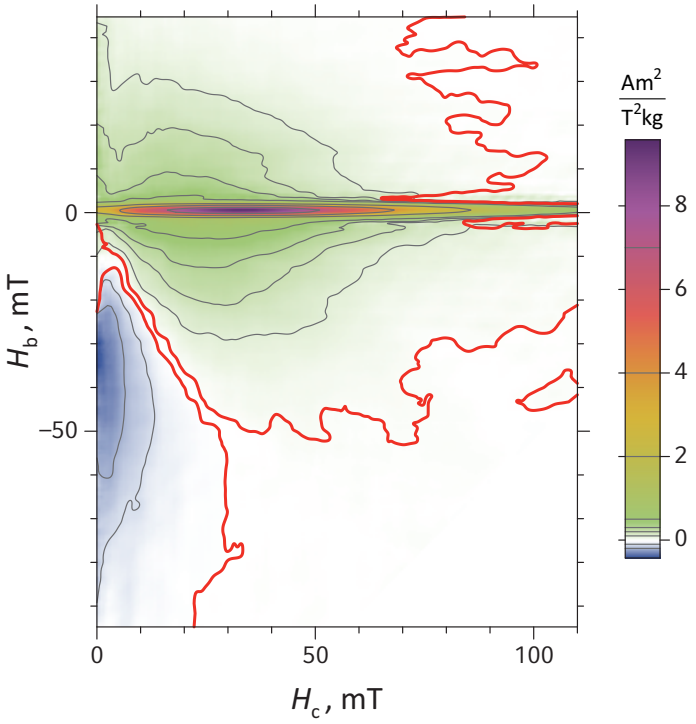
VARIFORC Quick Guide

VARIFORC PlotFORC



1. Needed files

Mathematica notebook

(→ User manual p. 5-6)

Files ending with `VARIFORC_CalculatePlotFORC.nb`

Location in the installation package:
`VARIFORC_Install/Functions/PlotFORC/Start_PlotFORC.nb`

Parameter file

(→ User manual p. 5-13)

Files ending with `VARIFORC_PlotFORC_parameters.txt`

Location in the installation package:
`VARIFORC_Install/Functions/PlotFORC/Start_PlotFORC_Parameters.txt`

FORC matrix

(→ User manual p. 5-11)

FORC matrix files produced by CalculateFORC and other VARIFORC functions (e.g. IsolateCR). All matrix files end with `FORC_VARIFORC.txt`.

3.2 Output files

FORC diagram graphics

(→ User manual p. 5-56)

Optional FORC diagram export to the following vector graphics formats:

- Encapsulated Post Script (EPS)
- Printable Document Format (PDF)

and the following raster graphics:

- JPEG (for print)
- GIF (for web usage)

No files are produced for further processing with VARIFORC functions.

3.3 Processing parameters

INPUT 01-02

(→ User manual p. 5-16)

Plotted range

INPUT 01: H_c-range
INPUT 02: H_b-range

- Option 1 (*whole matrix*):
  `All`
  The maximum range covered by the imported FORC matrix is plotted.
- Option 2 (*selected range*):
  `Hmin, Hmax`
  The range defined by *Hmin* < *Hmax* is plotted compatibly with the range covered by the imported FORC matrix. *Hmin* and *Hmax* are expressed in field units of the FORC matrix, as specified in the header of the imported file.

Option 2 is used to plot only part of the FORC space covered by the imported FORC matrix.

INPUT 03

(→ User manual p. 5-18)

Diagonal FORC space limits

- Option 1 (*whole matrix*):
  `None`
  The FORC matrix is plotted within the range specified with INPUT 01-02, without further limits.

- Option 2 (*diagonal limits*):
  `Hclower, Hcupper`
  Diagonal FORC space limits are defined by the intercepts `Hclower` > 0 and `Hcupper` > 0 of lower and upper quadrant diagonals with the H_c-axis (i.e. H_b = 0). If `Hclower` or `Hcupper` is set to `None`, no diagonal limit is imposed to the lower and upper quadrant, respectively. `Hclower` and `Hcupper` are expressed in field units of the FORC matrix, as specified in the header of the imported file.

The intrinsic maximum extension of the FORC function is given by `Hclower` = `Hcupper` = H_s, where H_s is the positive field in which the major hysteresis loop becomes closed. Option 2 can be used to exclude parts of the FORC function that are intrinsically not significant.

Parts of the rectangular FORC space defined by INPUT 01-02, which are not covered by measurements or excluded with INPUT 03, are set to 0 by default.

