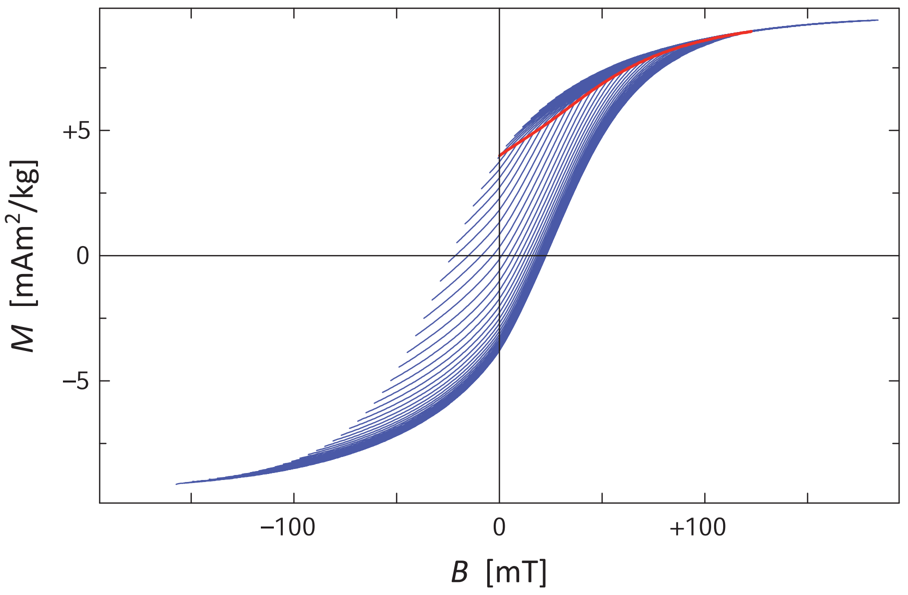
VARIFORC Quick Guide

ImportFORC



1. Needed files

Mathematica notebook	Files ending with `VARIFORC_ImportFORC.nb`
(→ User manual p. 3-6)	Location in the installation package: `VARIFORC_Install/Functions/ImportFORC/Start_ImportFORC.nb`
Parameter file	Files ending with `VARIFORC_ImportFORC_parameters.txt`
(→ User manual p. 3-14)	Location in the installation package: `VARIFORC_Install/Functions/ImportFORC/Start_ImportFORC_Parameters.txt`
FORC measurement file	File containing FORC measurements.
(→ User manual p. 3-11)	Accepted formats: all MicroMag^{TM} formats (→ User manual p. 3.71).

2. Output files

Corrected measurements	File ending with `_CorrectedMeasurements_VARIFORC.frc`
(→ User manual p. 3-74)	Contains drift-corrected FORC measurements with removed outliers.
	For further processing of regular FORC measurements.
Corrected measurement differences	File ending with `_CorrectedMeasurementDifferences_VARIFORC.frc`
(→ User manual p. 3-74)	Contains drift-corrected FORC measurements with removed outliers, after subtraction of the lower hysteresis branch.
	For further processing of FORC measurements with artifact-prone common features.

3. Processing parameters

INPUT 01

(→ User manual p. 3-18)

Field and magnetization column numbers

- Unique option:
  `field column number, magnetization column number`
  for the column number of field values (usually 1) and the column number of magnetization values (usually 2) in the measurement file.

Examples:

- `1, 2` is the usual option for MicroMag™ measurement files, where field and magnetization values are stored in the first and second column, respectively.

INPUT 02-07

(→ User manual p. 3-20)

FORC protocol parameters

- Option 1 (*recommended*):
  `Automatic`
  ImportFORC looks for the required parameters in the measurement file header.

- Option 2:
  `Number`
  Explicit parameter specification (number ≥ 0).

INPUT 02: FORC saturation field (`Hsat`)
INPUT 03: Field slew rate (`SlewRate`)
INPUT 04: Averaging time of FORC measurements
INPUT 05: Pause at FORC reversal field (`PauseNtl` or `PauseRvrsl`)
INPUT 06: Pause at FORC calibration field (`PauseCal`)
INPUT 07: Pause at FORC saturation field (`PauseSat`)

These parameters are needed only for drift correction purposes.

