

## ■ Description

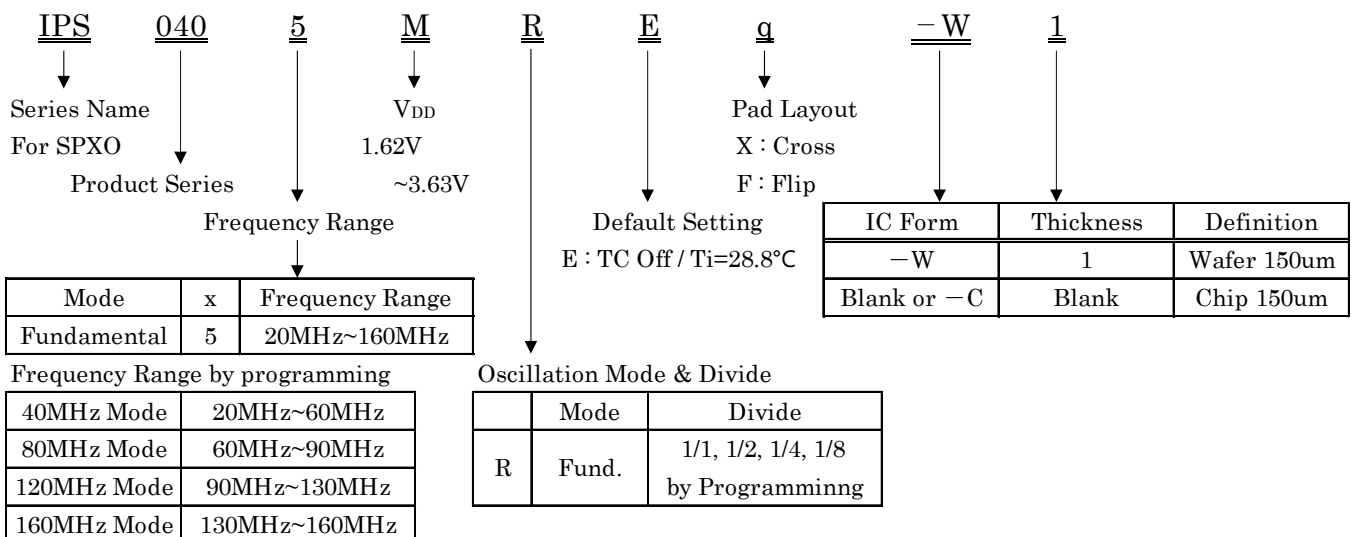
IPS040 is the IC for simple Frequency Temperature Compensation combined with F0 adjustment, corresponding to the fundamental crystal from 20MHz to 160MHz. F0 adjustment can independently be applied to 20MHz to 160MHz by turning off the temperature compensation function.

The temperature compensation using IPS040 is quite simple compared to common TCXO IC, so it is very easy to achieve High Precision SPXO.

## ■ Features

- Frequency Temp. deviation : ±10ppm Typ. ±5ppm achievable
- Operation temperature : -40°C~90°C
- Frequency dev. at room temp. : Within ±1ppm
- F0 compensation range : Over ±30ppm
- Frequency stability to V<sub>DD</sub> : Within ±1ppm
- Crystal frequency : 160MHz maximum
- Memory : Interchip original Non-volatile memory
- Pad number : 6 pads. No additional pin is necessary to program it.
- Power supply voltage : 1.62V~3.63V
- Standby function : Oscillation stop
- Output : CMOS
- Divide function : Divide is selectable by program
- Chip size : 0.74mm × 0.85mm
- Duty cycle : Within 50%±5%

### 1. Part number rule



## 2. Series

| Part Number      | Output Frequency<br>F0 (MHz) |      | TC<br>Default<br>Setting | Ti<br>Default<br>Setting | Pad<br>Layout | Remark  |
|------------------|------------------------------|------|--------------------------|--------------------------|---------------|---|
|                  | Min.                         | Max. |                          |                          |               |   |
| IPS040 5 M R E X | 20                           | 160  | TC Off                   | Ti=28.8°C                | Cross         | 1/1, 1/2, 1/4 & 1/8 is<br>selectable by program.<br>Default is 1/1. |
| IPS040 5 M R E F |                              |      |                          |                          | Flip          |   |