Examples:

- `None` is equivalent to `None, None` and is used to plot the FORC matrix over the range defined by INPUT 01-02 without exclusions.
- `None, 120` sets FORC matrix values with coordinates $H_b > 120 - H_c$ to zero.
- `120, None` sets FORC matrix values with coordinates $H_b < -120 + H_c$ to zero.
- `120, 100` sets FORC matrix values with coordinates $H_b < -120 + H_c$ and $H_b > 1000 - H_c$ to zero.

INPUT 04

(→ User manual p. 5-20)

FORC unit factor

- Option 1 (*automatic, recommended*):
  `Automatic`
  The FORC unit of the diagram is chosen automatically in order to avoid very small or very large numbers for color scale and contour labeling.
- Option 2 (*explicit unit multiplier*):
  p
  With this option, the original FORC unit of the imported FORC matrix (reported in the file header) is multiplied with the power-of-ten factor $p > 0$. Use $p = 1$ to keep the original FORC unit.

Both options are used to produce nice plot legends with compact numbers and no scientific notation needs. Option 1 is recommended for plotting individual FORC diagrams. Option 2 can be used for plotting several FORC diagrams with the same unit for comparison purposes.

Examples:

- `Automatic`, if applied to a FORC matrix with maximum amplitudes of 2×10^4 $Am^2/(kg\,T^2)$, produces a FORC diagram expressed in 10^3 $Am^2/(kg\,T^2)$, so that color scale labels range from 0 to 20.
- `1e3` transforms the FORC matrix unit $Am^2/(kg\,T^2)$ into 10^3 $Am^2/(kg\,T^2)$, regardless of actual FORC amplitudes.
- `1` keeps the original unit of the FORC matrix, regardless of actual FORC amplitudes.

INPUT 05

(→ User manual p. 5-22)

Color scale range

- Option 1 (*whole range*):
  `All`
  The whole range of FORC matrix values is covered by the color scale.
- Option 2 (*automatic, recommended*):
  `Automatic`
  The whole range of significant FORC matrix values is covered by the color scale.
- Option 3 (*explicit range specification*):
  `fmin, fmax` or *`fmin, fmax%`*
  The range of FORC values covered by the color scale is specified explicitly by *`fmin`* < *`fmax`*, where the limits *`fmin`* and *`fmax`* are understood to be expressed in original FORC matrix units, as specified in the header of the imported file. The color scale range can exceed actual FORC matrix values. In this case, only part of the color scale is used to represent the FORC function.

Option 2 is recommended for general purpose and preliminary FORC diagram plots. Option 3 is useful for clipping very large amplitudes concentrated over few pixels, and for producing several FORC diagrams with identical color scales for comparison purposes.

Option 3 specifications can be prepared on the basis of summary tables of previous PlotFORC runs with option 1. These tables reports statistical properties of the FORC matrix in original units. The `%` symbol enables to enter limits as percent of the FORC maximum value.

Examples:

- `-1e3, 1.9e4` defines a color range that exceeds maximum negative values of $(-0.2 \pm 1) \times 10^3$ Am^2/(kg T^2), so that negative amplitudes are represented in pale blue, avoiding the use of saturated colors for insignificant contributions. The same result is obtained by setting INPUT 05 to `Automatic`.

INPUT 06

(→ User manual p. 5-26)

Color function specifications

- Option 1 (*automatic, recommended*):
  `ColorScaleName`
  Use the color scale `ColorScaleName` with default settings for plotting the FORC diagram.
- Option 2 (*semi-automatic with color saturation specification*):
  `ColorScaleName, S`
  Same as option 1, with color saturation $0 \leq S \leq 1$ expressed as fraction of the maximum saturation. Recommended values of S are comprised between 0.8 and 1.
- Option 3 (*explicit color function specifications*):
  `ColorScaleName, S, g`
  Same as option 2, with gamma correction $g > 0$. The gamma correction regulates color transitions to white. Within such transitions, $g > 1$ expand light tones, while the opposite effect is obtained with $g < 1$. Original color scale transitions are maintained with $g = 1$ (recommended with the color scales `Iridescent` and `Sunsky`).

Available color scales are `Iridescent` (blue-white-green-yellow-red-purple) and `Sunsky` (blue-white-yellow-red-violet) for full color diagrams, as well as `Aquamarine` (white-aquamarine) and `Sepia` (white-sepia) for monochrome representations.

Default color scale settings are given by $S = 0.9$ and $g = 1$.

The gamma correction of `Aquamarine` and `Sepia` can be used to enhance the color contrast of low-amplitude features ($g < 1$). `Iridescent` and `Sunsky` provide good color contrasts over low-amplitude features and do not require a gamma correction, except for fine tuning of high-quality prints.

