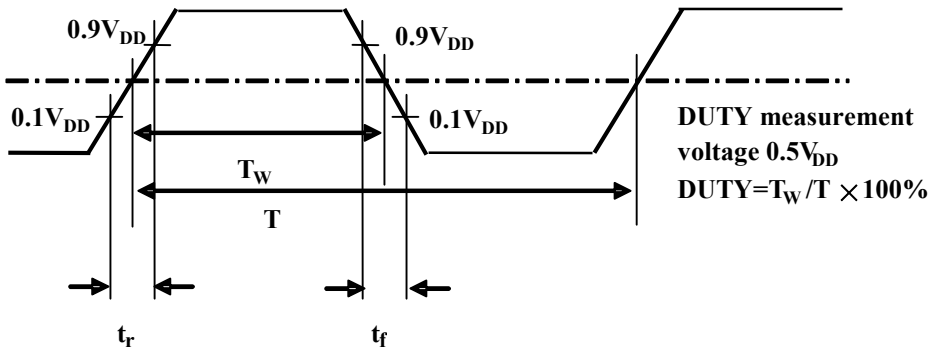
*2 : It is the value in access to temperature compensation control registers and OTP.

8.2. AC Characteristics 1 (Q pin output characteristics)

V_{SS}=0V, V_{DD}=1.5V to 3.63V, Ta=-40°C to +105°C unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Output duty cycle	Duty	C_{LOUT}=30pF, 0.5V_{DD} threshold, Measurement circuit 2	40	50	60	%
Output rise time	t_r	C_{LOUT}=30pF, 10%→90% Measurement circuit 2	-	-	40	ns
Output fall time	t_f	C_{LOUT}=30pF, 90%→10% Measurement circuit 2	-	-	40	ns

Timing Chart

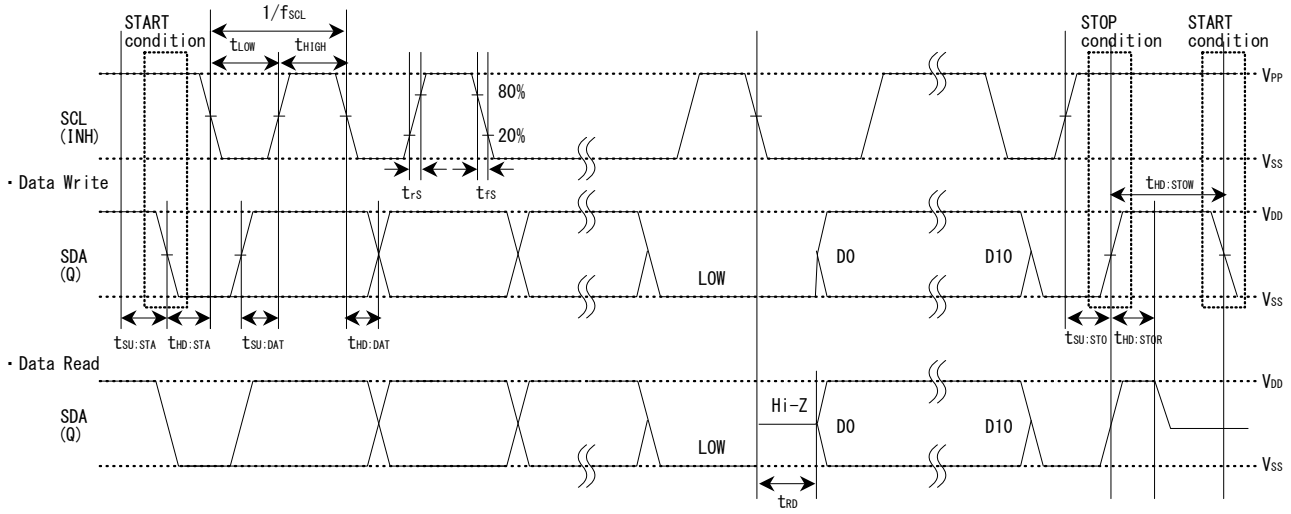


8.3. AC Characteristics 2 (2-wire type serial interface)

When accessing to the temperature compensating control register or OTP

V_{SS}=0V, V_{DD}=1.5V to 3.63V, Ta=-40°C to +105°C unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
SCL clock frequency	f_{SCL}	After start condition	20	-	500	kHz
Start condition setup time	$t_{SU;STA}$	—	0.3	-	-	µs
Start condition hold time	$t_{HD;STA}$	—	0.3	-	-	µs
Data setup time	$t_{SU;DAT}$	—	0.3	-	-	µs
Data hold time	$t_{HD;DAT}$	—	0.3	-	-	µs
Stop condition setup time	$t_{SU;STO}$	—	0.3	-	-	µs
Stop condition hold time	$t_{HD;STOW}$	Write the data to OTP	1.7	-	-	ms
	$t_{HD;STOR}$	Read the data from OTP, Access the registers	0.2	-	-	µs
SCL "L" period	t_{LOW}	—	1	-	-	µs
SCL "H" period	t_{HIGH}	—	1	-	-	µs
SCL rise time	t_{rS}	20%→80%	-	-	0.2	µs
SCL fall time	t_{fS}	80%→20%	-	-	0.2	µs
Read data delay time	t_{RD}	C_{LOUT}=15pF	-	-	0.5	µs



8.4. Oscillation characteristics

WF7290A oscillation characteristics is in the below crystal parameters

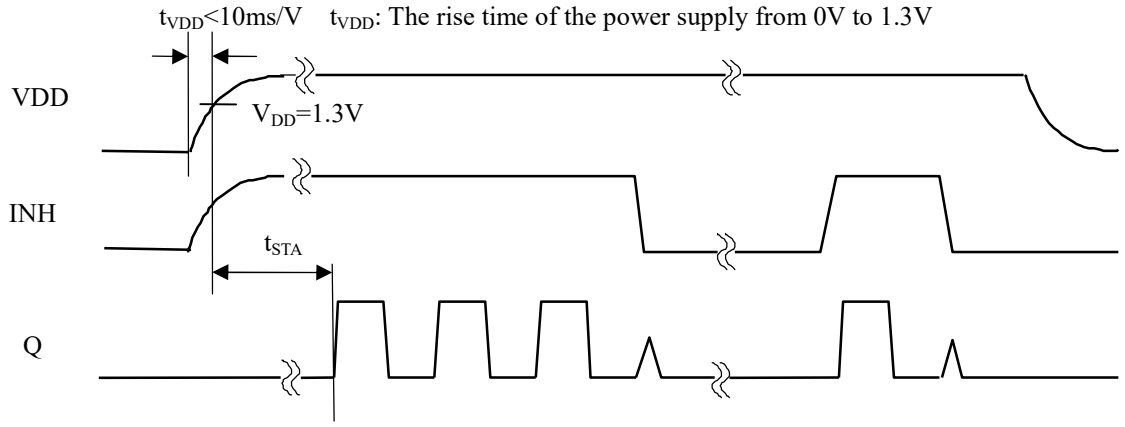
Parameter	Symbol	Rating
Frequency	f0	32.768kHz
Frequency permission deviation	⊿f	±20ppm(25°C)
Peak temperature	Ti	25°C±5°C
Parabolic coefficient	B	-0.04ppm/°C ^{2}min
Load capacitance	CL	9.0pF
Serial resistance	R1	100kΩmax