## 3. Absolute Maximum Ratings

Unless otherwise stated,  $V_{SS}=0V$ ,  $T_a=25^{\circ}C\pm 2^{\circ}C$

| Parameter            | Symbol    | Condition        | Ratings      |              | Unit |
|----------------------|-----------|------------------|--------------|--------------|------|
|                      |           |                  | Min          | Max          |      |
| Supply Voltage       | $V_{DD}$  | Program Mode     | $V_{SS}-0.5$ | 7.0          | V    |
|                      |           | Oscillation Mode | $V_{SS}-0.5$ | 5.0          |      |
| Input Voltage        | $V_{IN}$  | All Input Pin    | $V_{SS}-0.5$ | $V_{DD}+0.5$ | V    |
| Output Voltage       | $V_{OUT}$ |                  | $V_{SS}-0.5$ | $V_{DD}+0.5$ | V    |
| Output Current       | $I_{OUT}$ |                  |              | 25           | mA   |
| Junction Temperature | $T_j$     |                  | -55          | 150          | °C   |
| Storage Temperature  | $T_{stg}$ |                  | -55          | 125          | °C   |

## 4. Recommended Operating Condition

Unless otherwise stated,  $V_{SS}=0V$ ,  $T_a=-40^{\circ}C\sim 90^{\circ}C$

| Parameter                       | Symbol    | Condition     | Min                | Typ  | Max                | Unit | Note     |
|---------------------------------|-----------|---------------|--------------------|------|--------------------|------|----------|
| Supply Voltage<br>(Programming) | $V_{DD}$  | Low Vdd mode  | 1.62               | 3.30 | 3.63               | V    | $V_{DD}$ |
|                                 |           | High Vdd mode | 2.25               | 3.30 | 3.63               |      |          |
| “H” Input Voltage               | $V_{IH}$  |               | $V_{DD}\times 0.7$ |      |                    | V    | CE       |
| “L” Input Voltage               | $V_{IL}$  |               |                    |      | $V_{DD}\times 0.3$ | V    | CE       |
| Input Voltage                   | $V_{IN}$  |               | $V_{SS}$           |      | $V_{DD}$           | V    | CE       |
| Cryatal Frequency               | f         | 40MHz Mode    | 20                 |      | 60                 | MHz  | X1<br>X2 |
|                                 |           | 80MHz Mode    | 60                 |      | 90                 |      |          |
|                                 |           | 120MHz Mode   | 90                 |      | 130                |      |          |
|                                 |           | 160MHz Mode   | 130                |      | 160                |      |          |
| Output Load Capacitance         | CL        | CMOS          |                    |      | 15                 | pF   | OUT      |
| Ambient Temperature             | $T_{opt}$ |               | -40                |      | 90                 | °C   |          |

This IC has enough immunity against ESD and Latch-up, but handle with care.

