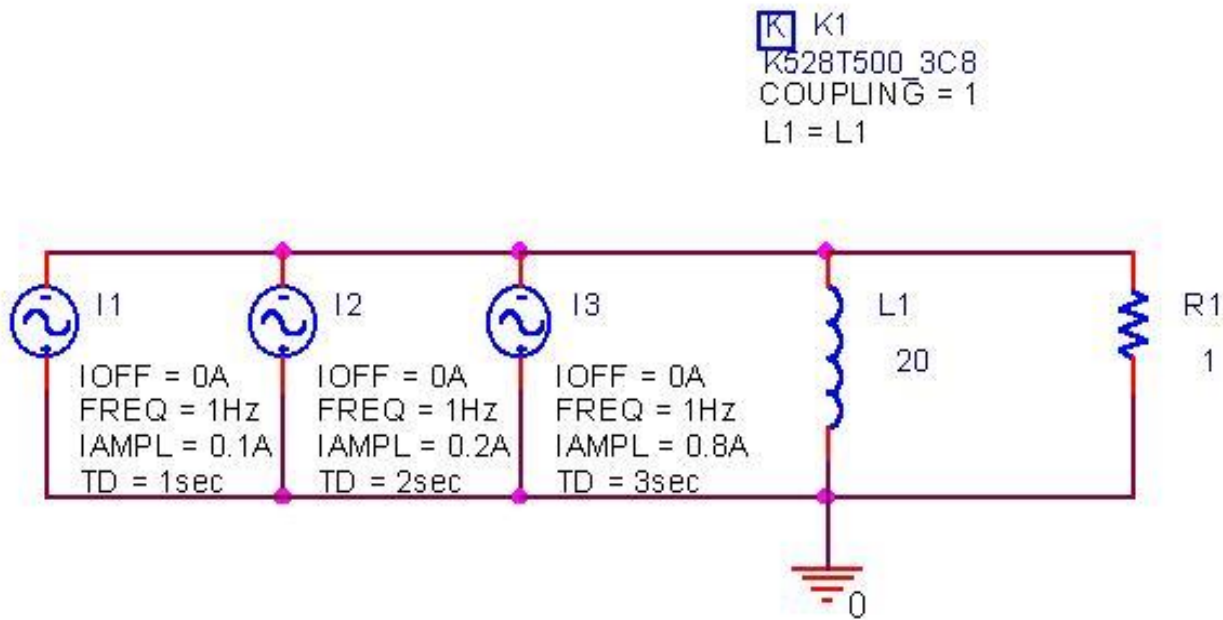


Procedure for setting a kbreak device to correct B-H curve

- 1) Set up the circuit as shown below with 3 ISIN devices in parallel with an inductor and a resistor.
 - a) Rotate the ISIN device 180° (Ctrl + R, twice),
 - b) Enter values by double clicking on IOFF, FREQ, or IAMPL box,
 - c) Enter TD by double clicking on graphic symbol, horizontally scroll to the TD field in the Properties Editor, enter the value,
 - d) Make TD visible by selecting entire TD column, right click and chose Display..., and select Name and Value from the Display Format box, save and close Property Editor.
 - e) Enter 20 for the value of L1. This is the number of turns around the coil since we are now using a kbreak device (not the inductance value). The number of turns and current values are chosen to just saturate the core.
 - f) Double click the K, and set the L1 field to the inductor L1 in the Properties Editor, and make it visible, and close Editor.
 - g) Also make COUPLING=1.



See: http://www.pspice.com/upload/appnotes/inductors_cores.doc

- 2) In PSpice/Edit Simulation Profile, chose Time Domain (Transient) from the Analysis type box of the Analysis tab,
 - a) Make Run to time to be 6s,
 - b) Make Maximum step size to be 1000u (microseconds),
 - c) In the Probe Window tab, chose during simulation for the Display Probe window.
- 3) Go to Edit/PSpice Model and enter the effective magnetic path length and the effective magnetic cross sectional area in the format shown below:
(Insert the effective magnetic path length and area as reported in your data sheets)

```
.model Kbreak CORE
+ PATH=12.90399
+ AREA=3.271756
+ GAP=0.0
+ K=0
+ MS=97772.47
+ A=1E+3
+ C=0.2
```

Remember: for the kbreak device, Path length is in cm (10mm=1cm), and cross sectional AREA is in cm² (100mm²=1 cm²). The Path length is the value for a core that would have no air gap.

The effective path length and effective cross sectional area (core parameters) can be calculated using the formulas defined by IEC Publication 205. These are approximations that should be close enough to prove a concept. Or manufactures data sheets may have these parameters listed for various core geometries.

The effective length and area have no effect on the hysteresis curve to be generated.

- 4) Make K=0 to begin with in the Model Editor for the kbreak device. This will produces a single line (no hysteresis) that runs through the orgin that would also be the average of the left and right sides of an open B-H curve that does have hysteresis.
- 5) Then set MS=Bmax/0.01257 (MS is in gauss), where Bmax is the saturation flux density (in gauss) reported in the data sheets of manufactuers. Ferrites saturate at about 3300G.(Remember 1gauss = 10⁻⁴tesla, and 1Oe = 79.5A/m)
- 6) Set the parameter A=1E+3 and C=0.2 (their default values) to begin with.

- 7) Run the simulation by clicking on the icon with the blue, right pointing arrow in the tool bar.
- 8) When the Probe Window appears, go to Trace/Add Trace, click on B(K1) in the Simulation Output Variables. This will set the vertical axis. After the trace is drawn on the screen, double click anywhere in the vertical axis area. The Axis Settings dialog box will appear. Chose the X-Axis tab, and click on the Axis Variables button at the bottom. Chose H(K1) from the Simulation Output Variables list, and click OK. Then click OK in the Axis Settings dialog box. A hysteresis curve should appear, one without any open area to begin with. This can be automated using File/Log command in PSpice.
- 9) Adjust the curve by adjusting the A parameter, a value of 15 will give a distinct "s" shape to the curve. The value of MS may have to be readjusted after adjusting the A parameter. Do a trial and correction method to get the curve to look similar to the manufactures B-H curve in their data sheets. (without the hysteresis)

You can adjust the current sources to give an amplitude required for a maximum magnetic field strength (H) from the equation:

$$I = H * \text{PATH} / (0.4 * \pi * N),$$

Where,

I is in Amperes,

H is in Oersted

PATH is in centimeters,

N is the number of turns around the core.

- 10) Adjust the K value in the Model Editor to get the desired width of the B-H curve. Make sure you have the correct values for Br (the remanence, outermost curve at H=0) and Hc (the coercivity, the outermost curve at B=0) as reported in the manufactures data sheets. You may have to readjust MS and A.
- 11) Then adjust the parameter C to get the right initial permeability. You may have to zoom in on the graphs origin to examine the initial permeability. Permeability is equal to dB/dH.

Note: The permeability of free space is, $\mu_0 = 1.257 * 10^{-6} \text{ T/(A/m)}$ in MKS units and 1G/Oe in CGS units. Thus, the value of B/H for the initial curve in (G/Oe) gives both the relative and absolute permeability of the material.

- 12) Adjust the GAP parameter to give the maximum difference between Br and Bmax without overheating the core.