INPUT 08

(→ User manual p. 3-25)

Correction options for first FORC points (updated)

- Option 1 (*recommended*):
  `None, None`
  No corrections applied to first FORC points.
- Option 2:
  `1, None`
  Field value set according to a regular grid, no magnetization corrections.
- Option 3:
  `r, None`
  Field value corrected so, that the first step corresponds to $r \times \delta H$, where δH is the mean field step size, and $r > 0$ a numerical value. No magnetization corrections.
- Option 4 (*recommended*):
  `None, Automatic`
  No field correction. Magnetization of first point in each curve set to a second-order polynomial extrapolation of following points.
- Option 5:
  `r, Automatic`
  Field value corrected so, that the first step corresponds to $r \times \delta H$, where δH is the mean field step size $r > 0$ a numerical value. Magnetization of first point in each curve set to a second-order polynomial extrapolation of next points.
- Option 6:
  `Option for field, Automatic, 2`
  No field correction. Magnetization of first two points in each curve set to a second-order polynomial extrapolation of following points. The *option for field* applies to the first point only.

INPUT 09

(→ User manual p. 3-30)

Correction options for last FORC points (updated)

- Option 1 (*recommended*):
  `None, None`
  No corrections applied to last FORC points.
- Option 2:
  `1, None`
  Field value set according to a regular grid, no magnetization corrections.
- Option 3:
  `r, None`
  Field value corrected so, that the last step corresponds to $r \times \delta H$, where δH is the mean field step size, and $r > 0$ a numerical value. No magnetization corrections.
- Option 4:
  `None, Automatic`
  No field correction. Magnetization of last point set to a second-order polynomial extrapolation of preceding points in each curve.
- Option 5:
  `r, Automatic`
  Field value corrected so, that the last step corresponds to $r \times \delta H$, where δH is the mean field step size $r > 0$ a numerical value. Magnetization of last point set to a second-order polynomial extrapolation of preceding points in each curve.
- Option 6:
  `Option for field, Automatic, 2`
  No field correction. Magnetization of last two points set to a second-order polynomial extrapolation of preceding points in each curve. The *option for field* applies to the last point only.

INPUT 10

(→ User manual p. 3-32)

FORC smoothing factor for error calculations

- Unique option:
  `Positive integer`
  Minimum: 1 (no smoothing).

Used only for error calculation and outlier identification. Recommended values are comprised between 3 and 5.

INPUT 11

(→ User manual p. 3-37)

FORC smoothing factor for drift calculations

- Unique option:
  `Positive integer`
  Minimum: 1 (no smoothing, calibration measurements assumed to be exact).

Used only for drift calculations. Recommended values are comprised between 3 and 5.

INPUT 12

(→ User manual p. 3-40)

Lower limits for outlier detection/replacement

- Unique option:
  λ_1, λ_2
  Outlier detection if polynomial regression residual is $>\lambda_1\varepsilon$, where ε is the residuals standard deviation and $\lambda_1>0$. Outlier replacement if polynomial regression residual is $>\lambda_2\varepsilon$, where ε is the residual standard deviation and $\lambda_2>0$.

  Outlier detection only for plotting purposes. Outlier replacement effective for exported data. Recommended values: $\lambda_1\geq 2$ and $\lambda_2\geq 2.5$.

Examples:

- `3, 3` detects and replaces measurements with regression residuals exceeding 3 standard deviations of residuals.

INPUT 13

(→ User manual p. 3-44)

Maximum amplitude of the residuals color scale

- Unique option:
  `λ3`
  Polynomial regression residuals $>\lambda_3\,\varepsilon$, where ε is the residual standard deviation and $\lambda_3>0$, are represented with white pixels on a color map (for diagnostic purposes).

Recommended values: $\lambda_3=\lambda_2$, where λ_2 is the outlier replacement limit (second number in INPUT 12).