Pure contour plots with no color shading are obtained with color saturation set to zero ($S = 0$), and appropriated contour specifications (INPUT 11-14).

INPUT 07

(→ User manual p. 5-33)

Expanded color range

INPUT 07 applies only to the color scales “Iridescent” and “Sepia” and regulates the range of color transitions to white, which is the color used for coding zero FORC amplitudes.

- Option 1 (*automatic, recommended*):
  `Automatic`
  The color scale is automatically tuned with the statistical distribution of significant FORC values for best color rendering of small and large amplitudes.
- Option 2 (*fixed, not recommended*):
  `Fixed`
  The unmodified color scale is tied to zero and the positive limit of the color scale range.
- Option 3 (*for single-domain signatures*):
  `Negative`
  Color transitions to white are symmetric over positive/negative values, with tied points corresponding to zero (white) and maximum negative (blue) FORC amplitudes.
- Option 4 (*for regular FORC diagrams*):
  `Positive`
  The color scale is fixed over positive amplitudes, while blue-white transitions are automatically tuned over negative amplitudes.
- Option 5 (*explicit specification*):
  A or *A*%
  The positive limit of the color transition to white is specified explicitly by a positive number *A* expressed in original FORC matrix units, as specified in the header of the imported file, or as percent (*A*%) of the maximum FORC value. The color scale is tied to zero, *A*, and the color scale range set by INPUT 05. This option, along with explicit specifications of the color range, is recommended for representation of several FORC diagrams with identical color scales.

INPUT 08

(→ User manual p. 5-38)

Field ticks specifications

- Option 1 (*automatic, recommended*):
  `Automatic`
  FORC diagram ticks are chosen automatically. In this case, H_c- and H_b-ranges are divided into ~10 equal intervals by major ticks.
- Option 2 (*same explicit specification for H_c- and H_b-ticks*):
  `d, n`
  Major ticks are drawn at d-intervals along H_c and H_b, where $d \geq 0$ is expressed in field units of the imported FORC matrix, as specified in the file header. Each interval is divided into n parts by minor ticks. Theses specifications apply in the same manner for H_c- and H_b-ticks.
- Option 3 (*different explicit specifications for H_c- and H_b-ticks*):
  `d_c, n_c, d_b, n_b`
  Major ticks are drawn at d_c-intervals along H_c and d_b-intervals along H_b, where $d_c \geq 0$ and $d_b \geq 0$ are expressed in field units of the imported FORC matrix, as specified in the file header. Each interval is divided into n_c or n_b parts by minor ticks. This option is used for FORC diagrams with very different H_c- and H_b-ranges.

Examples:

- `10, 5` places major ticks every 10 mT, and minor ticks every 2 mT, if the field unit of imported FORC measurements is mT.
- `10, 5, 3, 3` places major H_c-ticks every 10 mT with minor ticks every 2 mT, and major H_b-ticks every 3 mT with minor ticks every 1 mT, if the field unit of imported FORC measurements is mT.

INPUT 09

(→ User manual p. 5-40)

Vertical exaggeration factor

- Unique option:

  v

  The natural aspect ratio of the FORC diagram is multiplied by a positive factor $v > 0$. Use $v = 1$ to keep the natural aspect ratio unmodified. Use $v > 1$ to stretch the FORC diagram vertically and $0 < v < 1$ to stretch the diagram horizontally.

This option is used to modify the aspect ratio of FORC diagrams with very different horizontal and vertical ranges (e.g. the central ridge).

Examples:

- 5 is used to stretch the vertical range of the FORC diagram obtained from a central ridge FORC matrix (produced by the VARIFORC function IsolateCR).

INPUT 10

(→ User manual p. 5-42)

Color bar range

- Option 1 (*default*):

  `All`

  The color bar range covers all FORC amplitudes.

- Option 2 (*recommended for diagrams containing large-amplitude artifacts*):

  `Automatic`

  The color bar range covers only FORC amplitudes within the color scale range chosen with INPUT 05. Regardless of the color scale, the color bar range never exceeds the interval set by minimum and maximum values of the FORC function, respectively.

This option is used in combination with INPUT 05 to control the range of FORC function amplitudes that should be plotted, enabling to ignore large-amplitude artifacts.

INPUT 11

(→ User manual p. 5-43)

Color bar normalization

- Option 1 (*default*):
  No
  The color bar is labeled with the original unit of the FORC function.
- Option 2 (*recommended when absolute amplitudes are not important*):
  Yes
  The color bar labels are normalized to the maximum value of the FORC function that is covered by the color scale in its unsaturated range. This value is set to 100%.