V_{SS}=0V, V_{DD}=1.3V to 3.63V, Ta=-40°C to +105°C, C_{LOUT}=30pF unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Oscillation frequency	fo	Ta= +25°C,V_{DD}= 1.3V to 5.5V	-	32.768	-	kHz
Oscillation start up voltage	V_{STR}	V_{DD} rises gradually. Measurement circuit 2	-	-	1.3	V
Oscillation stop voltage	V_{STO}	V_{DD} descends gradually. Measurement circuit 2	0.5	-	1.3	V
Frequency accuracy *2	⊿f / fo	V_{DD}= 1.8V	-	-	± 5.0	ppm
Oscillation start up time*3	t_{STA}		-	-	0.5	s
Frequency-voltage characteristic	⊿f /⊿V	V_{DD} ±10%	-1.0	-	+1.0	ppm

*1: CL setting is built-in capacitance value for crystal oscillation (C_L).
*2: Frequency accuracy is the theoretical value.

*3: **Timing Chart at power supply**



9. FUNCTIONAL DESCRIPTION

9.1. INH Function

Q outputs 32.768 kHz when INH goes "L" level or OPEN (in initial setting). When a high voltage is input to INH, INH becomes SCL, which is the input terminal to which the clock of the serial interface is input, and Q becomes SDA, which is the data of the serial interface, I/O terminal. The oscillator circuit don't stop the operation. Input the voltage of V_{IH1} or V_{IL1} to INH certainly. After power-on, the Q terminal outputs "L" level until the OTP data of QS bit is read. The polarity of the INH can be changed with OTP memory.

	Q			Oscillator
INH	QS[1:0]=[00]*1	QS[1:0]=[01]	QS[1:0]=[10]	
"H" level	Hi-Z	32.768kHz	32.768kHz	Operating
"L" level	32.768kHz	Hi-Z	32.768kHz	Operating
OPEN	32.768kHz*2	32.768kHz*2	32.768kHz	Operating

*1: Initial value.
*2: In the case of PUDN="0" (initial value).

	INH		
PUDN	QS[1:0]=[00]	QS[1:0]=[01]	QS[1:0]=[10]
0*1	Pull-down resistor connected	Pull-up resistor connected	Pull-down resistor connected
1	Hi-Z	Hi-Z	Hi-Z

*1: Initial value.

9.2. SPXO Function

Temperature compensation operation is not performed by setting the SPXO bit to 0. (initial value)
If OTP is not written, CL setting will be 400/H.

SPXO	Temperature compensation
0*1	disable (Only the first temperature compensation operation after start-up is performed. The C_L load capacitance setting value at that time is held.)
1	enable

*1: Initial value.

9.3. Temperature compensation function

Built-in capacitance for crystal oscillation is the capacitance array. This is controlled by CL registers to adjust frequency. The data of OTP which makes the A/D conversion output of an internal thermometer an address is periodically stored in CL registers. The adjustment data which makes the frequency constant to temperature is written in OTP. These data will be stored to CL registers at a temperature compensation interval and will change the value of built-in oscillator capacitance to adjust frequency. The temperature compensation interval is selected from 2s/0.5s/0.25s/0.125s/0.0625s.

TSC[2:0] (T[9:7])			Temperature compensation interval
TSC2 (T9)	TSC1 (T8)	TSC0 (T7)	
0	0	0	0.5s
0	0	1	0.25s
0	1	0	0.125s
0	1	1	0.0625s
1	1	1	2s

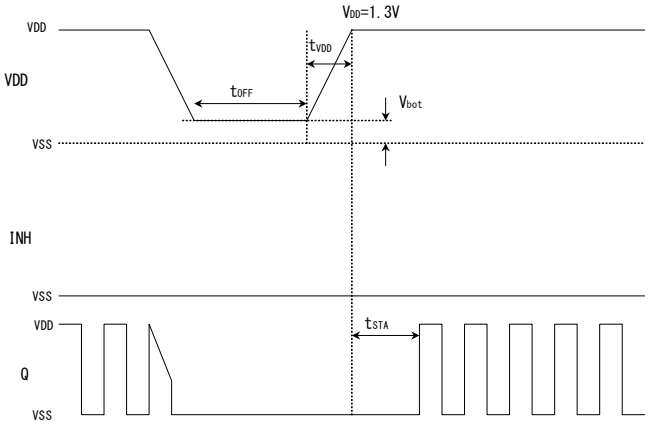
9.4. Power activation

It is the power-on clear circuit built-in. This circuit sets 300/H to CL registers at power activation. After starting oscillation, the first temperature compensation operates at 0.5s. After that, it operates at the selected temperature compensation interval.

The boot circuit operates to 0.5s after starting oscillation from power activation.

9.5. Attention at the time of the power supply setup

The instability of IC inside circuit in the power supply start might cause malfunction. Therefore, built-in power-on clear circuit prevents it. Start up the power supply under the recommended conditions of t_{VDD}, t_{OFF}, V_{bot} in order to operate it certainly.



t_{VDD}	t_{OFF}	V_{bot}
under 10ms/V	over 0.5ms	0V

10. TEMPERATURE COMPENSATION REGISTERS TABLE

D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	A7～A0
Data											Address
AD10	AD9	AD8	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	00/h
STA	TCL	PTM1	PTM0	TOSC	–	–	TS3	TS2	TS1	TS0	01/h
VDT	TSC2	TSC1	TSC0	CRC	CR5	CR4	CR3	CR2	CR1	CR0	02/h
CL10	CL9	CL8	CL7	CL6	CL5	CL4	CL3	CL2	CL1	CL0	03/h
SPXO	QS1	QS0	PUDN	OSC2	OSC1	OSC0	OFS3	OFS2	OFS1	OFS0	04/h
T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	08/h
C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	C0	10/h
Temperature compensation data (Address 10/h to F0/h C[10:0])											20/h ・ ・ ・ E0/h F0/h
K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0	00/h

*The double line indicates OTP field.

