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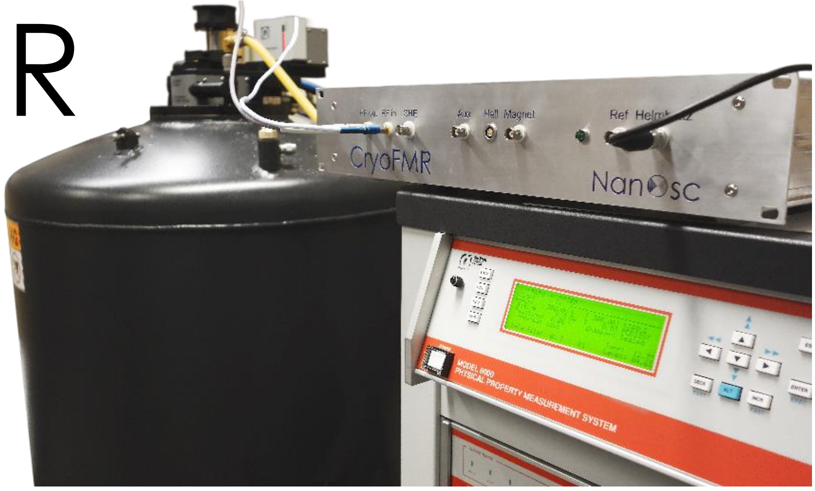
CryoFMR

for PPMS®

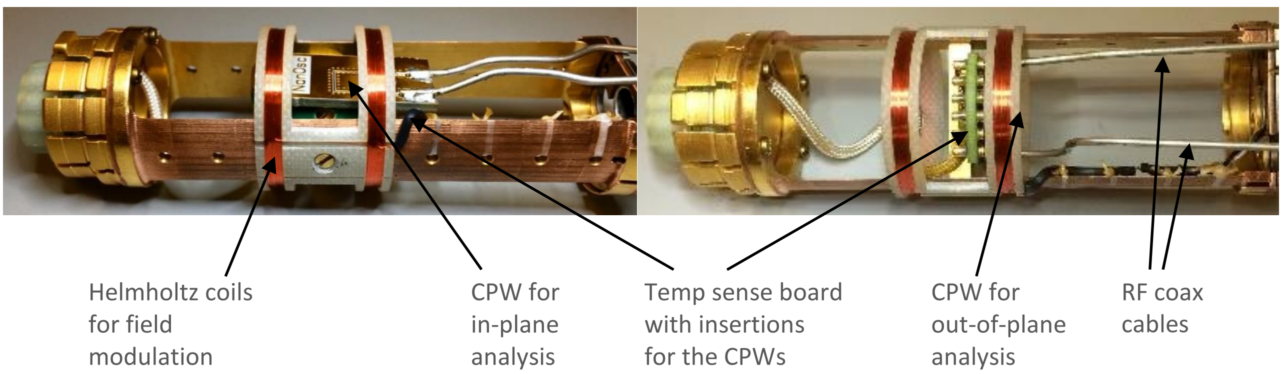


FMR analysis is very useful for characterizing static and dynamic magnetic properties of ferromagnetic thin films since the user does not have to know or measure the volume of the sample.

CryoFMR allows for broadband coplanar waveguide (CPW) FMR analysis over a range of temperatures. The **CryoFMR for PPMS** is dedicated for use with all Quantum Design PPMS platforms.

The instrument includes an RF frequency source and a lock-in detection module, and comes with easy-to-use software that provides the user with extracted magnetic parameters for the sample:

- Static behavior, such as saturation magnetization M_s and anisotropies; and
- Dynamic behavior, such as the intrinsic damping α and the inhomogeneous line broadening ΔH_o.



For integration with cryostats in the PPMS family, only the PPMS FMR probe insert is required. This probe includes local thermometry at the sample location, Helmholtz modulation coils around the sample mount, and cryogenic coax running down to the sample. NanOsc Instruments provides two CPWs for analysis of thin films with in-plane and out-of-plane magnetic fields.

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Data extraction

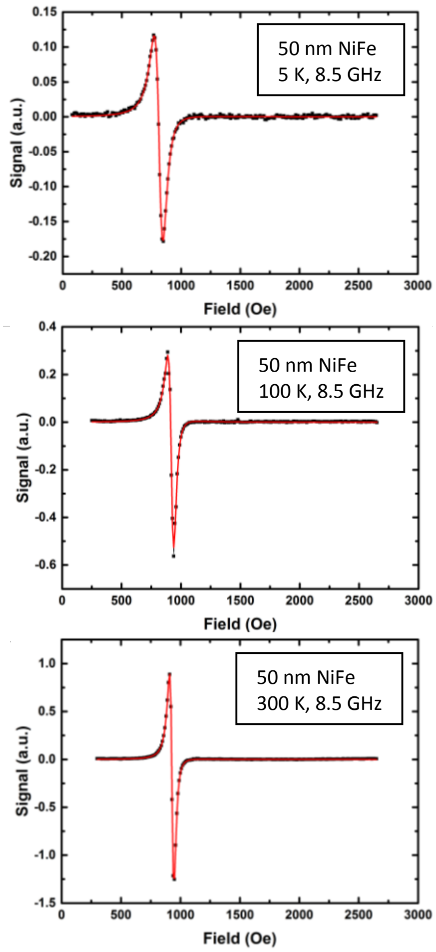
Typical FMR sweeps using the CryoFMR for PPMS over a range of cryogenic temperatures are shown to the left together with asymmetrical Lorentzian curve fits in red.

