■ 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℃~90℃
- Frequency dev. at room temp. : Within ±1ppm
- F0 compensation range : Over ±30ppm
- Frequency stability to V_{DD} : 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

IPS 040 5 M R E q －W 1

- IPS: Series Name For SPXO
- 040: Product Series
- 5: Frequency Range
- M: V_{DD} 1.62V ~3.63V
- R: Oscillation Mode & Divide
- E: Default Setting E : TC Off / Ti=28.8℃
- q: Pad Layout X : Cross F : Flip
- －W: IC Form
- 1: Thickness

Mode	x	Frequency Range
Fundamental	5	20MHz~160MHz

Frequency Range by programming

40MHz Mode	20MHz~60MHz
80MHz Mode	60MHz~90MHz
120MHz Mode	90MHz~130MHz
160MHz Mode	130MHz~160MHz

Oscillation Mode & Divide

	Mode	Divide
R	Fund.	1/1, 1/2, 1/4, 1/8 by Programminng

IC Form	Thickness	Definition
－W	1	Wafer 150um
Blank or －C	Blank	Chip 150um

2. Series

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

3. Absolute Maximum Ratings

Unless otherwise stated, V_{SS}=0V, Ta=25℃±2℃

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	Tj		-55	150	℃
Storage Temperature	Tstg		-55	125	℃

4. Recommended Operating Condition

Unless otherwise stated, V_{SS}=0V, Ta=-40℃~90℃

Parameter	Symbol	Condition	Min	Typ	Max	Unit	Note
Supply Voltage (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}×0.7			V	CE
“L” Input Voltage	V_{IL}				V_{DD}×0.3	V	CE
Input Voltage	V_{IN}		V_{SS}		V_{DD}	V	CE
Cryatal Frequency	f	40MHz Mode	20		60	MHz	X1 X2
		80MHz Mode	60		90		
		120MHz Mode	90		130		
		160MHz Mode	130		160		
Output Load Capacitance	CL	CMOS			15	pF	OUT
Ambient Temperature	Topt		-40		90	℃	

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

5. Electrical Specification

5-1 Electrical Specification

Unless otherwise stated, Vss=0V, Ta=25℃±2℃

Parameter	Symbol	Condition	Specification			Unit
			Min	Typ	Max	
Out put Leak current	Iz	CE≦0.3V			10	μA
"L" input current	I_{IL}	CE pad, V_{IN}=V_{SS}		-10		μA
Output Disable Time	Tplz	OUT pad			0.2	μs
Output Enable Time	Tpzl	OUT pad			2.0	ms
Osc. start up time	Tstart				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≦0.3V		1.5	5.0	μA
Frequency deviation at room temperature	F0				±1.0	ppm
F0compensation range	F_{0r}		±30			ppm
Frequency Temperature deviation (Reference value)	Ftst	-40℃~90℃		±5.0	±10.0	ppm
Freq. V_{DD} deviation	Fvst	V_{DD}±10%			±1.0	ppm
Output Duty Ratio	Duty	CL=15pF, V_{DD}=2.25~3.63V ※3	45	50	55	%
		CL=15pF, V_{DD}=1.62~2.25V ※3	43	50	57	
Rise/Fall time	Tr/Tf	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≧V_{DD} -0.3V, Low Voltage Mode
※2 Condition : CL=15pF, V_{DD} =3.3V, CE≧V_{DD} -0.3V, High Voltage Mode
※3 Condition : 1/2V_{DD} point
※4 Condition : 10%~90%V_{DD}, V_{DD}=1.62V~3.63V, Low Voltage Mode
※5 Condition : 10%~90%V_{DD}, V_{DD}=1.62V~3.63V, Low Voltage Mode & High Voltage Mode