This option is used to switch between absolute and relative units.

Examples:

- A FORC function with a maximum amplitude of 5.2 Am^2/T^2 and a color range extending to 4.8 Am^2/T^2 is normalized by 4.8 Am^2/T^2 if INPUT 05 is set to Yes .
- A FORC function with a maximum amplitude of 5.2 Am^2/T^2 and a color range extending to 6.5 Am^2/T^2 is normalized by 5.2 Am^2/T^2 if INPUT 05 is set to Yes .

INPUT 12

(→ User manual p. 5-44)

Color bar ticks

- Option 1 (*default*):
  `Automatic`
  Color bar ticks are chosen automatically by dividing the color bar range in regular intervals.
- Option 2 (*recommended when plotting contours*):
  `Contours`
  The color bar ticks coincide with contour levels chosen with INPUT 14. All ticks are labeled, except those being too close to 0 or the lower end of the color bar range.
- Option 3 (*for explicit tick specification*):
  $f_1, f_2, f_3, ...$ or $f_1, f_2, f_3, ...\%$
  The color bar ticks are set according to a list of values in units of the imported FORC matrix, as specified in the file header, or as percent of the FORC maximum value, if the list ends with `%`. All ticks are labeled, except those being too close to 0 or the lower end of the color bar range. Ticks are labeled according to the choice of INPUT 11, regardless of whether values are entered in original units or as percent.

This option is used to optimize the color bar labeling.

Examples:

- `-2, 2, 5, 10` draws four ticks at specified values expressed in original units of the FORC matrix.
- `-2, 2, 5, 10%` draws four ticks at specified values expressed in percent of the normalization value (i.e. the maximum value of the FORC function that is covered by the color scale in its unsaturated range).

INPUT 13

(→ User manual p. 5-45)

Color bar vertical stretch

- Unique option:

  v

  The default height of the color bar drawn near the FORC diagram is stretched by a factor *v* > 0. Use *v* = 1 to keep the default color bar height, which works fine with FORC diagrams whose aspect ratio is ≥ 1. Use *v* < 1 to shorten the color bar of FORC diagrams with aspect ratios <1, such as those of central ridges.

This option is used to customize the color bar height of FORC diagrams with very different horizontal and vertical ranges (e.g. the central ridge).

Examples:

- `0.5` is used to shorten the color bar of a central ridge FORC matrix (produced by the VARIFORC function IsolateCR).

INPUT 14

(→ User manual p. 5-46)

Contour specifications

- Option 1 (*no contours*):
  `None`
  Contours are not drawn.

- Option 2 (*specified number of regularly spaced contours*):
  n
  A single positive integer $1 \le n \le 100$ specifies the number of contours to be drawn at equally spaced levels. Contours levels are chosen so, that 0 is avoided and at least one contour is drawn over significant negative contributions.

- Option 3 (*contours drawn at given levels*):
  f_1, f_2, f_3, ... or f_1, f_2, f_3, ...%
  With this option, a list f_1, f_2, f_3, …, of numbers specifies the contour levels in units of the imported FORC matrix, as specified in the file header, or as percent of the FORC maximum value, if the list ends with %. An arbitrary number ≥ 1 of contours can be entered in this way. If a single contour level is entered, this level must be specified with a non-integer number, e.g. 200.0 instead of 200, in order to avoid confusions with option 1. Contour levels exceeding the FORC range are ignored.

Option 2 gives good results with regular FORC diagrams, while option 3 is best suited for representing FORC diagrams containing high-amplitude features such as the central ridge. A strategy for choosing ideally spaced contour levels is explained in the user manual (p. 5.46).

Examples:

- `12` draws 12 contours at equally spaced levels.
- `12.0` draws a single contours at 12 $Am^2/(kg\,T^2)$, where $Am^2/(kg\,T^2)$ is the FORC matrix unit.
- `-2, 2, 5, 10` draws four contours at specified levels.

INPUT 15

(→ User manual p. 5-51)

Contour spline type

This option is ignored if INPUT 11 was set to `None`.

- Option 1 (*B-splines, recommended*):
  `BSpline, p`
  Use B-Splines of polynomial degree $p \geq 1$ for contour drawing. Small-scale contour irregularities due to measurement noise are smoothed by choosing large polynomial degrees, e.g. $p = 100$ (recommended).
- Option 2 (*Bézier*):
  `Bezier`
  Use Bézier splines with no internal knots for contour drawing. The contour degree is chosen automatically.

Option 2 is slower than option 1 and draws smoother, more inaccurate contours.

INPUT 16

(→ User manual p. 5-53)

Exclusion limit for short contours

This option is ignored if INPUT 11 was set to `None`.