10.1. Serial Port Field Description

Field	description	Initial value
AD[10:0] (R)	These are an A/D conversion result output bits of a temperature sensor. These are read only. *1 Maximum temperature setup is [001 0000 0000], Minimum temperature setup is [111 1111 1111]	000 0000 0000*5
STA (W)	This is the bit for A/D conversion start up. A/D conversion starts when 1 is written in this bit, and then it will be finished after 7.8ms. Normal intermittent operation is stopped by starting serial communication. And, A/D conversion starts to use the data from serial communication. Don't write and read from serial interface while A/D conversion operates.	0
TCL (W)	For IC test	0 For IC test *2
PTM[1:0]	For IC test	00 For IC test *2
TOSC (W)	For IC test	0 For IC test *2
TS[3:0] (W)	For IC test	0000 For IC test*2
VDT (R)	For IC test	For IC test*2
TSC[2:0] (R/W) **(T[9:7])**	This is the bit of the temperature compensation interval setup. T[9:7] data of OTP is written in here during a normal function.	000*4 (000)

TSC2	TSC1	TSC0	Temperature compensation interval
0	0	0	0.5s
0	0	1	0.25s
0	1	0	0.125s
0	1	1	0.0625s
1	1	1	2s

<table>
<tr><th>Field</th><th>description</th><th>Initial value</th></tr>
<tr><td>CRC
(R/W)

(T6)</td><td>Initial setting data for counter of A/D conversion
Written the trimming data T6 in normal operation.

*Write the below data to T6 in EEPROM
・Temperature compensation ranges -40 to +85°C : 1
・Temperature compensation ranges -40 to +105°C : 0</td><td>0*4

(0)</td></tr>
<tr><td>CR[5:0]
(R/W)

(T[5:0])</td><td>CR oscillation frequency adjustment bits
Written the trimming data T[5:0] in normal operation.
*Adjust CR oscillation frequency to near the below frequency
by changing CR[5:0] at Ta = 25°C. And then, write the adjustment CR data to T[5:0] in OTP.
・Temperature compensation ranges -40 to +85°C : 57.0kHz @ 25°C
・Temperature compensation ranges -40 to +105°C : 51.8kHz @ 25°C
<table>
<tr><th>CR5</th><th>CR4</th><th>CR3</th><th>CR2</th><th>CR1</th><th>CR0</th><th>CR oscillation frequency*3</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>22.2kHz</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>23.1kHz</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>23.9kHz</td></tr>
<tr><td colspan="7">CR oscillation frequency adjustment step*2 0.84kHz(1.5% of 57.0kHz) 6bits</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>68.6kHz</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>69.3kHz</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>70.0kHz</td></tr>
</table></td><td>100000*4

(000000)</td></tr>
<tr><td>CL[10:0]
(R/W)</td><td>These are the bits for setting the C_L load capacitance of crystal oscillator</td><td>011 0000 0000*4</td></tr>
<tr><td>SPXO
(K[10])</td><td>Temperature compensation circuit operation stop bit
[0] : disable [1] : enable
When “0” is set, only the first temperature compensation operation after start-up is performed. The C_L load capacitance setting value at that time is held.</td><td>0*4

(0)</td></tr>
<tr><td>QS[1:0]

(K[9:8])</td><td>Polarity selection bits of INH terminal
Written the trimming data K[9:8] in normal operation.
<table>
<tr><th rowspan="2">QS1</th><th rowspan="2">QS0</th><th colspan="3">Output state of Q</th></tr>
<tr><th>INH=”H”</th><th>INH=”L”</th><th>INH=”OPEN”</th></tr>
<tr><td>0</td><td>0</td><td>Hi-Z</td><td>32.768kHz</td><td>32.768kHz*6</td></tr>
<tr><td>0</td><td>1</td><td>32.768kHz</td><td>Hi-Z</td><td>32.768kHz*6</td></tr>
<tr><td>1</td><td>0</td><td>32.768kHz</td><td>32.768kHz</td><td>32.768kHz</td></tr>
</table></td><td>00*4

(00)</td></tr>
<tr><td>PUDN
(K7)</td><td>INH pin pull-down, pull-up resistor connection setting bit
Written the trimming data K7 in normal operation.
[0] : connect [1] : non-connect</td><td>0*4
(0)</td></tr>
<tr><td>OSC[2:0]
(K[6:4])</td><td>Oscillator current adjustment bits. Write “100b”</td><td>011*4
(000)</td></tr>
<tr><td>OFS[3:0]
(K[3:0])</td><td>Correction bits for the calculation result of the C_L load capacitance setting value</td><td>0000*4
(0000)</td></tr>
</table>

*1: A/D conversion of the temperature sensor is 11-bit and they are read in the serial interface. The higher 5 bits is actually used as the address of OTP. As a result of A/D conversion, when the lower 6 bits are not “0”, compensation data is interpolated from the OTP data of the higher 5bits address and the address added to it.

*2: This bit is for IC test only. Write “0” to them.

*3: designed value

*4: Value just after power-up. The data written to OTP is stored in the register in the temperature compensation. All data of OTP are “0” in shipping this device.

*5: Value just after power-up. The result of conversion is stored after A/D conversion.

*6: Value in PUDN=0. INH is Hi-Z in PUDN=1. Input voltage according to the specification of the input voltage constantly.

10.2. OTP data

D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	A7～A0
Data											Address
T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	T0	08/h
C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	C0	10/h
Temperature compensation data (Address 10/h to F0/h C[10:0])											20/h ・ ・ ・ E0/h
											F0/h
K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0	00/h

- T[9:0] bits
  These are the bits of the analog circuit compensation data. Write the adjustment CRC data and CR data in T[6:0].
  T[9:7] is for the temperature compensation interval setup.

- C[10:0] bits
  These are the bits of the set value of C_L load capacitance of crystal oscillator. Write the adjustment data for temperature compensation.

