Oscillators are required as references of frequency. All clocks are for (micro)processors but all timing circuits also need a clock. The highest precision is obtained by using a crystal as a reference. Without a lot of effort, 0.1% precision is easily achieved. This is why we start this chapter with crystal oscillators. It will be shown that only one single transistor is required to make a crystal oscillator.

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An oscillator is a kind of feedback amplifier. The signal that is fed back is exactly what the amplifier requires, to sustain oscillation. Its input is now zero. This is called the Barkhausen criterion.

The amplifier has a gain $A(j\omega)$ which depends on frequency. Also, the feedback block has an attenuation $F(j\omega)$ which is frequency dependent. The loop gain $F(j\omega)A(j\omega)$ must be large enough so that the signal $v_f$ which is fed back, exactly equals $v_e$, which is required.

As a consequence, the loop gain must be slightly larger than unity in amplitude and its phase zero.
This means that $A(j\omega)$ must be an amplifier if $F(j\omega)$ is an attenuator. This also means that $F(j\omega)$ must be inductive if $A(j\omega)$ is capacitive. All amplifiers that we have seen contain capacitances. As a consequence, we are looking for an inductor for $F(j\omega)$.

Clearly, these two conditions are a result of the complex nature of both $A(j\omega)$ and $F(j\omega)$. Complex numbers are always pairs of numbers.

Another way to write the Barkhausen criterion is given by the split analysis. The amplifier is now represented by the impedance $Z_{\text{circuit}}$ and the feedback element by the resonator impedance.

As the circuit maintains oscillation by itself, no current is needed from outside. Its total input admittance is zero. The sum of the impedances must also be zero.

The Barkhausen criterion can now be stated as given by the two expressions in this slide. Rather than the amplitude and phase, the Real and Imaginary parts are used now. They are obviously related as reminded in the Appendix.

We will see later, that the first expression determines the minimum gain required, and the other the actual frequency of oscillation.