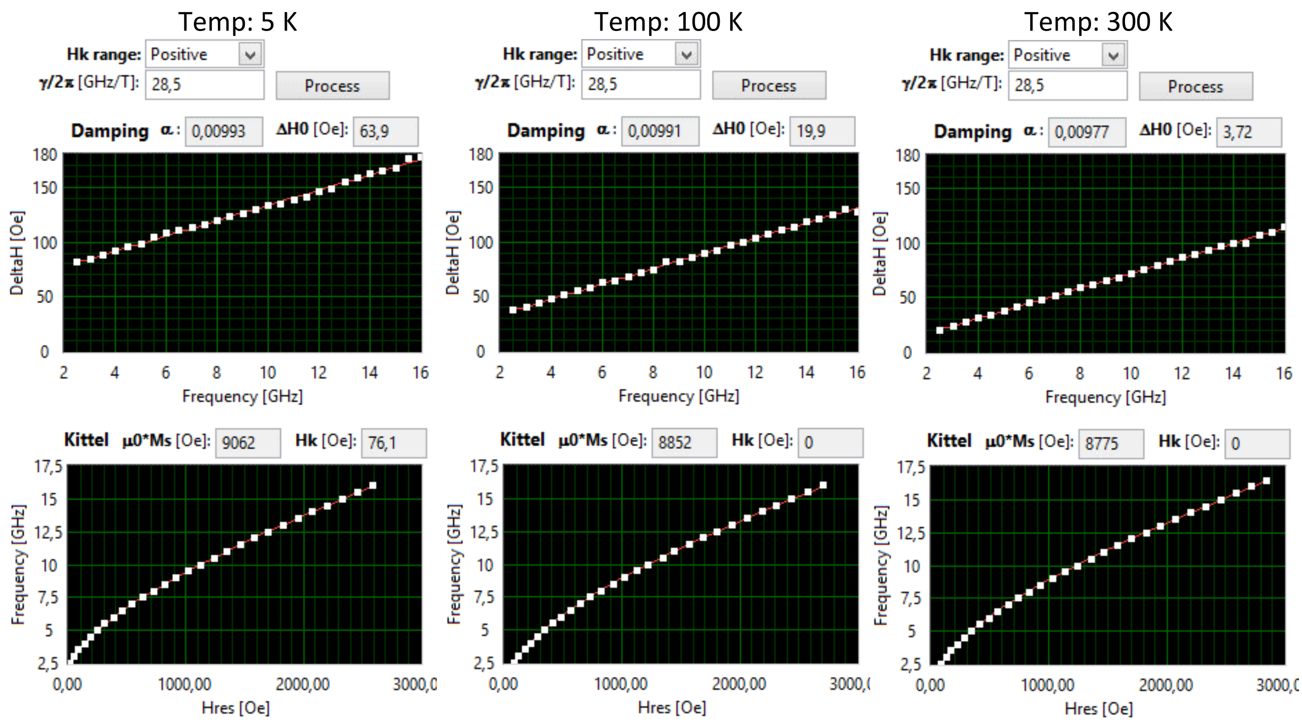
The built in lock-in amplifier recovers FMR response signals that may be obscured by noise orders of magnitude larger than the signal itself. Due to the modulation from a pair of Helmholtz coils connected to an internal AC source, the output of the lock-in will be a derivative FMR trace instead of an FMR absorption trace.

The software combines selected sweeps over a range of frequencies in order to extract the desired magnetic properties, as shown in the screen snapshots below.

In the upper three graphs below, the linewidth Delta H is plotted vs the RF frequency and straight line fits in red. This allows the extraction of the intrinsic damping α and the inhomogeneous line broadening ΔH_o for each temperature.

The lower three graphs show the RF frequency plotted vs the resonance field together with fitted Kittel equations in red. Here the extracted parameters are the saturation magnetization M_s and the anisotropy field H_k.





