Introduction to Lock-in amplifiers

Dorothée Hug
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Overview

- Introduction to lock-in amplifiers
- Different building blocks of a lock-in
  - Reference channel
  - Preamplifier
  - Signal filtering
  - Phase sensitive detector
- Conclusion
Introduction

- Why using a Lock-in?
  - Noise reduction: improve signal to noise ratio
  - Measure rms amplitude and phase of a signal
  - Phase sensitive detection

- What is needed?
  - An AC signal and an AC reference signal
  - A phase sensitive detector (psd)
  - A phase shifter
Introduction

- sample signal and preamplifier
- Filtering of sample signal
- External Reference signal
- Internal Reference signal
- phase adjustment
- amplifier
- PSD
Reference channel
Preamplifier

Direct mode:
100MΩ, 30pF

Input impedance

Transformer:
Very low impedance

• Single ended or differential mode
• Direct or transformer mode:
  Choose depending on source resistance and working frequency
Filtering the signal of the sample
Notch, Bandpass, Low pass and High pass filters

Notch

Bandpass

Lowpass

Highpass
Phase sensitive detector (PSD)
Phase Sensitive Detector

Diagram showing the components of a phase-sensitive detector, including a signal, reference, switch output, and low-pass filter.
Low drift, Normal and High dynamic range

- Depending on the sensitivity the system functions in a different mode than chosen:

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>For other sensitivity system changes to</th>
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<tbody>
<tr>
<td>Low drift</td>
<td>1μV-500mV</td>
<td>100nv-500nV: Normal</td>
</tr>
<tr>
<td>Normal</td>
<td>100nV-50mV</td>
<td>100mV-500mV: Low drift</td>
</tr>
<tr>
<td>High dyn. Range</td>
<td>100nV-5mV</td>
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Conclusion

- A lock-in can be used to increase the signal to noise ratio and amplify small signals.
- It needs two ac signals of same frequency.
- To get good signals it is important to correctly adjust the different parameters.