INPUT 14

(→ User manual p. 3-45)

FORC plotting options

- Option 1 (*recommended*):
  `Automatic`
  Plots ~100 curves.
- Option 2:
  `All`
  Plots all curves.
- Option 3:
  `n`
  Plots $n>0$ curves (n is a positive integer).
- Option 4:
  `n1, n2`
  Every n_2-th curve is plotted starting from the n_1-th curve (n_1 and n_2 are positive integers).

These options do not affect exported data.

INPUT 15

(→ User manual p. 3-47)

Field units and calibration

- Unique option:
  `Input unit, calibration factor, output unit`
  Input unit is the field unit of imported measurements. Output unit is the field unit of the exported data. Units can be preceded by S.I. multipliers or S.I. prefixes (e.g. `mT` or `1e-3 T`) Calibration factor is a positive number by which original field measurements are multiplied to obtain corrected field values (e.g. `1` in case of measurements obtained from a calibrated magnetometer).

See Tables 3.1-2 of the user manual for a complete list of recognized input and output units and S.I. prefixes. Set the calibration factor to 1 unless field measurements need to be corrected due to a known calibration problem.

Examples:

- `T, 1, T` keeps the original unit (Tesla) of calibrated field measurements.
- `T, 0.99, T` keeps the original field unit (Tesla) and reduces all field values by 1%.
- `Oe, 1, mT` or `Oe, 1, 1e-3 T` converts calibrated field measurements from Oe to mT.

INPUT 16

(→ User manual p. 3-50)

Normalization factor(s) and unit

- Option 1 (*single measurement file*):
  `Normalization factor, normalization unit`
  Normalization factor is the specimen mass, volume, or area expressed with proper normalization unit, used to normalize magnetic moment measurements.
- Option 2 (*multiple measurement files*):
  `List of normalization factors, normalization unit`
  List of normalization factors, in form of masses, volumes, or areas of individual specimens, expressed with same unit, used to normalize magnetization measurements.

See Table 3.4 of the user manual for a complete list of recognized normalization units. Normalization is based on the assumption that original magnetization measurements are expressed in magnetic moment units (S.I.: Am^2 and multiples, C.G.S.: emu and multiples). Normalization is decoupled from magnetization units if the normalization unit is set to `none`. Normalization units can be entered with S.I. multipliers or prefixes.

Examples:

- `1, none` keeps the original magnetization measurements.
- `27.4, mg` normalizes original magnetic moment measurements by specimen mass. Works for a single specimen and for multiple specimens with same mass. The unit of exported measurements will be a mass magnetization.
- `27.4, 26.5, 28.1 mg` normalizes original magnetic moment measurements of three specimens by their masses (list of normalization factors applies to alphabetically sorted file names). The unit of exported measurements will be a mass magnetization.
- `10, none` normalizes measurements with inconsistent units. Original measurements are divided by 10 and output unit specified with INPUT 17 is given, regardless of the input unit.

INPUT 17

(→ User manual p. 3-53)

Magnetization units and calibration

- Unique option:
  `Input unit, calibration factor, output unit`
  Input unit is the magnetization unit of imported measurements. Output unit is the magnetization unit of the exported data, after normalization with INPUT 16. Units can be preceded by S.I. multipliers or S.I. prefixes (e.g. `mAm2` or `1e-3 Am2`) Calibration factor is a positive number by which original magnetization measurements are multiplied to obtain corrected magnetization values (e.g. `1` in case of measurements obtained from a correctly calibrated magnetometer).

See Table 3.5 of the user manual for a complete list of recognized input and output units and S.I. prefixes. Set the calibration factor to 1 if the magnetometer was correctly calibrated.

