LoL demodulation with the eLockIn203
(LoL → LockIn on LockIn)

General idea

For some technical applications, measurement signals are provided as amplitude modulated results with a high carrier frequency and a much lower amplitude modulation frequency (as for instance used in AM radio signals). Then, they need to be demodulated sequentially, which means that the result of the first demodulation at f_1 (carrier frequency, one can use its amplitude R or its real part X) is provided as input to a 2^{nd} demodulator (or lock-in amplifier) working at f_2 (amplitude modulation frequency).

Important condition for the frequencies: $f_1 \gg f_2$ (Equ. 1)

Technically, this demodulation can be realized with two lock-in amplifiers (LIA):

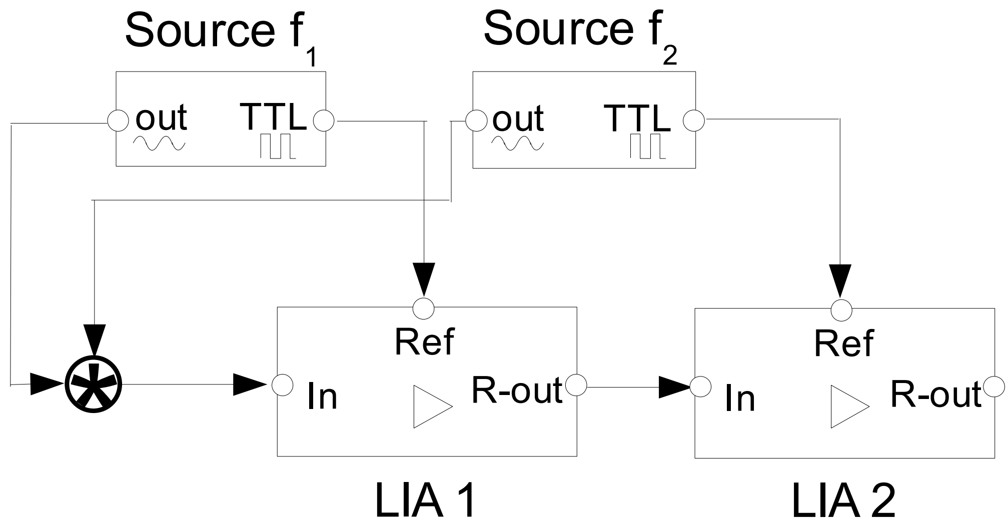

Figure1: Functional diagram of an amplitude modulation realized with two independent lock-in amplifiers.

- mixed signal from two sources → 'In' of LIA 1
- source 1 for f_1 triggers reference 1 of LIA 1
- LIA 1 measures amplitude (R-out) @ f_1
- from R-out (or X-out) the signal is sent to 'In' of LIA 2
- source for f_2 triggers reference input of LIA 2
- LIA 2 measures modulation amplitude @ f_2

The two LIAs are operated at different time constants τ_1 and τ_2 , respectively.

Important conditions for τ_1 and τ_2: $\tau_2 > \frac{1}{f_2} > \tau_1 > \frac{1}{f_1}$ (Equ. 2).

Sequential demodulation with one eLockIn203 in LoL-mode

The eLockIn203 is a quad-phase lock-in amplifier. It allows to demodulate one signal at two frequencies simultaneously, or two signals at the same frequency simultaneously. Thus, it is like two LIAs in one instrument. Operated in LoL-Mode, these two LIAs are used in sequence.

Thus, the eLockIn is able to overtake the tasks of both LIAs in Fig. 1 at the same time:

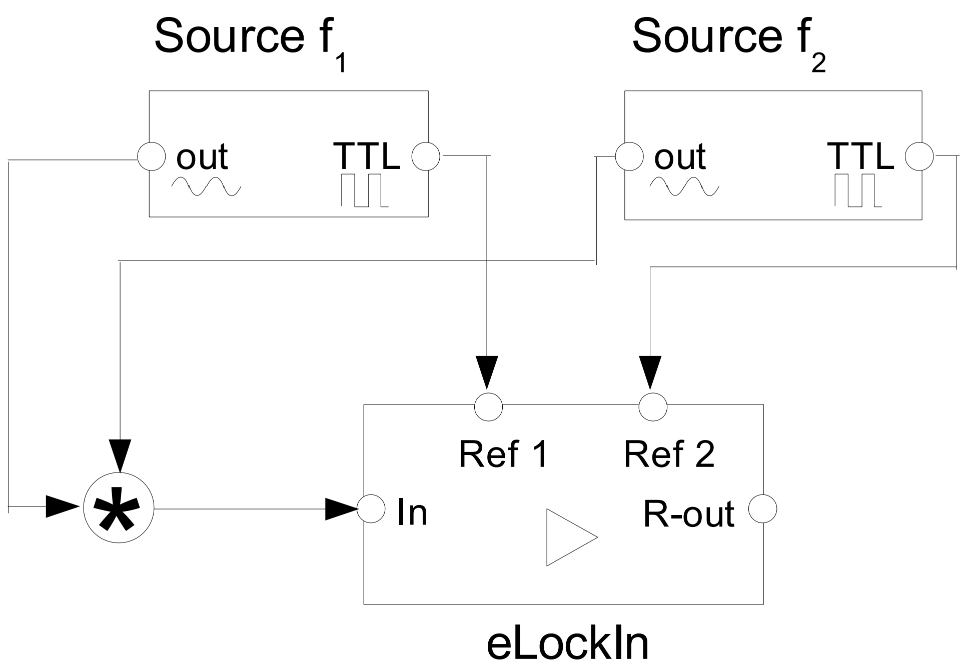

Figure 2: Functional diagram of an amplitude demodulation with the eLockIn.