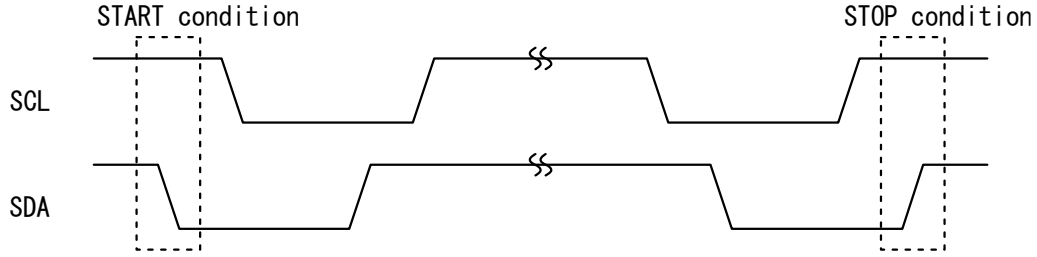
- K[10:0] bits (Address to control the INH function)
  These are bits for SPXO setting, INH function selection and IC testing. Write temperature compensation operation control data to K[10]. Write to the data to select INH function in K[9:7]. K [6:4] are the oscillator current adjustment bits. Write “100b”.K[3:0] are correction bits for the calculation result of the C_L load capacitance setting value.

* About OTP data, write the data to all address and all bits under predetermined conditions
And it prohibited the accessing to the addresses except the above address.
Note that the data “0” are written to each address in shipping this device. (When read from outside, all 1 is returned but internal data is 0.)
The C_L load capacitance is set to 400/H when it is used with all data (C[10:0] = 000/H) at the time of shipment from our company. When the OTP memory initial value 000/H is called into the register, the circuit is set to be around C_L = 6.5pF.
Be careful when using with the default value of OTP memory.

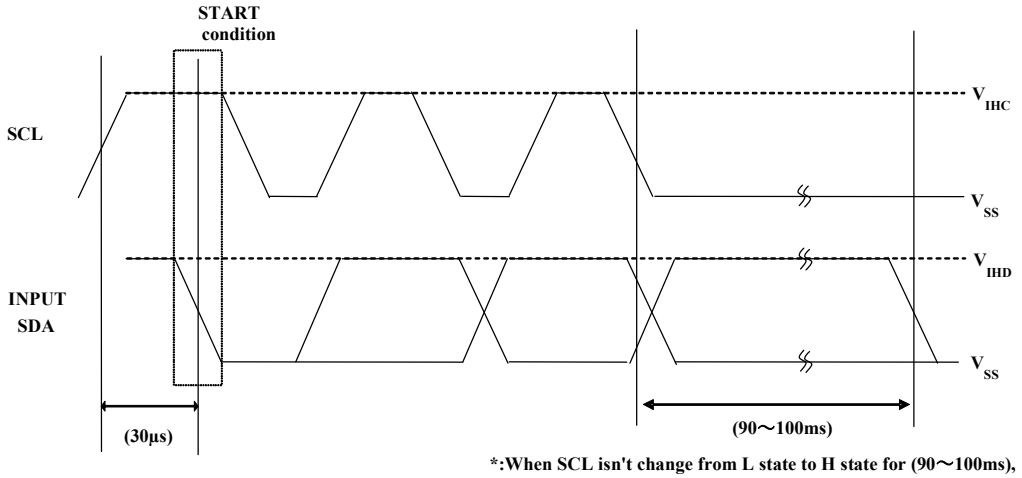
10.3. 2-WIRE TYPE SERIAL INTERFACE

WF7290A transmits and receives data by the 2-wire type serial interface of SCL (INH: clock line) and SDA (Q: data line). "H" level of SCL is V_{PP} and "H" level of SDA is V_{IH1}.

While serial interface is not performing data transfer, set SCL and SDA to "H" level. At this time, if SDA changed from "H" level to "L" level, the state will be in START condition. After detecting START condition, it is possible to start access and to perform data transmission. And, when SCL is "H" level, if SDA changed from "L" level to "H" level, the state will be in STOP condition. After detecting STOP condition, access is finished. These conditions are recognized on the way of data transfer too. Be sure to make these conditions at the data transfer start timing and end timing. About the data transfer format, refer to 10.4.



32.768kHz output of Q pin is disabled and becomes serial interface mode when SCL is inputted V_{PP}. If there is no clock input of 90ms to 100ms or more in SCL on the way of communication, the interface is initialized and communication is finished.



Wait for 30us before changing SDA into "L" level from "H" level after making SCL "H" level when transmitting START condition in order to access the serial interface while the temperature compensation in normal operation.

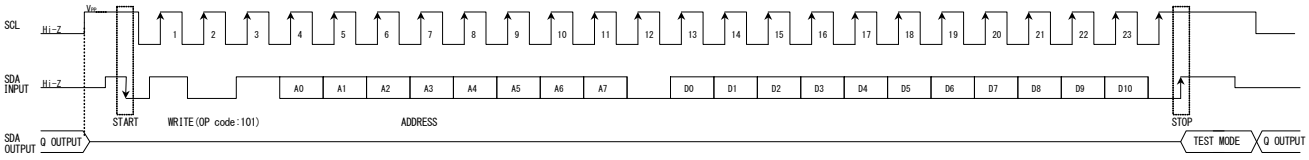
10.4. Data transmission Format of Temperature Compensating Control Register and OTP

Data transmission format of temperature compensating control register and OTP is the below. Transmit from LSB data first.

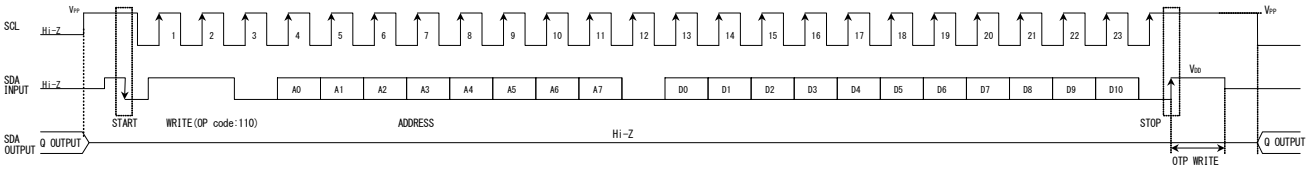
10.4.1. Data Write-in Format

After start condition, the transmitter transmits 23 bits of WRITE opcode (101 in register, 110 in OTP, 111 in OTP address to control INH function), an address and a data. And then, it transmits STOP condition. The data of registers are written in synchronizing with the rising edge of 23rd SCL clock. OTP is written by OTP write-in circuit. OTP write-in circuit starts after detecting STOP condition and write-in time takes 1.7ms. Keep SCL and SDA of STOP condition（SCL=V_{PP}, SDA=V_{IH1}）for 1.7ms. And, to finish serial communication and return to the normal operation, it needs to release SDA (Hi-Z) by set "L" (V_{IL1}) to SCL after STOP condition.