**5. Electrical Specification**
**5-1 Electrical Specification**

 Unless otherwise stated,  $V_{SS}=0V$ ,  $T_a=25^{\circ}C\pm 2^{\circ}C$ 

| Parameter   | Symbol      | Condition                            | Specification |           |            | Unit    |
|---|-------------|--------------------------------------|---------------|-----------|------------|---------|
|   |             |                                      | Min           | Typ       | Max        |         |
| Out put Leak current                              | $I_z$       | $CE \leq 0.3V$                       |               |           | 10         | $\mu A$ |
| “L” input current                                 | $I_{IL}$    | CE pad, $V_{IN}=V_{SS}$              |               | -10       |            | $\mu A$ |
| Output Disable Time                               | $T_{plz}$   | OUT pad                              |               |           | 0.2        | $\mu s$ |
| Output Enable Time                                | $T_{pzl}$   | OUT pad                              |               |           | 2.0        | ms      |
| Osc. start up time                                | $T_{start}$ |                                      |               |           | 2.0        | ms      |
| “H” output voltage                                | $V_{OH}$    | OUT pad, $I_{OH}=-4mA$               | $V_{DD}-0.4$  |           |            | V       |
| “L” output voltage                                | $V_{OL}$    | OUT pad, $I_{OL}=4mA$                |               |           | 0.4        | V       |
| Current consumption                               | $I_{DD}$    | 40MHz Mode, $f=40MHz$ ※1             |               | 3.5       | 5.5        | mA      |
|   |             | 80MHz Mode, $f=77MHz$ ※1             |               | 7.0       | 11.0       |         |
|   |             | 120MHz Mode, $f=122MHz$ ※1           |               | 10.0      | 16.0       |         |
|   |             | 160MHz Mode, $f=160Hz$ ※1            |               | 15.5      | 25.0       |         |
|   |             | 160MHz Mode, $f=160Hz$ ※2            |               | 18.0      | 28.5       |         |
| Current consumption at oscillation disable        | $I_{DDD}$   | $CL=15pF, V_{DD}=3.3V, CE \leq 0.3V$ |               | 1.5       | 5.0        | $\mu A$ |
| Frequency deviation at room temperature           | $F_0$       |                                      |               |           | $\pm 1.0$  | ppm     |
| F0compensation range                              | $F_{0r}$    |                                      | $\pm 30$      |           |            | ppm     |
| Frequency Temperature deviation (Reference value) | $F_{tst}$   | $-40^{\circ}C \sim 90^{\circ}C$      |               | $\pm 5.0$ | $\pm 10.0$ | ppm     |
| Freq. $V_{DD}$ deviation                          | $F_{vst}$   | $V_{DD} \pm 10\%$                    |               |           | $\pm 1.0$  | ppm     |
| Output Duty Ratio                                 | Duty        | $CL=15pF, V_{DD}=2.25 \sim 3.63V$ ※3 | 45            | 50        | 55         | %       |
|   |             | $CL=15pF, V_{DD}=1.62 \sim 2.25V$ ※3 | 43            | 50        | 57         |         |
| Rise/Fall time                                    | $T_r/T_f$   | $CL=15pF, 40MHz$ Mode ※4             |               | 2.5       | 6.0        | ns      |
|   |             | $CL=15pF, 80MHz$ Mode ※4             |               | 1.2       | 3.0        |         |
|   |             | $CL=15pF, 120MHz$ Mode ※4            |               | 1.2       | 3.0        |         |
|   |             | $CL=15pF, 160MHz$ Mode ※5            |               | 1.0       | 2.5        |         |

 ※1 Condition :  $CL=15pF, V_{DD}=3.3V, CE \geq V_{DD}-0.3V$ , Low Voltage Mode

 ※2 Condition :  $CL=15pF, V_{DD}=3.3V, CE \geq V_{DD}-0.3V$ , High Voltage Mode

 ※3 Condition :  $1/2V_{DD}$  point

 ※4 Condition :  $10\% \sim 90\%V_{DD}, V_{DD}=1.62V \sim 3.63V$ , Low Voltage Mode

 ※5 Condition :  $10\% \sim 90\%V_{DD}, V_{DD}=1.62V \sim 3.63V$ , Low Voltage Mode & High Voltage Mode

Memory Setting (Please refer to 5-2 Memory Function)

40MHz Mode ... [A26:A01]=[111001100000000000000000]

80MHz Mode ... [A26:A01]=[1110011001000000000000010]

120MHz Mode ... [A26:A01]=[1110011010000000000000010]

