Magnetic Delay Transformer, another Viewpoint.

The B v. H loop for magnetic materials is well known, it is traversed counter clockwise and its area represents an energy density, an energy *loss* per cubic meter of material. An adjustment to each axis involving the geometry yields the flux Φ v. mmf U which has the same shape, but now the area of the loop represents total energy loss, Figure 1.

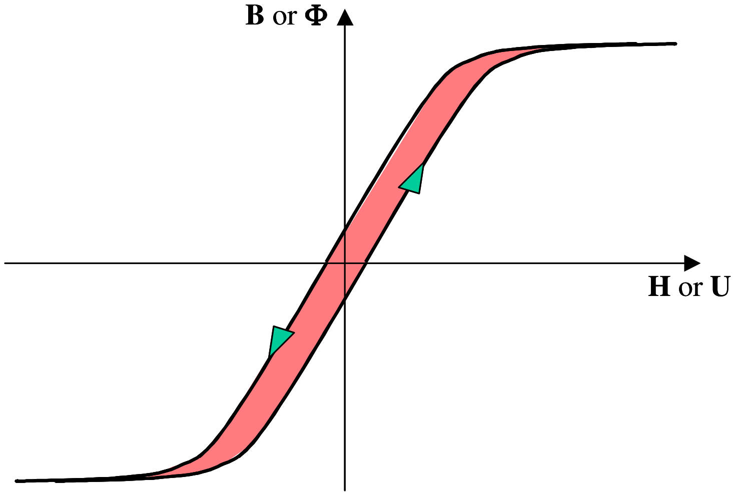

Figure 1. Typical BH or ΦU Loop

We are interested in the effects due to a finite magnetization velocity through the material associated with the motion of domain walls. If we consider an idealized low-loss permeable material it would have the straight-line ΦU curve of Figure 2. The slope of this line is the permeance (inverse reluctance $\mathcal{R}$) of the magnetic path.

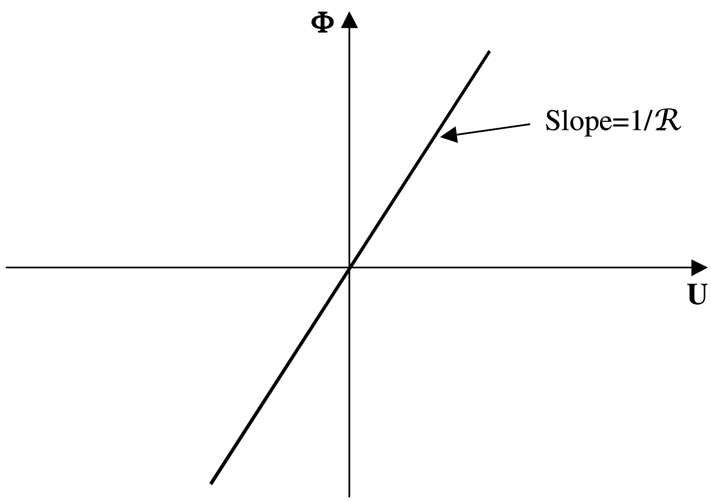

Figure 2. Idealized ΦU Curve for Low loss Material.

Considering steady state sinusoidal signals, the effect of a magnetic delay through the material is to create a phase shift between the otherwise in-phase relationship between Φ and U. This results in the ΦU characteristic becoming a Lissajous figure, an ellipse as seen in Figure 3.

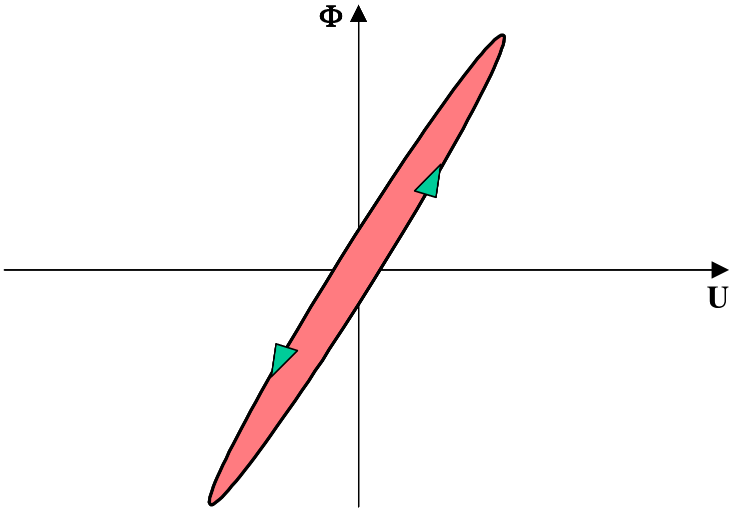

Figure 3. Effect of Magnetic Propagation Delay

The ellipse is traversed counter clockwise, which represents an energy loss. It is therefore generally assumed that domain wall movement is a lossy characteristic resulting in heat dissipation within the magnetic material. It would be interesting to know whether this assumption has been proved by calorimeter measurements.