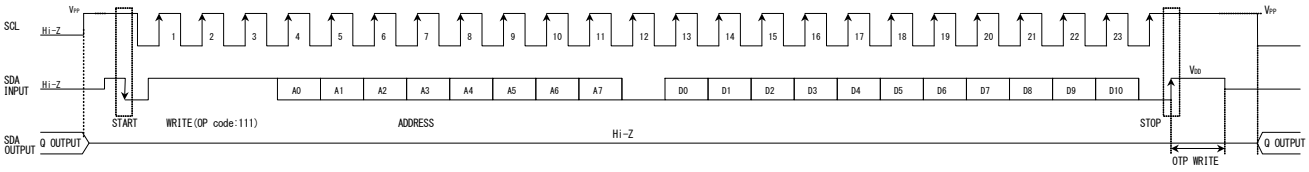
-Write-in the register



-Write-in OTP

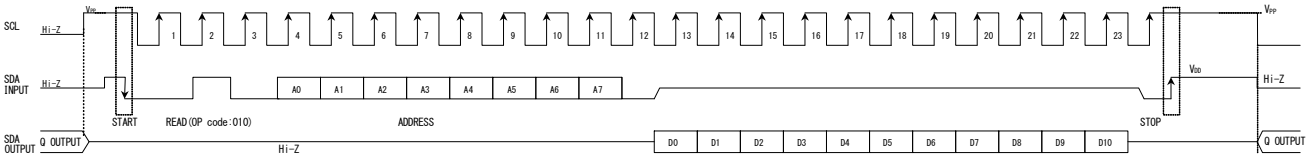


-Write-in OTP address to control INH function

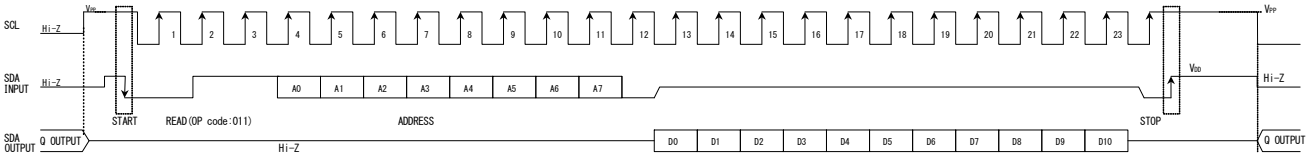


10.4.2. Data Read-out Format

After start condition, the transmitter transmits 11 bits of READ opcode (010 in registers and OTP, 011 in OTP address to control INH function), and an address. The 12th bit transfers "L" level. And, it releases SDA(Hi-Z) at the falling edge of 12th SCL clock. The receiver sends out the read data in synchronizing with the falling edge of 12th SCL clock. To finish serial communication, it needs to execute the same procedure as 10.4.1.

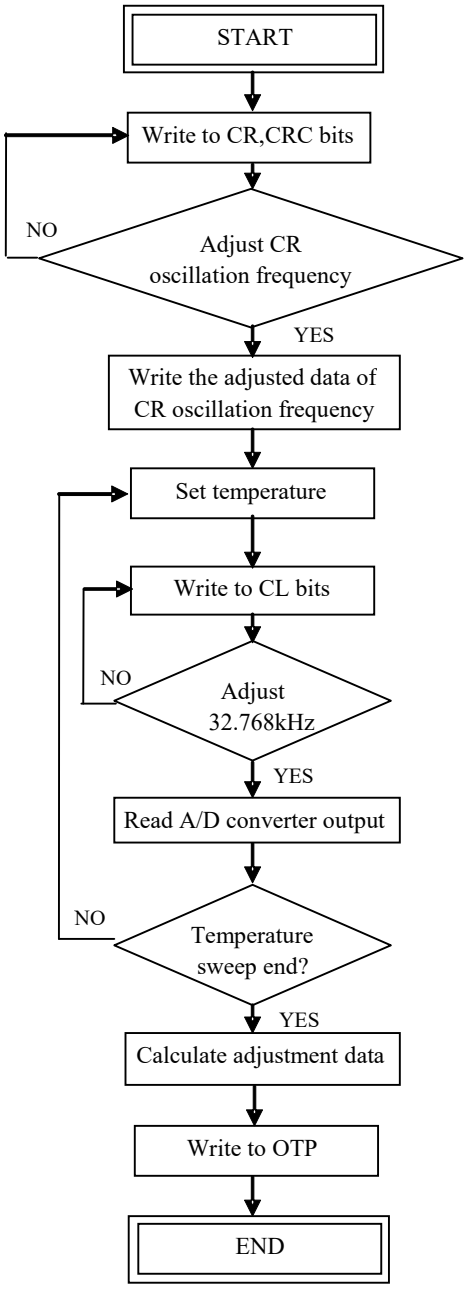


-Read OTP address to control INH function



10.5. Temperature Compensation Adjustment Flow Chart

(Temperature compensation range -40°C～＋105°C)



- Write 400h to K [10: 0].
  Set to perform temperature compensation operation. Refer to 10.4.1.

-Adjust CR oscillation frequency nearest to 51.8kHz by changing CR[5:0] at Ta=25°C. Refer to 10.5.1.

-Write 4h to TS[3:0] bits. CR oscillation frequency is outputted from Q pin. Refer to 10.5.2.

-Write the adjusted data to T[10:0]. Refer to 10.4.1.
T[9:7]=000, T6=0, T[5:0]=CR[5:0]=the adjusted data nearest to 51.8kHz@25°C

-Vary the oscillator circuit load capacitance CL, and determine the optimum load capacitance CL. Refer to 10.5.3.

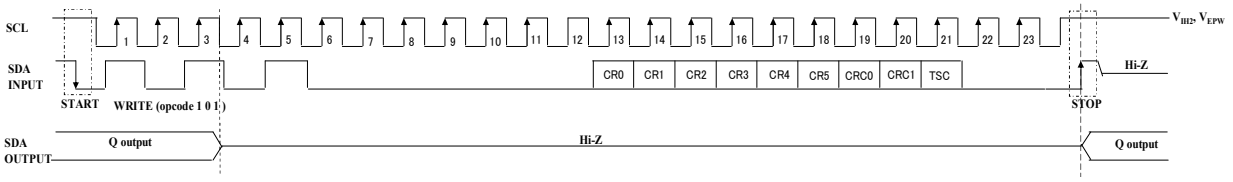
- The A/D conversion starts when 1 was written to STA bit.
  And it takes 7.8ms.
  Obtain the A/D converter output by reading Address 00h at the specified temperature. Refer to 10.5.4.
  Average the several obtained data.