Memory Setting (Please refer to 5-2 Memory Function)
40MHz Mode … [A26:A01]=[11100110000000000000000000]
80MHz Mode … [A26:A01]=[11100110010000000000000010]
120MHz Mode … [A26:A01]=[11100110100000000000000010]
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 [A26]=[1]→1.5V typ	Recommendation is [A26]=[1]
A25	DBETA3	Slope(β) of Temperature compensation curve	[A25:A22]=[0000] →Maximum slope (For the crystal which has large ß value) [A25:A22]=[1111] →Minimum slope (For the crystal which has small ß value)	The order is [0000]→[0001]→[0010]→[0011] … [1110]→[1111]
A24	DBETA2			
A23	DBETA1			
A22	DBETA0			
A21	EFTC2	Strength of temperature compensation	[A21:A19]=[000]→Maximum Compensation [A21:A19]=[111]→Minimum Compensation	The order is [000]→[100]→[010]→[110]→[001]→[101]→[011]→[111]
A20	EFTC1			
A19	EFTC0			
A18	DAMP1	Strength of Oscillation Amp. (nR control)	[A18:A17]=[00]→40MHz Mode [A18:A17]=[01]→80MHz Mode [A18:A17]=[10]→120MHz Mode [A18:A17]=[11]→160MHz 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			