The Φ v. U characteristic regards the magnetic circuit as a single component, much like a resistor in an electric circuit. A loaded coil around the magnetic path can also be represented as a magnetic component having its own Φ v. U curve, and of particular interest is a coil shunted with a capacitor, Figure 4.

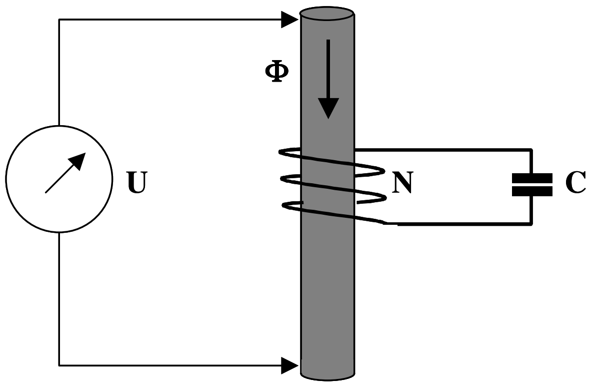

Figure 4. Capacitively loaded Coil

The induced voltage across the capacitor creates a current that is seen as an mmf U obeying $U = N^2 C \dfrac{d^2 \Phi}{dt^2}$ which for sinusoidal flux becomes $U = -\omega^2 N^2 C \Phi$. Thus the loaded coil acts like a *negative* reluctance, having the characteristic shown in Figure 5.

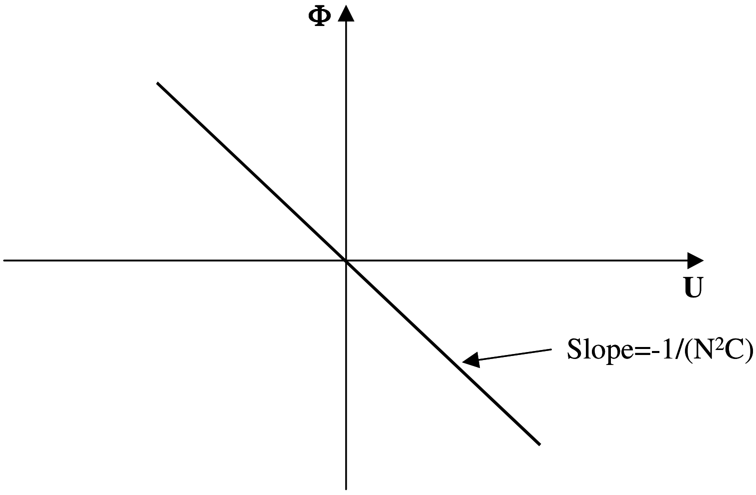

Figure 5. ΦU Curve for Capacitively loaded Coil.

Now when we introduce a magnetic delay we obtain an ellipse, but this time the loop is traversed *clockwise*, Figure 6. A clockwise orbit represents energy *gain*. This result agrees with the magnetic modeling of the MDT. It remains to be seen whether this apparent gain is real, or just a math artefact.

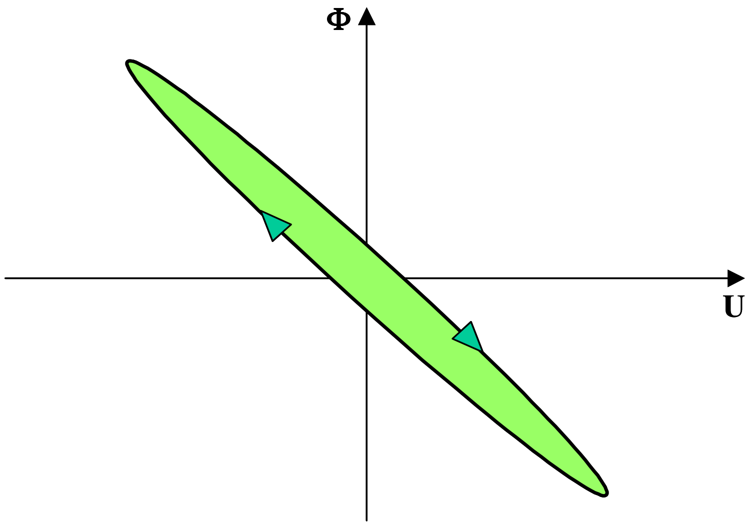

Figure 6. Curve of Figure 5 but including Magnetic Delay