Examples:

- `Am2, 1, Am2` keeps the original unit (magnetic moment in Am^2) of calibrated magnetization measurements, without normalization (i.e. INPUT 16 set to `1, none`).
- `Am2, 1.02, Am2` keeps the original unit (magnetic moment in Am^2) and increases all magnetization values by 2% in order to compensate for a calibration error (e.g. specimen was not properly centered).
- `emu, 1, mAm2` or `emu, 1, 1e-3 Am2` converts the unit of correctly calibrated magnetization measurements, without normalization (i.e. INPUT 16 set to `1, none`).
- `Am2, 1, mAm2/kg` converts the original unit (magnetic moment in Am^2) into a mass magnetization (in mAm^2/kg) by normalizing measured magnetic moments with the specimen mass entered with INPUT 16 (e.g. `27.4, mg`).
- `none, 1, mAm2/kg` converts an improper measurement unit (e.g. volume magnetization in A/m for a given standard volume) into mass magnetization (in mAm^2/kg). The conversion is based on a proper normalization entered with INPUT 16 (e.g. `11.4, none`).

INPUT 18

(→ User manual p. 3-57)

High-field limit for paramagnetic correction

- Option 1 (*simplest*):
  `None`
  No paramagnetic correction is applied to the measurements. In this case, exported measurements do not contain an estimate of the saturation magnetization M_S.
- Option 2 (*automatic*):
  `Automatic`
  Paramagnetic correction is performed using a high-field susceptibility estimate obtained from field amplitudes >80% of the maximum field of FORC measurements. The field range set by option 2 corresponds to the range chosen by the automatic paramagnetic correction performed by MicroMag™ magnetometers.
- Option 3 (*explicit range specification*):
  `Field amplitude`
  Paramagnetic correction is performed using a high-field susceptibility estimate obtained from field amplitudes larger than the specified field (a positive number expressed in output field units).

Paramagnetic correction does not affect FORC diagram calculations, but is recommended for a proper representation of FORC measurements. Option 2 is recommended for preliminary processing.

Examples:

- `90` is entered for performing a paramagnetic correction based on field amplitudes >90 mT, where mT is the output field unit chosen with INPUT 15.

INPUT 19

(→ User manual p. 3-61)

High-field model constraint

This option is ignored if INPUT 18 was set to `None`.

- Option 1 (*automatic*):
  `None` or `Automatic`
  High-field susceptibility and saturation magnetization are calculated automatically with an approach-to-saturation law. Reliable results are obtained only if FORC measurements extend to the saturation range of hysteresis.
- Option 2 (*explicit high-field susceptibility specification*):
  `Numerical value` or `Numerical value/Xhf`
  The (positive or negative) high-field susceptibility is specified explicitly by the numerical value entered with INPUT 19. The assumed unit is (*output magnetization unit*)/(*output field unit*).
- Option 3 (*explicit saturation magnetization specification*):
  `Numerical value/Ms`
  The (positive) saturation magnetization is specified explicitly by the numerical value entered with INPUT 19. The assumed unit is (*output magnetization unit*).

Options 2-3 are recommended if a reliable susceptibility or saturation magnetization estimate is available from other sources (e.g. hysteresis measurements in large fields).

Examples:

- `-1.28e-4` is entered for specifying a high-field susceptibility in $\mu Am^2/T$, where T and μAm^2 are the output field and magnetization units, respectively, as specified with INPUT 15 and INPUT 17.
- `0.235/Ms` is entered for specifying a saturation magnetization in the same magnetization unit used for the output.

INPUT 20

(→ User manual p. 3-63)

Approach-to-saturation exponent

This option is ignored if INPUT 18 was set to `None`.

- Option 1 (*explicit exponent specification*):
  `Exponent`
  The approach-to-saturation law used for estimating the high-field susceptibility of paramagnetic corrections relies on an exponent controlling how fast the hysteresis of ferrimagnetic minerals approaches the saturation magnetization. This exponent is a positive number comprised between 1 (strong domain wall pinning) and 2 (single-domain particles).
- Option 2 (*automatic*):
  `Automatic`
  With this option, the exponent of the approach-to-saturation law used for estimating the high-field susceptibility is determined automatically.

Option 1 is recommended if the approach-to-saturation exponent is known a-priori, or if it is deduced from the nature of the sample being measured. Option 2 is recommended only if FORC measurements extend abundantly into the saturation range of hysteresis.

Examples:

- `2` is a suitable option for magnetofossil-rich sediment.

Notes: