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}

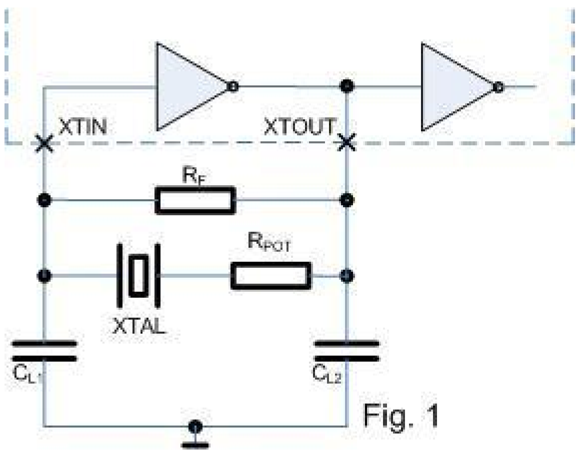

Fig. 1

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

- calculate the resonance load 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 resonance load 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 it's 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

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

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

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 (RS = 0).

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

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.