A16	DIV1	Divider setting	[A16:A15]=[00]→1/1 [A16:A15]=[01]→1/2 [A16:A15]=[10]→1/4 [A16:A15]=[11]→1/8	
A15	DIV0			
A14	DDTY2	DUTY ratio of Output waveform	[A14:A12]=[100]→Maximum [A14:A12]=[000]→Center [A14:A12]=[011]→Minimum	MSB is inverted to set [000], which is the default value, to the center.
A13	DDTY1			
A12	DDTY0			
A11	DOFT7	Center frequency (F0) adjustment	[A11:A04]=[10000000] →Minimum F0 [A11:A04]=[00000000] →Center F0 [A11:A04]=[0111111] →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 [A03:A02]=[11]→Tr/Tf<1ns	
A02	DOUT0			
A01	DREG	Regulator Voltage for Oscillator circuit.	[A01]=[0]→1.5V typ Low Voltage Mode [A01]=[1]→1.8V typ High Voltage Mode	For example, at high frequency, when nR is insufficient, this can be used.

Phase noise of IPS0405MR F0=40MHz, V_{DD}=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

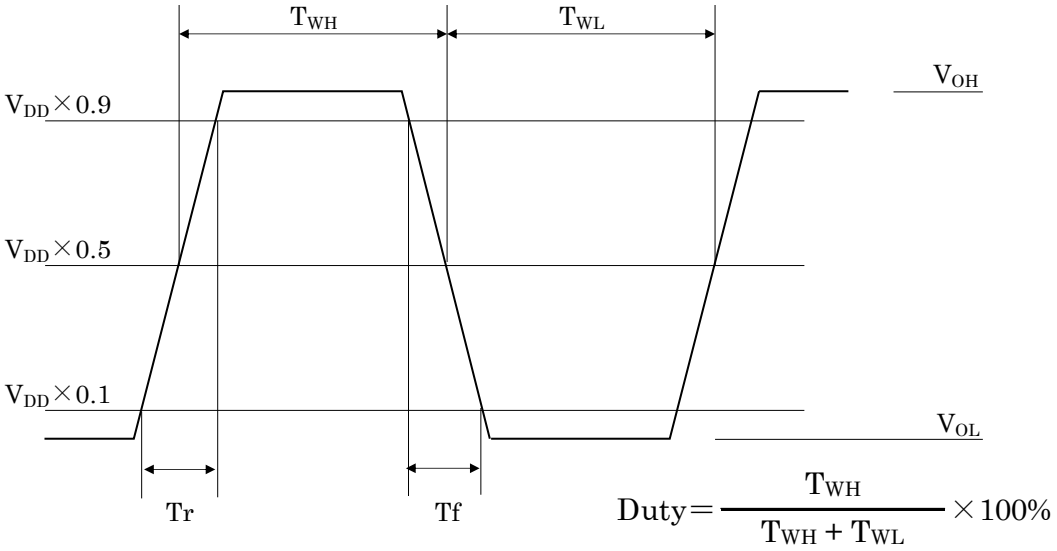
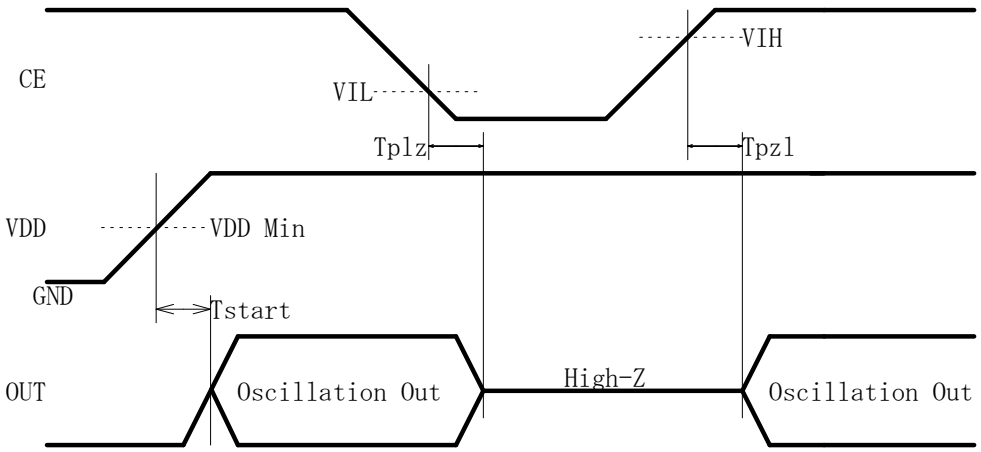