- mixed signal from two sources → 'In' of LockIn
- both TTL signals trigger two internal PLL (phase locked loop) circuits in the same eLockIn through Ref1 and Ref2
- only one input of the two available inputs is used! (see next section)
- first, the carrier frequency is demodulated @ f_1
- internally, the result is provided to the 2^{nd} lock-in channel operating at f_2
- then, the modulation frequency is demodulated @ f_2

Settings for LoL-mode in the eLockIn203

Enable the LoL-mode: [LockIn / Ref / RefIn] → turn right until "1 & 2" appears.

The Reference input level can be TTL or sine wave and is set under [Setup / MISC / RefPLL] to ***"low/low", "low/high", "high/low"*** and ***"high/high"***. ***low*** stands for a sine input; ***high*** stands for a TTL input. Thus, ***"low/high"*** means that Ref1 is provided as sine-wave and Ref2 is provided as TTL. (for specification check out Manual Page 8).

Input configuration [LockIn / Input / Config] in LoL-mode can be chosen between "A" and "A-B". If "A&B" is selected, the input A only is taken into account.

Which frequencies are suitable for the LoL-Mode?
Best performance is achieved with F2 should be

Time constant settings under [LockIn / Input / Time]: see manual Page 21. ***Tau*** is used for the 1st demodulation and ***Tau1*** is used for the 2nd demodulation

LoL-Mode is just applicable if $\tau_2 > \frac{1}{f_2} > \tau_1 > \frac{1}{f_1}$

Synchronous filtering (***Sync*** in [LockIn / Input / Time]) is recommended for: $\tau_1 \simeq \frac{1}{f_1}$.

Advantages of LoL demodulation

- Compact and cost effective solution
- No signal loss due to D/A- and A/D-conversion between two LIAs
- Optimization with synchronous filtering possible

Example for use

Lets assume the sample is a semiconductor with a thin metal layer on top and one wants to analyse the I(U)-dependence of the metal-semiconductor interface with spatial resolution in order to find the local distribution of defects.

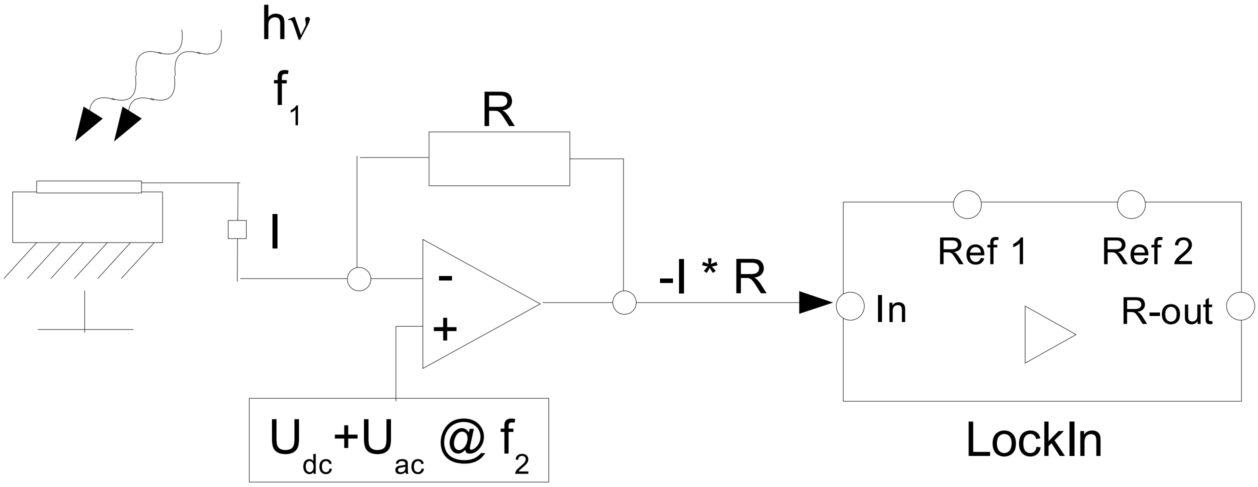

Figure 3: Experimental setup for a typical example in which the demodulation of an AM signal allows to achieve spatial resolution.

By applying a biased alternating voltage without local illumination, one can achieve a very highly resolved measurement of the bias dependent current due to a demodulation at f_2. However, this current is related to an average over the whole sample area.

When the current depends on the intensity of light, one can use a small light spot, which is choppered at f_1, to achieve spatial resolution. At positions, where the light spot hits the surface, the signal is modulated with f_1 and f_2. Positions with no illumination generate a signal that is modulated with f_2 only. After LoL demodulation, only signal components that contain both modulations remain as output signal. Thus, information from the non-illuminated surface region is ignored.