INTEGRATED CIRCUITS

APPLICATION NOTE

AN413

Using the datacomm product's on-chip oscillator

Author: D. Ibarra

1998 Oct 02

Philips Semiconductors

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DESCRIPTION

This application note discusses how to use the on-chip oscillator circuitry for the Philips Semiconductors UART and DUSCC families of data communications devices; the SCC2691, SCC2692, SCN68681, SCN26562, and SCN68562.

THE CRYSTAL OSCILLATOR

The on-chip oscillator circuitry consists of an inverting amplifier and a feedback resistor which are used to implement a Pierce oscillator (see Figure 1). The addition of an external crystal and external capacitance into the feedback loop provides the positive reactance necessary for oscillation and controls the frequency of oscillation. The oscillator operates at the frequency for which the crystal is anti-resonant (parallel resonant) with the load capacitance across the crystal. The load capacitance is given by:

C_L = ((C1 x C2) / (C1 + C2)) + Stray

The only difference between "parallel" and "series" crystals is how they were calibrated. Crystals are calibrated to achieve their specified frequency either at parallel resonance with a particular load capacitance, or at series resonance (with no load capacitance). Crystals which were calibrated at their series resonant frequency will still operate at parallel resonance in this oscillator, however the resulting frequency will be slightly higher than the frequency specified for the crystal.

In general, the oscillator frequency can be adjusted slightly by trimming the external capacitors, larger capacitors will lower the oscillator's frequency while smaller ones will raise it. The small errors in frequency, due to using a crystal calibrated at a different load capacitance than is present in the circuit, are negligible for typical applications. Reliability is much more important.

SCC2691, SCC2692, SCC68692 AND SCC2698 OSCILLATOR RECOMMENDATIONS

For these parts, the X1/CLK pin is connected to the input of the inverter and the X2 pin is connected to the output. For best results, a parallel calibrated crystal should be adjusted until the total circuit capacitance matches the capacitance specified for the crystal.

Typical crystal parameters:
Frequency – 2–4MHz
Mode of operation – Parallel resonant, fundamental mode
Load Capacitance (C_L) – 12–32pF

For operation at nominal frequency, the values recommended below will give accurate, reliable results. The frequency will vary slightly depending on the amount of stray capacitance in the individual circuit, but will typically be off no more than 0.01%.

C1 = C2 = 24pF
Y1 = Saronix NYP037-20; 3.6864MHz at C_L = 20pF with R_S = 160Ω

SCN26562 AND SCN68562 OSCILLATOR RECOMMENDATIONS

For these parts, the X1/CLK pin is connected to the output of the inverter, the X2 pin is connected to the input, and the inverter is a Schmitt trigger. For best results, a parallel calibrated crystal should be obtained and the external capacitors should be adjusted until the total circuit capacitance matches the capacitance specified for the crystal.

Typical crystal parameters:
Frequency – 2–16MHz
Mode of operation – Parallel resonant, fundamental mode
Load Capacitance (C_L) – 12–32pF

For operation at nominal frequency, the values recommended below will give accurate, reliable results. The frequency will vary slightly depending on the amount of stray capacitance in the individual circuit, but will typically be off no more than 0.01%.

C1 = C2 = 24pF
Y1 = Saronix NYP147-20; 14.7456MHz at C_L = 20pF with R_S = 25Ω

SCN2681 AND SCN68681 OSCILLATOR RECOMMENDATIONS

For these parts, the X1/CLK pin is connected to the output of the inverter, the X2 pin is connected to the input, and the inverter is a Schmitt trigger. Because of the Schmitt trigger inverter, the SCN2681 and SCN68681 are limited to using small value external capacitors. If capacitors of 15pF or greater are used, intermittent power-on problems may be experienced. The oscillator may stay in relaxation mode, oscillating at a frequency much lower than the one the crystal is specified for. For this reason, we recommend using external capacitors of around 5pF, and board supplied stray capacitance of no more than 5pF. It has also been found that adding an external resistor of 100k–1MΩ across X1 and X2 will solve other start up problems for some designs. While we recommend using balanced capacitors (C1 = C2) of 5pF, unbalanced values may be used. Since the X2 pin (input to the inverter) has the most sensitivity to capacitance, many designs use a larger value capacitor (10–15pF) on the X1 pin while leaving 5pF on the X2 pin.

Typical crystal parameters:
Frequency – 2–4MHz
Mode of operation – Parallel resonant, fundamental mode
Load Capacitance (C_L) – 12–32pF

For operation at nominal frequency, the values recommended below will give accurate, reliable results. The frequency will vary slightly depending on the amount of stray capacitance in the individual circuit.

C1 = C2 = 5pF
Y1 = Saronix NYP037-20; 3.6864MHz at C_L = 20pF with R_S = 25Ω, or series calibrated with R_S = 160Ω

USING AN EXTERNAL CLOCK SOURCE

Some designs may have an external clock source available and don't need to use the on-chip oscillator. In this case, the external clock should be applied to the X1/CLK pin for all of the UART and DUSCC/DMSC parts. The X2 pin can be driven with the complement of the signal going to the X1/CLK pin for all parts. If the X2 pin is not driven, it must be left open for the SCC2691 and SCC2698. The oscillator output pin should be left open. The X2 pin on the SCC2692 and SCC68682 can be either grounded or left open when it is not being driven.

See Figures 2 through 5 for oscillator schematics.

REFERENCES FOR FURTHER READING

Parzen, Benjamin, Design of Crystal and Other Harmonic Oscillators, John Wiley and Sons, New York, 1983.

Frerking, Marvin E., Crystal Oscillator Design and Temperature Compensation, Van Nostrand Reinhold Co. Inc., New York, 1978.

Holmbeck, John D., "Frequency Tolerance Limitations with Loagic Gate Oscillators", Proc. 31st Annual Symposium on Frequency Control, U.S. Army Electronics Command, Fort Monmouth, N.J., pp. 390–395, 1977. Copies available from Electronic Industries Association, 2001 Eye St., NW, Washington, D.C. 20006.

THEORETICAL INFORMATION ON DUSCC/DMSC CRYSTAL OSCILLATOR (Oct. 1987)

The information contained in Table 1 is based on computer simulations over the expected process range. It is not based on characterization data or actual device testing.

Table 1. Theoretical Information on DUSCC Crystal Oscillators

Parameter	Min	Typ	Max	Units
Feedback resistor[2]	121	160	210	kΩ
X1/ground capacitance	1.0	1.7	3.0	pF
X2/ground capacitance	3.0	4.3	6.0	pF
X1/X2 capacitance	0.5	1.0	2.0	pF
Inverter AC gain (14.7456MHz)[3]		2.8		
Inverter phase shift (14.7456MHz)[3]		249		deg.
Inverter AC gain (16MHz)[3]		2.6		
Inverter phase shift (16MHz)[3]		253		deg.
Inverter AC gain (2MHz)[3]		9.7		
Inverter phase shift (2MHz)[3]		210		deg.
X1/X2 bias level	1.8	2.3	2.9	V
Inverter prop delay[1]	6	11	18	ns

NOTES:
1. 10pF load on output X1. Delay from X2 = 3V to X1 = 3V.
2. Based on I–V characteristics of depletion transistor.
3. V_{OUT} / V_{IN} at bias point. X1 10pF loading.

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Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088–3409
Telephone 800-234-7381

Date of release: 10-98

Document order number: 9397 750 04613