Determination of the Oscillation Safety Factor (OSF)

To ensure a reliable operation of a crystal oscillator circuit, the oscillation safety factor (OSF) is worth to take a closer look at. The oscillation safety factor (OSF) shows the feedback gain margin of the oscillator amplifier for a worst-case crystal according to its specification.

The OSF should be >5 for consumer applications and >10 for automotive applications. OSF factors <2 are very risky and should be avoided.

Fig. 1 shows a typical oscillation circuit in a Pierce configuration with an added resistor R_{Pot}

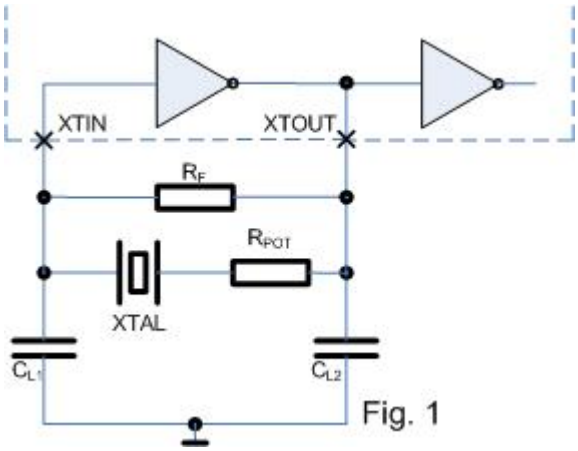

Fig. 1

To verify the oscillation safety factor (OSF) of an oscillator circuit, the following steps should be investigated:

- calculate the individual loaded series resistance R_L at the original circuit conditions, using the parameters of the individual crystal* in the circuit using formula (1):

$$R_L = R_S * \left(1 + \frac{C_0}{C_L}\right)^2 \qquad (1)$$

- calculate the worst-case loaded series resistance R_{Lmax} using the max. specified series resonance of the selected crystal* series (2):

$$R_{L\max.} = R_{S\max.} * \left(1 + \frac{C_0}{C_L}\right)^2 \qquad (2)$$

- insert a series resistor or miniature potentiometer R_{POT}, and increase its resistance till the oscillation stops

- measure the maximum resistance of $R_{POTmax.}$ where the oscillation just restarts, starting from max. value for $R_{POTmax.}$ or from a value which stopped the oscillation

General Remark: All measurements and calculations according to this method are valid for the individual crystal and customer circuit. Any change or variation of the crystal driving circuit and load capacitance will change the resulting OSF.

- determine the oscillation safety factor (OSF) using the equation (3):

$$OSF = \frac{\left(R_L + R_{POT\,\max.}\right)}{R_{L\,\max.}} \qquad (3)$$

Note 1 *: To determine the equivalent data of the individual crystal which is used to determine the OSF (like C_0 and R_S) special crystal measurement equipment is required. Also, if the effective load capacitance C_L (including stray capacitances) is not exactly known, this can only be determined using special crystal test equipment. All measurements refer to the individual crystal parameters and amplifier parameters

Note 2 *: As an estimate, the oscillation safety factor (OSF) can be calculated from (4), assuming an ideal crystal without any losses (R_S = 0).

$$OSF = \frac{R_{POT\,\max.}}{R_{L\,\max.}}$$

OSF judgement table:

	Judgement	
OSF	**MHz-oscillators**	**kHz-oscillators**
OSF ≥ 10	Very Safe	Very Safe
5 ≤ OSF ≤ 10	Safe	Very Safe
3 ≤ OSF ≤ 5	Not Safe	Safe
OSF < 3	Risky	Not Safe

General Remark: All measurements and calculations according to this method are valid for the individual crystal and customer circuit. Any change or variation of the crystal driving circuit and load capacitance will change the resulting OSF.