160MHz Mode ... [A26:A01]=[1110011011000000000000011x]

x=0 : Low Voltage Mode, x=1 : High Voltage Mode

**5-2 Memory Function (Bank1)**

| Address | Name   | Outline  | Explanation  | Note   |
|---------|--------|--|--|--|
| A26     | DSV    | Regulator Voltage for Temperature compensation circuit | [A26]=[0]→1.8V typ<br>[A26]=[1]→1.5V typ   | Recommendation is [A26]=[1]  |
| A25     | DBETA3 | Slope( $\beta$ ) of Temperature compensation curve     | [A25:A22]=[0000]<br>→Maximum slope   | The order is [0000]→[0001]→[0010]→[0011] ... [1110]→[1111]   |
| A24     | DBETA2 |  | (For the crystal which has large $\beta$ value)  |  |
| A23     | DBETA1 |  | [A25:A22]=[1111]<br>→Minimum slope   |  |
| A22     | DBETA0 |  | (For the crystal which has small $\beta$ value)  |  |
| A21     | EFTC2  | Strength of temperature compensation                   | [A21:A19]=[000]→Maximum Compensation   | The order is [000]→[100]→[010]→[110]→[001]→[101]→[011]→[111]   |
| A20     | EFTC1  |  | [A21:A19]=[111]→Minimum Compensation   |  |
| A19     | EFTC0  |  |  |  |
| A18     | DAMP1  | Strength of Oscillation Amp. (nR control)              | [A18:A17]=[00]→40MHz Mode  | The recommendation setting must depend on Crystal parameter, Stray capacitance, etc. Please check the nR by user yourself and determine the frequency range. |
| A17     | DAMP0  |  | [A18:A17]=[01]→80MHz Mode<br>[A18:A17]=[10]→120MHz Mode<br>[A18:A17]=[11]→160MHz Mode                            |  |
| A16     | DIV1   | Divider setting  | [A16:A15]=[00]→1/1   |  |
| A15     | DIV0   |  | [A16:A15]=[01]→1/2<br>[A16:A15]=[10]→1/4<br>[A16:A15]=[11]→1/8   |  |
| A14     | DDTY2  | DUTY ratio of Output waveform                          | [A14:A12]=[100]→Maximum  | MSB is inverted to set [000], which is the default value, to the center.   |
| A13     | DDTY1  |  | [A14:A12]=[000]→Center   |  |
| A12     | DDTY0  |  | [A14:A12]=[011]→Minimum  |  |
| A11     | DOFT7  | Center frequency (F0) adjustment                       | [A11:A04]=[10000000]<br>→Minimum F0<br>[A11:A04]=[00000000]<br>→Center F0<br>[A11:A04]=[01111111]<br>→Maximum F0 | MSB is inverted to set [00000000], which is the default value, to the center.  |
| A10     | DOFT6  |  |  |  |
| A09     | DOFT5  |  |  |  |
| A08     | DOFT4  |  |  |  |
| A07     | DOFT3  |  |  |  |
| A06     | DOFT2  |  |  |  |
| A05     | DOFT1  |  |  |  |
| A04     | DOFT0  |  |  |  |
| A03     | DOUT1  | Tr and Tf of output waveform                           | [A03:A02]=[00]→Tr/Tf=2~3ns   |  |
| A02     | DOUT0  |  | [A03:A02]=[11]→Tr/Tf<1ns   |  |
| A01     | DREG   | Regulator Voltage for Oscillator circuit.              | [A01]=[0]→1.5V typ<br>Low Voltage Mode<br>[A01]=[1]→1.8V typ<br>High Voltage Mode                                | For example, at high frequency, when nR is insufficient, this can be used.   |

Phase noise of IPS0405MR F0=40MHz, V<sub>DD</sub>=3.3V (40MHz Mode)

| Offset Frequency | IPS0405MR   |
|------------------|-------------|
| 10Hz             | -70 dBc/Hz  |
| 100Hz            | -100 dBc/Hz |
| 1kHz             | -128 dBc/Hz |
| 10kHz            | -148 dBc/Hz |
| 100kHz           | -156 dBc/Hz |
| 1MHz             | -160 dBc/Hz |

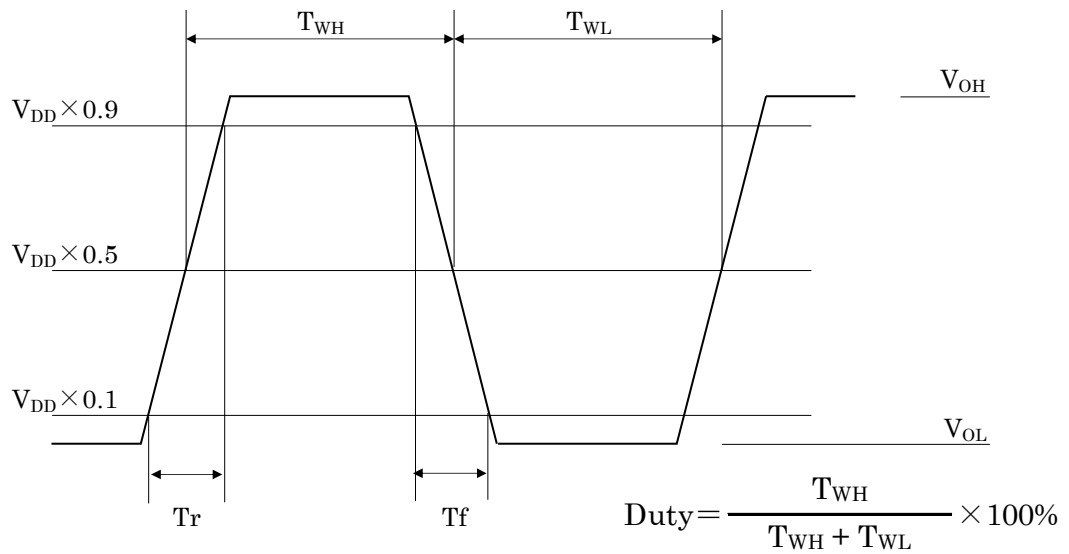
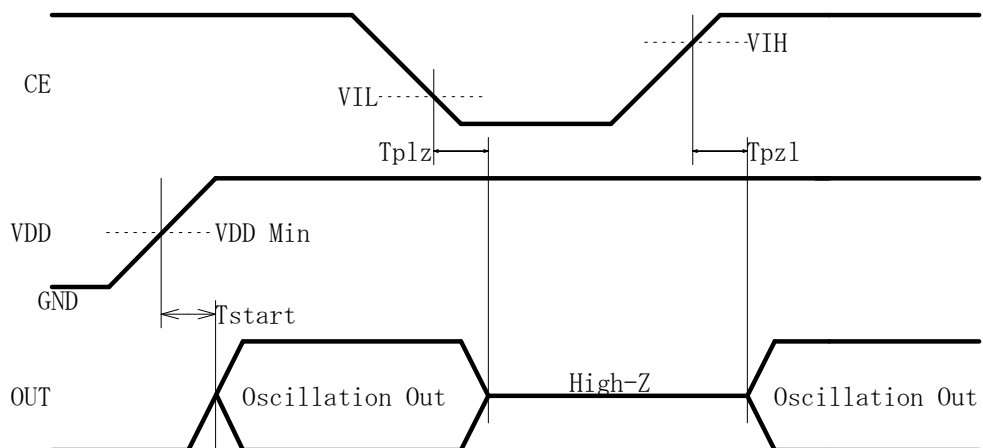


Fig. 5-1 Output wave form (Duty, Tr, Tf, V<sub>OH</sub>, V<sub>OL</sub>)



V<sub>IH</sub> : Threshold voltage for Oscillation Start

V<sub>IL</sub> : Threshold voltage for Oscillation Stop

Fig. 5-2 Input output signal timing

**6. Circuit Parameters of Oscillator (Reference Data for Circuit Design)**
 $T_a=25^{\circ}\text{C}, V_{DD}=3.3\text{V}$ 