Fig. 5-1 Output wave form (Duty, Tr, Tf, V_{OH}, V_{OL})



V_{IH} : Threshold voltage for Oscillation Start
V_{IL} : Threshold voltage for Oscillation Stop

Fig. 5-2 Input output signal timing

6. Circuit Parameters of Oscillator (Reference Data for Circuit Design)

Ta=25℃, V_{DD}=3.3V

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		kΩ
Driving Resistor	Rd	40MHz Mode [A18:A17]=[00]		1000		Ω
		80MHz Mode [A18:A17]=[01]		500		
		120MHz Mode [A18:A17]=[10]		250		
		160MHz Mode [A18:A17]=[11]		125		
Oscillating Capacitor	Cg/Cd	Offset Center [A11:A04]=[00000000]		4/4		pF
		Offset Max. [A11:A04]=[01111111]		2/2		
		Offset Min. [A11:A04]=[10000000]		6/6		

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

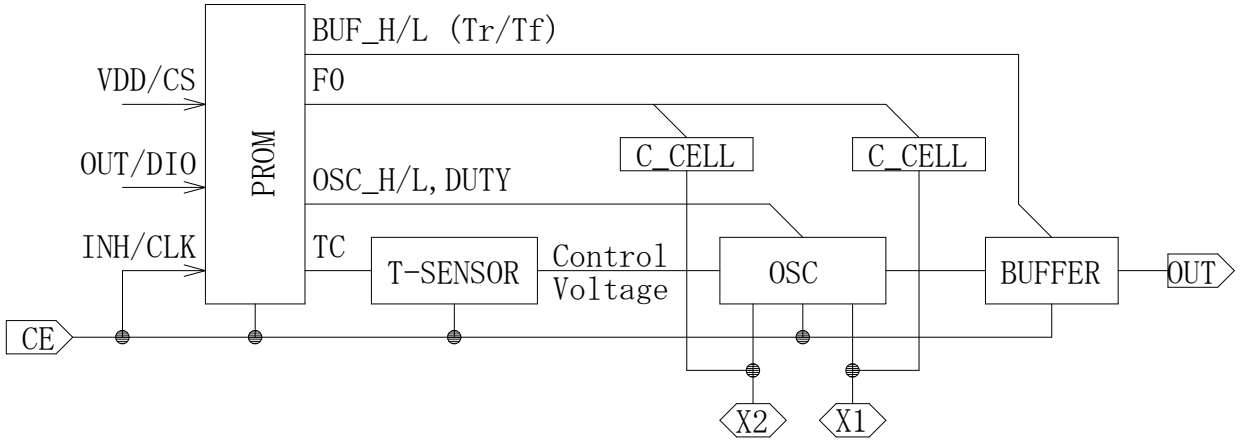


Fig. 6-1-(1) Block Diagram (IC Block Diagram)

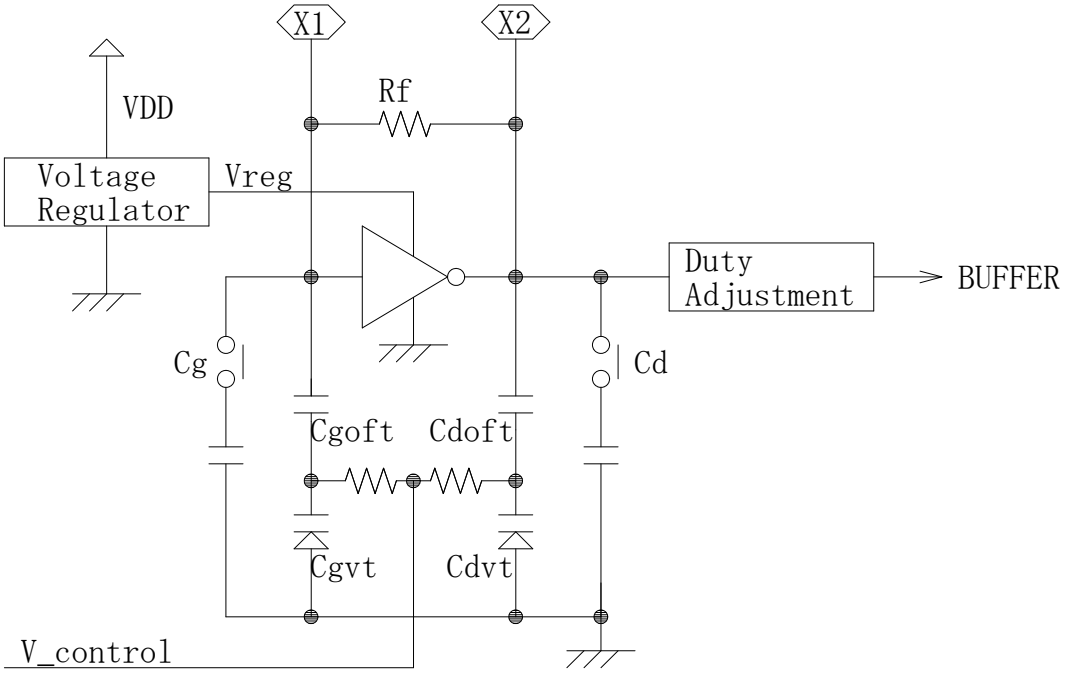


Fig. 6-1-(2) Block Diagram (Oscillation Block)