-Calculate all the data for temperature compensation adjustment from the data points obtained above.

-Write the temperature compensation adjustment data to each of the addresses in OTP.

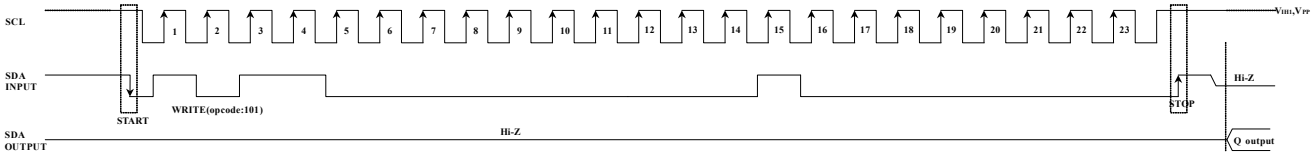
10.5.1. Data Write-in Format to adjust CR oscillation frequency

Write CR[5:0] and CRC to address 02h to adjust CR oscillation frequency. Refer to 10.1.3 in adjusting CR oscillation frequency. After writing data, carry out 10.5.2 with holding INH=H.



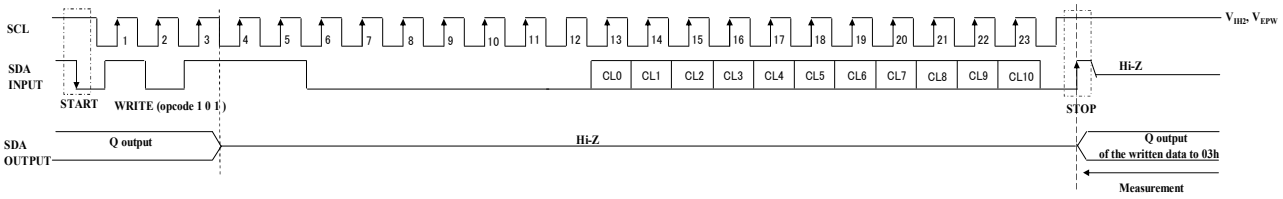
10.5.2. Data Write-in Format to output CR oscillation frequency at Q pin (Test mode)

Write 004h to address 01h to confirm CR oscillation frequency at Q pin. INH=L makes this mode cancel.



10.5.3. Data Write-in Format to adjust CL[10:0] bits (CL adjustment emulation mode)

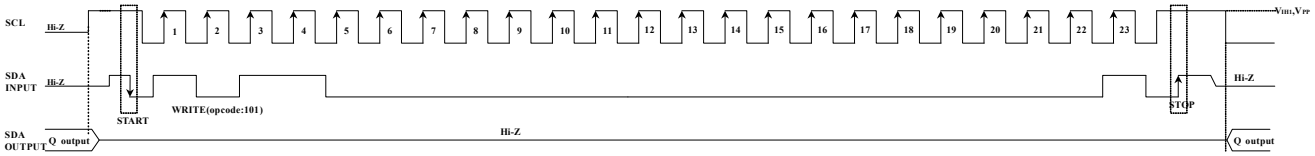
Write C_L load capacitance data to address 03h in order to obtain the optimum C_L load capacitance data. After recognized STOP condition, Q outputs crystal oscillation frequency with C_L load capacitance data of address 03h. Keep INH=H while measurement. INH=L makes this mode cancel. Determine the optimum C_L load capacitance by changing the data of address 03h.



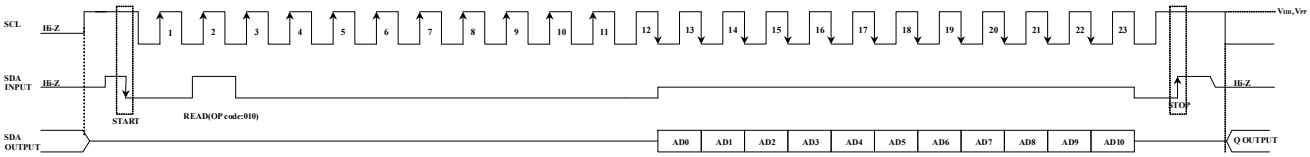
10.5.4. Data Read-out Format of A/D conversion results

Execute A/D conversion with writing the data of 400h(STA=1) to address 01h in order to obtain the results of A/D conversion. After that, read the data of address 00h .

・Data Write-in Format of A/D conversion execution.

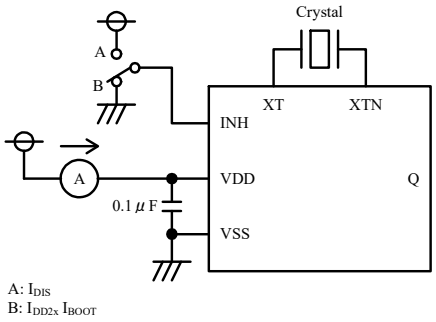


・Data Read-out Format of A/D conversion result.



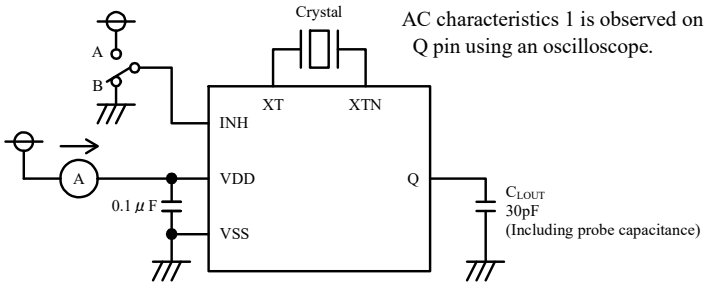
11. MEASUREMENT CIRCUIT

●Measurement circuit 1 (I_{DD2X},I_{BOOT}, I_{DIS})



A: I_{DIS}
B: I_{DD2x} I_{BOOT}

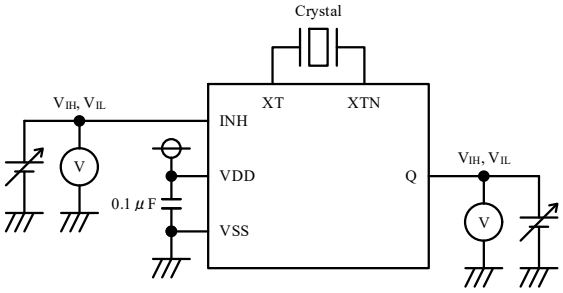
●Measurement circuit 2 (I_{DD1X},Duty, t_r, t_f)



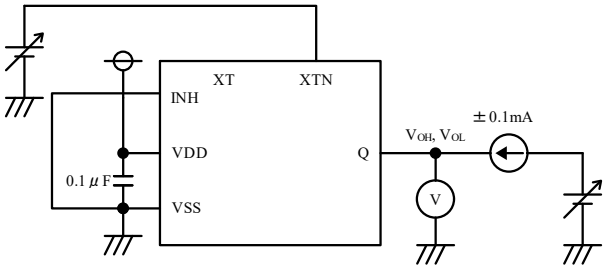
AC characteristics 1 is observed on Q pin using an oscilloscope.