| Parameter             | Symbol | Condition                             | Min | Typ  | Max | Unit       |
|-----------------------|--------|---------------------------------------|-----|------|-----|------------|
| Regulated Voltage     | Vreg   | Low Voltage Mode [A01]=[0]            |     | 1.5  |     | V          |
|                       |        | High Voltage Mode [A01]=[1]           |     | 1.8  |     |            |
| Feedback Resistor     | Rf     |                                       |     | 200  |     | k $\Omega$ |
| Driving Resistor      | Rd     | 40MHz Mode [A18:A17]=[00]             |     | 1000 |     | $\Omega$   |
|                       |        | 80MHz Mode [A18:A17]=[01]             |     | 500  |     |            |
|                       |        | 120MHz Mode [A18:A17]=[10]            |     | 250  |     |            |
|                       |        | 160MHz Mode [A18:A17]=[11]            |     | 125  |     |            |
| Oscillating Capacitor | Cg/Cd  | Offset Center<br>[A11:A04]=[00000000] |     | 4/4  |     | pF         |
|                       |        | Offset Max.<br>[A11:A04]=[01111111]   |     | 2/2  |     |            |
|                       |        | Offset Min.<br>[A11:A04]=[10000000]   |     | 6/6  |     |            |

\*The above values are the design values and are not guaranteed by test.

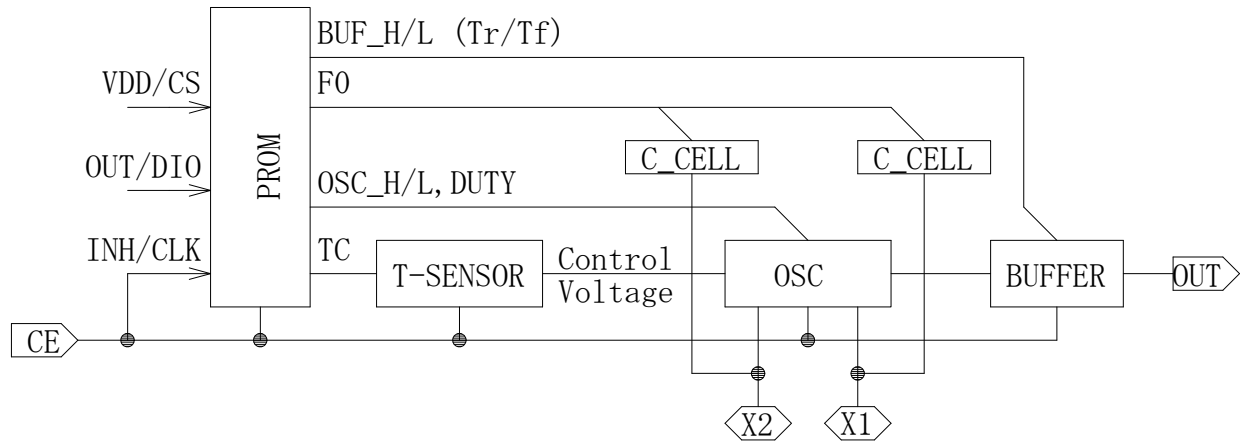


Fig. 6-1-(1) Block Diagram (IC Block Diagram)