7. Compensation Parameters

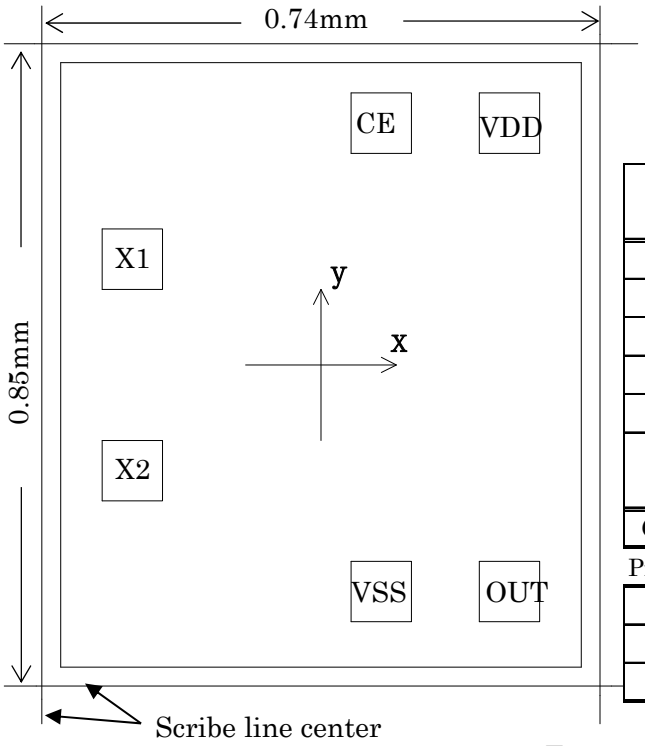
$$F(T) = \alpha (T - Ti)^3 + \beta (T - Ti) + \gamma$$

Name	Bit	Digit	Range	Remarks
α	3	8	$100\times10^{-6}\pm10\%$ ppm/℃^{3}	
β	4	16	-0.05~-0.40 ppm/℃	
γ	8	256	±30 ppm	~0.3ppm/digit
Ti	5	32	27±16℃	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 C0/C1≒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

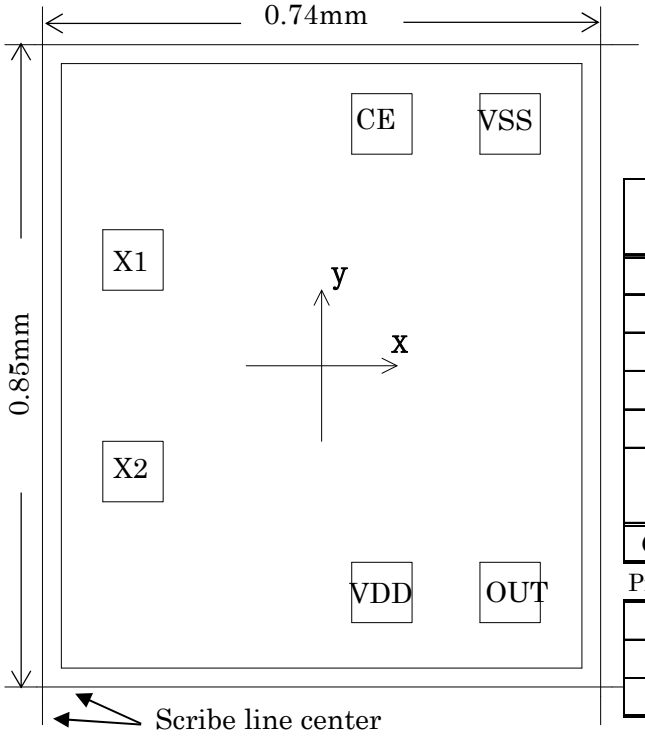
Pad Name	Function	Location (μm)	
		x	y
VDD	(+) Power Supply	251	306
OUT(Q)	Frequency Output	251	-306
VSS	(−) Ground	83	-306
X2	Crystal Drive	-251	-137
X1	Crystal Feedback	-251	137
CE	Oscillation stop "L": High-Impedance	83	306
Chip Center		0	0

Program Mode

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

Fig. 8-1 Cross Type

8-2 Flip Type



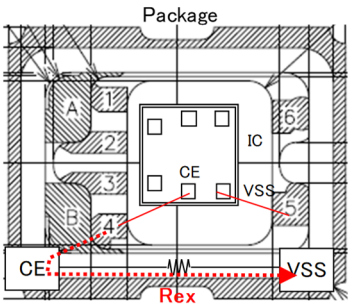
- Die Size : 0.74mm × 0.85mm
- Pad Size : 80um □
- Thickness : 150um±20um
- Scribe Line : 100um
- IC Backside : Gnd or Open

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 "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