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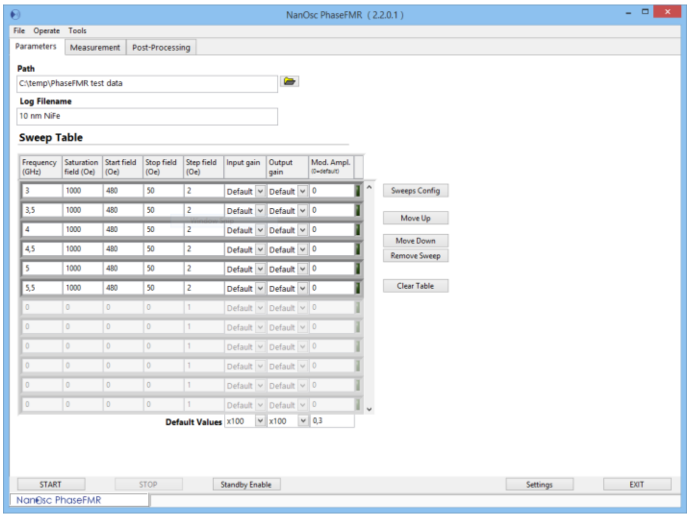
Software makes FMR easy

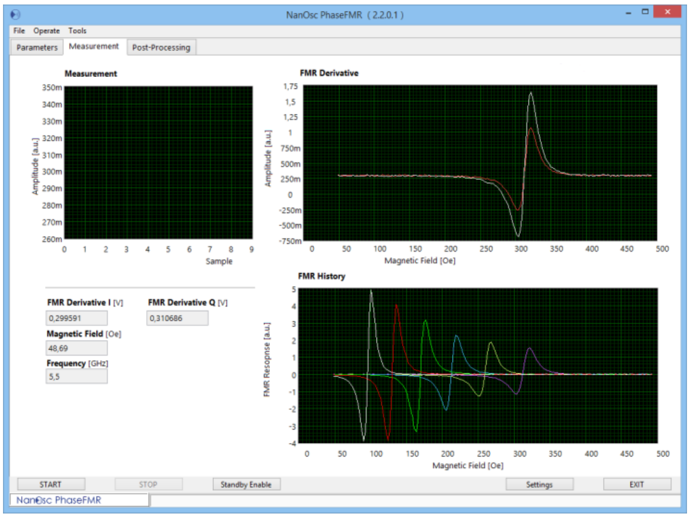
The software user interface is divided into three tabs:

1. Setting up the measurement sweeps
2. Monitoring the running measurements
3. Post-processing and parameter extraction

The table in the set-up tab has one row with individual parameters for each sweep. The user can select start and stop field values for each frequency to focus on the range where the response is expected and thereby reduce the total sweep time.

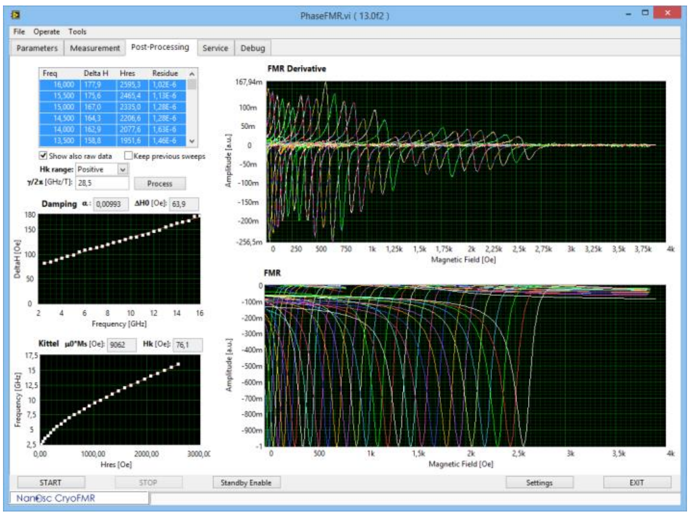


In the Measurement tab there are three graphs showing the lock-in output (upper left), the in-phase and quadrature components of the FMR response's derivative (upper right), and the history of measured FMR sweeps (lower right).



In the Post-Processing tab there is a list (blue, upper left) with results from curve fitting all the sweeps to a Lorentzian function. The user can click to select all or a subset of these and the two graphs to the right display the selected FMR sweeps and their corresponding normalized integrated responses.

The two remaining graphs on the left hand side present the final outcome of the whole measurement. The curve fits to the damping graph and the Kittel graph give the parameters for the magnetic properties.



Specifications

RF source	Range: 2 to 17 GHz, accuracy 0.05 GHz
FMR readout	SNR better than 10 for 10 nm NiFe in plane
AC field modulation	Range: 0 to 3 Oe peak-peak
Magnet control and readout	Via the Quantum Design MultiVu control software

ADDRESS
NanOsc Instruments AB
Electrum 205
SE-164 40 Kista, Sweden
Office: Isafjordsgatan 22, Kista

INTERNET
www.nanosc.se
E-MAIL
info@nanosc.se
PHONE
+46 (0) 8 751 9016

ORG. NO
556948-3042
VAT
SE556948304201

BANK
Handelsbanken
IBAN
SE38 6000 0000 0007 7916 1378
BIC/SWIFT
HANDSESS