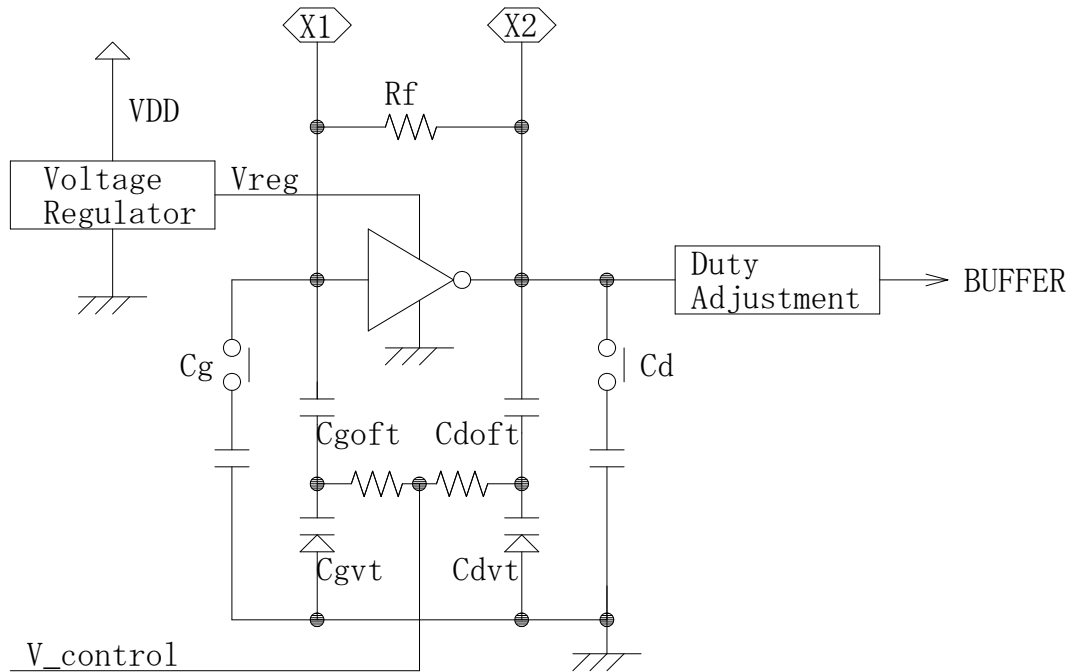


Fig. 6-1-(2) Block Diagram (Oscillation Block)

## 7. Compensation Parameters

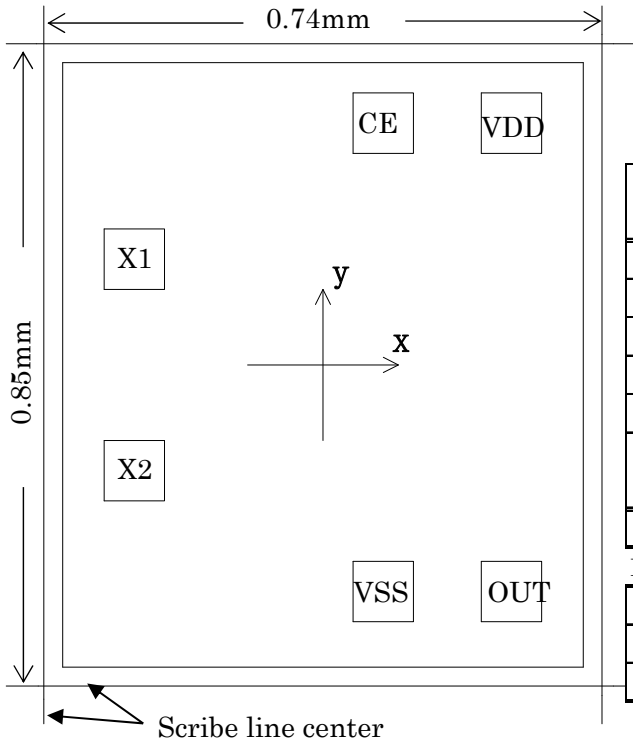
$$F(T) = \alpha(T - T_i)^3 + \beta(T - T_i) + \gamma$$

| Name     | Bit | Digit | Range  | Remarks                      |
|----------|-----|-------|--|------------------------------|
| $\alpha$ | 3   | 8     | $100 \times 10^{-6} \pm 10\% \text{ ppm}/^\circ\text{C}^3$ |                              |
| $\beta$  | 4   | 16    | $-0.05 \sim -0.40 \text{ ppm}/^\circ\text{C}$              |                              |
| $\gamma$ | 8   | 256   | $\pm 30 \text{ ppm}$                                       | $\sim 0.3 \text{ ppm/digit}$ |
| $T_i$    | 5   | 32    | $27 \pm 16^\circ\text{C}$                                  | Including IC deviation       |

\* The above value is just reference for crystal selection.

\* These value depends on the sensitivity of the crystal.

\* The above value corresponds to the crystal whose  $C_0/C_1 \doteq 300$ .