- Unique option:
  f
  Contours that are shorter than a fraction $0 \leq f < 1$ of the longest contour are not drawn.

This option is used to avoid short contour loops produced by measurement noise. A suitable exclusion limit is obtained with successive PlotFORC runs, starting with $f = 0$.

Examples:

- `0` draws all contours, independently of their length.
- `0.05` avoids contours whose length is <5% of the longest contour.

INPUT 17

(→ User manual p. 5-54)

Contour style

This option is ignored if INPUT 11 was set to `None`.

- Option 1 (*contour lines*):
  `Color name`
  Enter the name of the color to be used for contour drawing. Possible colors are `black`, `gray`, `white`, `red`, `blue`, and `green`. See Tab. 5.1 of the user manual (p. 5.51) for best compatibilities with color scales.

- Option 2 (*contours marked by stepped color scale*):
  `step` or `step, blur`
  The color scale is divided in homogeneous color bands delimited by the contour levels defined with INPUT 11. The optional parameter *`blur`* is a positive number indicating the pixel radius used to blur the diagram in order to reduce the pixelated appearance in case of low-resolution data. The default value of *`blur`* is `0`.

- Option 3 (*contours marked by shadows on the color scale*):
  `shadow` or `shadow, blur` or `shadow, blur, contrast`
  Contours are highlighted by shadows on the color scale. The optional parameter *`blur`* is a positive number indicating the pixel radius used to blur the diagram in order to reduce the pixelated appearance in case of low-resolution data. The optional parameter *`contrast`* is a positive number comprised between `0` (no contrast) and `1` (maximum contrast), which controls the shadowing strength, expressed as fraction of color saturation. The default value is `0.1`.

Examples:

- `black` draws black contour lines.
- `shadow,0,0.2` draws shadows with no blur and a maximum contrast of 20% of saturation.

INPUT 18

(→ User manual p. 5-57)

Significance contour options

- Option 1 (*no significance contour*):
  `None`
  Significant regions of the FORC diagrams are not highlighted.
- Option 2 (*all significance contours*):
  `s, All`
  Special contours are drawn at a level corresponding to the significance threshold $s > 0$. The significance threshold is defined as the signal-to-noise ratio above which FORC amplitudes are significantly different from zero. Significance thresholds corresponding to confidence levels comprised between 90 and 99% are reported in Table 5.2 (p. 5.56) of the user manual. A confidence level ≥ 99% is guaranteed with $s = 3$. All contours corresponding to the chosen significance threshold are plotted.
- Option 3 (*longest significance contours only*):
  `s, n`
  Same as option 2, but only the n longest significance contours are drawn in order to avoid short contour loops entirely controlled by measurement noise. Usually, $n = 2$ for FORC diagrams containing only positive values, and $n = 3$ with significant negative values. The correct number of significance contours is obtained with successive PlotFORC runs, starting with $n = 2$.

Significance contours are thicker than regular contours and their style is controlled by INPUT 16. Significance contours correspond to relatively small signal-to-noise ratios and are therefore influenced by measurement noise. Therefore, option 3 is recommended for best results.

Examples:

- `3, 3` draws the three longest significance contours corresponding to a signal-to-noise ratio of 3.

INPUT 19

(→ User manual p. 5-60)

Significance contour color

This option is ignored if INPUT 15 was set to `None`.

- Unique option:
  `Color name`
  Enter the name of the color to be used for significance contour drawing.

Possible colors are `black`, `gray`, `white`, `red`, `blue`, and `green`. See Tab. 5.3 of the user manual (p. 5.57) for best compatibilities with color scales.

Examples:

- `green` draws green contours.

INPUT 20

(→ User manual p. 5-61)

FORC diagram export format

- Option 1:
  `None`
  The FORC diagram graphics produced with the PlotFORC notebook is not exported. Notebook graphics can be exported at any time using the Mathematica® menu.
- Option 2:
  `Graphics format`
  A FORC diagram graphics with specified graphics format is exported to the file specified when PlotFORC was launched. Possible formats are: EPS, PDF, JPEG, and GIF.

Vector formats (EPS and PDF) are recommended whenever possible.

INPUT 21

(→ User manual p. 5-62)

Vertical profile normalization

- Option 1:
  No
  The plotted FORC diagram is not normalized.
- Option 2:
  Yes
  The plotted FORC diagram is normalized by the maximum amplitude in each vertical profile.

Vertical profile normalization is used to visualize the vertical width of FORC diagrams. In this case, the vertical distance of contour lines at 0.5 to the central maximum coincide with the vertical half-width.

Notes: