Magnetic Hysteresis Measurement Procedure

Goal: Measure major and minor hysteresis loops for training hysteresis models.

Procedure Notes:

* This procedure can be applied to any type of magnetic element (dipole, quadrupole, trim/steering/corrector magnet) and any type of power supply (bi- or uni-polar power supplies). To standardize the procedure, I describe it in terms of normalized currents 0 = the minimum current (the maximum opposite polarity current in the case of a bipolar power supply) that can be safely provided to the magnet and 1 = the maximum (positive) current that can be safely provided to the magnet.
* For each trial, please measure the relevant parameter of interest for a given magnet type, ie. field amplitude for dipole/trim magnets, field gradient for quadrupoles at a single location along the beam axis and provide error estimates.
* What is described here constitutes 180 total measurements.

Trials:

Major Hysteresis Loop

* Set norm. current to 0
* Increase current to 1 in 0.1 increments and take field measurements at each step (10 samples)
* Decrease current to 0 in 0.1 increments and take field measurements at each step (10 samples)
* Increase current to 1 in 0.05 increments and take field measurements at each step (20 samples)
* Decrease current to 0 in 0.05 increments and take field measurements at each step (20 samples)

Minor hysteresis loop 1

* Set norm. Current to 0
* Increase current to 0.5
* Increase current to 0.6 in 0.01 increments and take field measurements at each step (10 samples)
* Decrease current to 0.4 in 0.01 increments and take field measurements at each step (20 samples)
* Increase current to 0.5 in 0.01 increments and take field measurements at each step (10 samples)

Minor hysteresis loop 2

* Set norm. Current to 0
* Increase current to 1.0
* Decrease current to 0.9 in 0.01 increments and take field measurements at each step (10 samples)
* Increase current to 1.0 in 0.01 increments and take field measurements at each step (10 samples)

Minor hysteresis loop 3

* Set norm. Current to 0
* Increase current to 0.5
* Decrease current to 0.4 in 0.01 increments and take field measurements at each step (10 samples)
* Increase current to 0.6 in 0.01 increments and take field measurements at each step (20 samples)
* Decrease current to 0.5 in 0.01 increments and take field measurements at each step (10 samples)

Hysteresis Trial 1

* Set norm. Current to 0
* Follow the following sequence of settings and take field measurements at each step (10 samples)
  + 0, 0.9, 0.1, 0.8, 0.2, 0.7, 0.3, 0.6, 0.4, 0.5

Hysteresis Trial 2

* Set norm. Current to 0
* Increase current to 0.5
* Follow the reverse sequence of settings in Hysteresis Trial 2 and take field measurements at each step (10 samples)