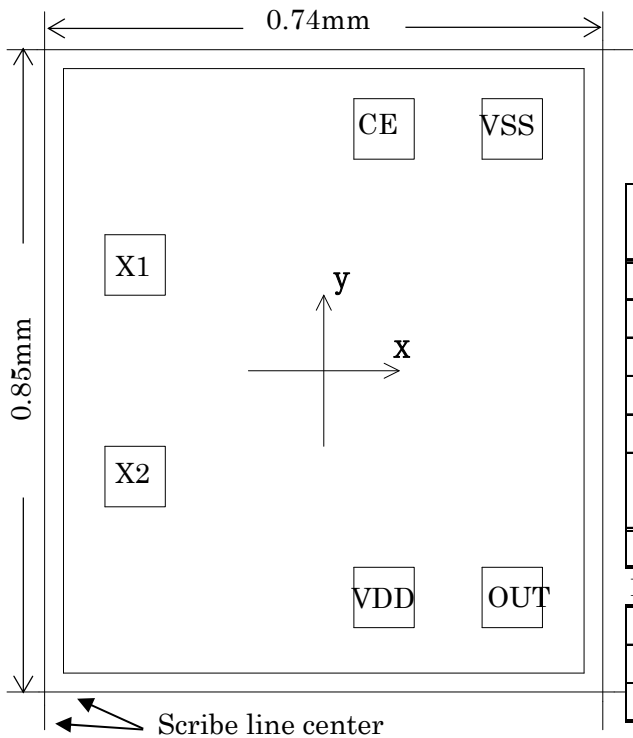
**8. Pad Layout**  
**8-1 Cross Type**


- Die Size : 0.74mm × 0.85mm
- Pad Size : 80um □
- Thickness : 150um±20um
- Scribe Line : 100um
- IC Backside : Gnd or Open

| Pad Name    | Function                                | Location (μm) |      |
|-------------|---|---------------|------|
|             |   | x             | y    |
| VDD         | (+) Power Supply                        | 251           | 306  |
| OUT(Q)      | Frequency Output                        | 251           | -306 |
| VSS         | (-) Ground                              | 83            | -306 |
| X2          | Crystal Drive                           | -251          | -137 |
| X1          | Crystal Feedback                        | -251          | 137  |
| CE          | Oscillation stop<br>"L": High-Impedance | 83            | 306  |
| Chip Center |   | 0             | 0    |

**Program Mode**

|        |                                      |
|--------|--------------------------------------|
| OUT(Q) | Clock                                |
| VDD    | Mode Select                          |
| CE     | ADIO : Digital Input / Output and DC |

**Fig. 8-1 Cross Type**
**8-2 Flip Type**


- Die Size : 0.74mm × 0.85mm
- Pad Size : 80um □
- Thickness : 150um±20um
- Scribe Line : 100um
- IC Backside : Gnd or Open

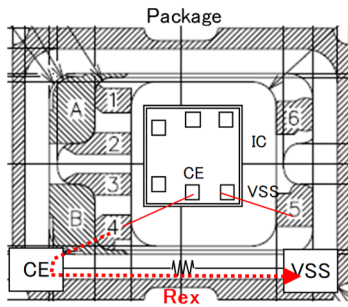
| Pad Name    | Function                                | Location (μm) |      |
|-------------|---|---------------|------|
|             |   | x             | y    |
| VSS         | (-) Ground                              | 251           | 306  |
| OUT(Q)      | Frequency Output                        | 251           | -306 |
| VDD         | (+) Power Supply                        | 83            | -306 |
| X2          | Crystal Drive                           | -251          | -137 |
| X1          | Crystal Feedback                        | -251          | 137  |
| CE          | Oscillation stop<br>"L": High-Impedance | 83            | 306  |
| Chip Center |   | 0             | 0    |

**Program Mode**

|        |                                      |
|--------|--------------------------------------|
| OUT(Q) | Clock                                |
| VDD    | Mode Select                          |
| CE     | ADIO : Digital Input / Output and DC |

**Fig. 8-2 Flip Chip Type**





### IMPORTANT Notice for CE function

- ※ Oscillation will not be activated when CE=Open after CE=Low if Rex is not large.
- ※ Reference value of Rex is over 10MΩ with CE=Open usage.
- ※ There is no such issue with CE=VDD usage.

Rex : Resistance value between CE and VSS of package