●Measurement circuit 3 ($V_{IH1,2}$, $V_{IL1,2}$)

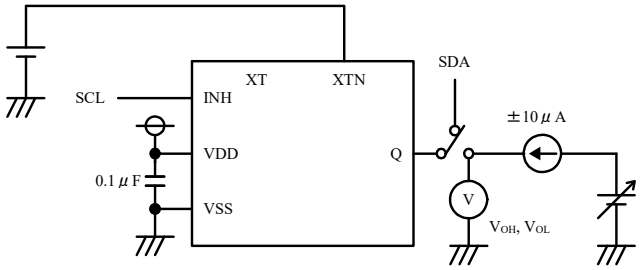
Apply voltage at the input pin and monitor a change of state



●Measurement circuit 4 (V_{OH1}, V_{OL1})

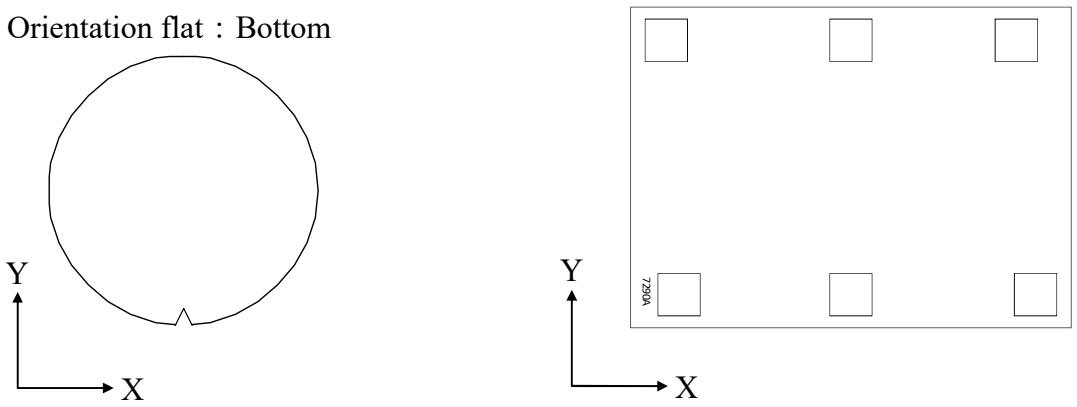


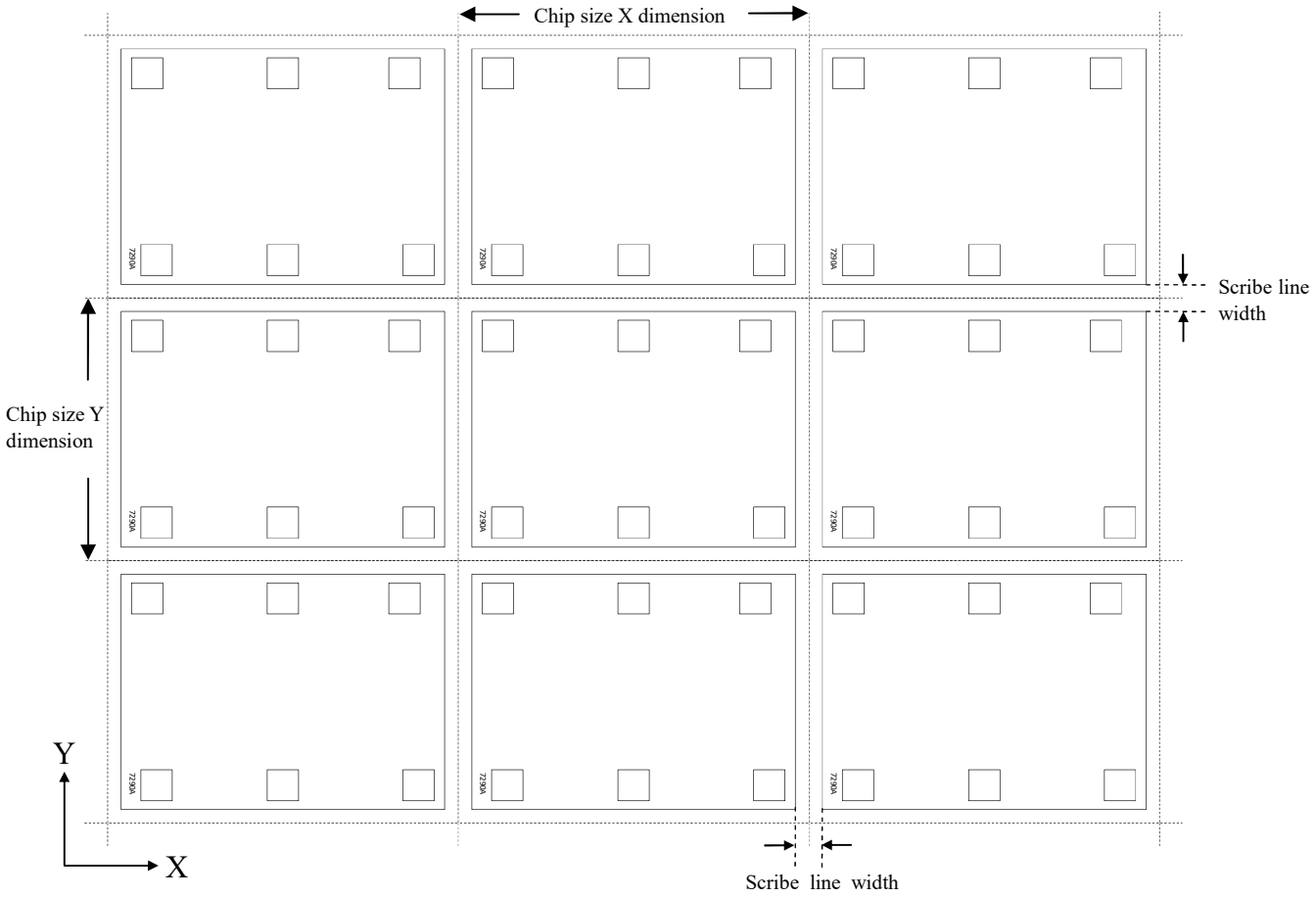
●Measurement circuit 5(V_{OH2}, V_{OL2})



12. WAFER SURFACE ALIGNMENT DIAGRAM

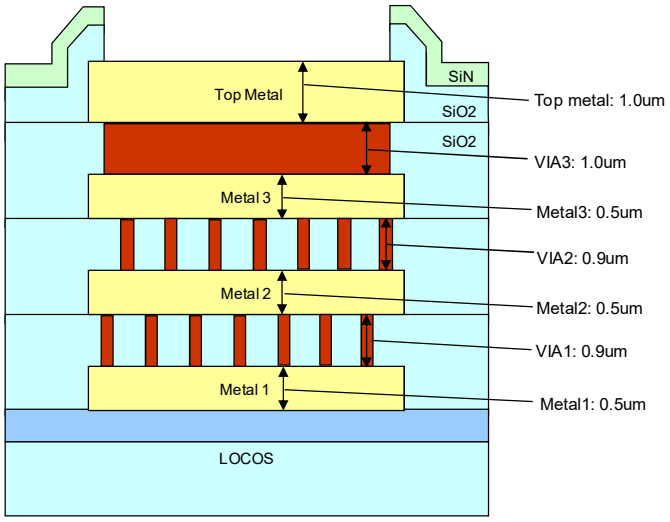
Wafer size : 200mm±0.5mm
Scribe line width : 64um (CAD data scribe area 60μm)





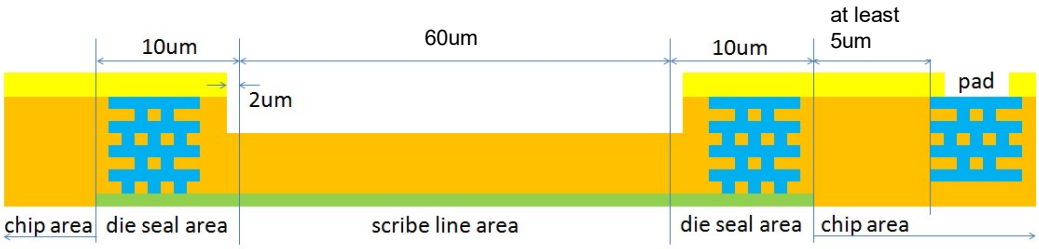
13. CROSS SECTION STRUCTURE

13.1. PAD Cross Section Structure

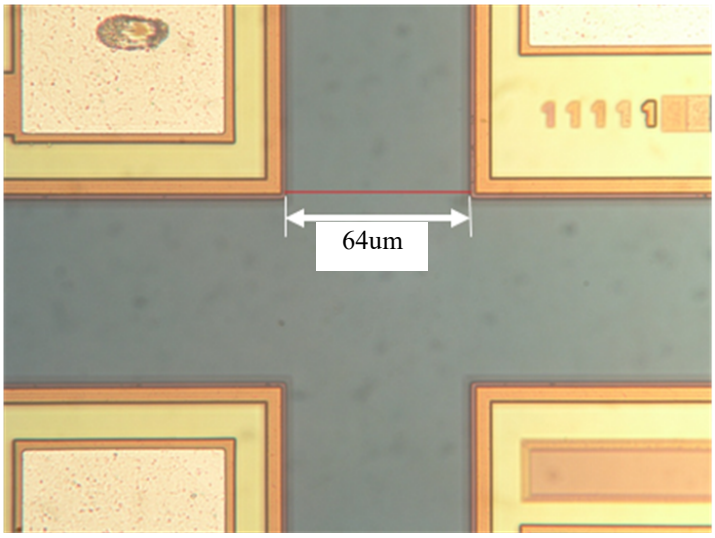


The film thicknesses described above are design values, not actual measurements on the chip.

13.2. Seal Ring and Scribe Line Cross Section Structure



The scribe line width "64µm" is the length of the flat area to be seen through a microscope as shown in the photo.



<Notes on UBM formation>

In UBM (Under Bump Metal) formation to the mounting pad electrode by electroless plating, UBM is similarly formed on the scribe line TEG and the metal exposed part of the accessory. So mask process covering the scribe line is required to prevent these effects.

14. USAGE AND PRECAUTIONS

This product is designed and manufactured to the generally accepted standards of reliability as expected for use in general electronic and electrical equipment, such as personal equipment, machine tools, and measurement equipment. This product is not designed and manufactured to be used in any other special equipment requiring extremely high level of reliability and safety, such as aerospace equipment, nuclear power control equipment, medical equipment, transportation equipment, disaster prevention equipment, security equipment.
If you wish to use this product in equipment requiring extremely high level of reliability, please contact our sales department or representative in advance.
In the event that this product is used in such equipment, please take scrupulous care and apply fail-safe techniques including redundancy and malfunction prevention in order to prevent damage to life, health, property, or infrastructure etc. in case there is some malfunction in the product.

Please pay your attention to the following points at time of using the products shown in this document.

1. The products shown in this document (hereinafter "Products") are designed and manufactured to the generally accepted standards of reliability as expected for use in general electronic and electrical equipment, such as personal equipment, machine tools and measurement equipment. The Products are not designed and manufactured to be used in any other special equipment requiring extremely high level of reliability and safety, such as aerospace equipment, nuclear power control equipment, medical equipment, transportation equipment, disaster prevention equipment, security equipment. The Products are not designed and manufactured to be used for the apparatus that exerts harmful influence on the human lives due to the defects, failure or malfunction of the Products.
   If you wish to use the Products in that apparatus, please contact our sales section in advance.
   In the event that the Products are used in such apparatus without our prior approval, we assume no responsibility whatsoever for any damages resulting from the use of that apparatus.
2. NPC reserves the right to change the specifications of the Products in order to improve the characteristics or reliability thereof.
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4. The constant of each circuit shown in this document is described as an example, and it is not guaranteed about its value of the mass production products.
5. In the case of that the Products in this document falls under the foreign exchange and foreign trade control law or other applicable laws and regulations, approval of the export to be based on those laws and regulations are necessary. Customers are requested appropriately take steps to obtain required permissions or approvals from appropriate government agencies.

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