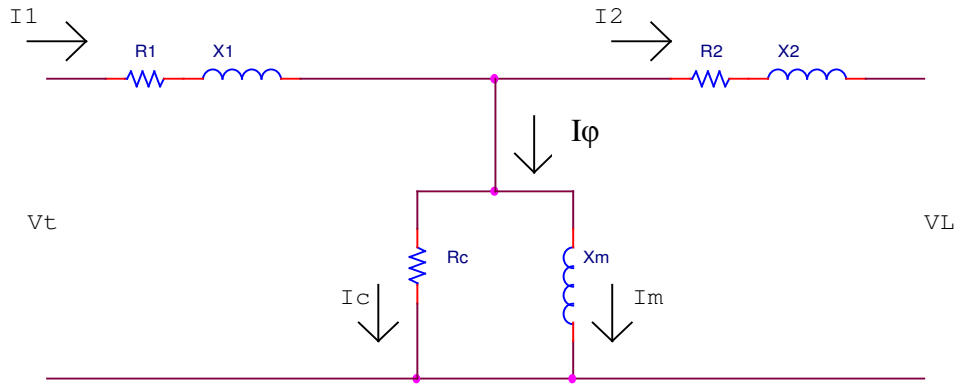
Transformer Waves -- Lab Review Sheet

Objectives:

In this lab you will explore the voltages, currents and fluxes present in a single phase transformer during operation.

Transformer Model:

Last week you looked at the transformer model and the derivation of its parameters. For this lab we will explore how voltages and current flow through the transformer while it is operating. The currents and voltages we will be looking at are shown below on the transformer equivalent circuit model.



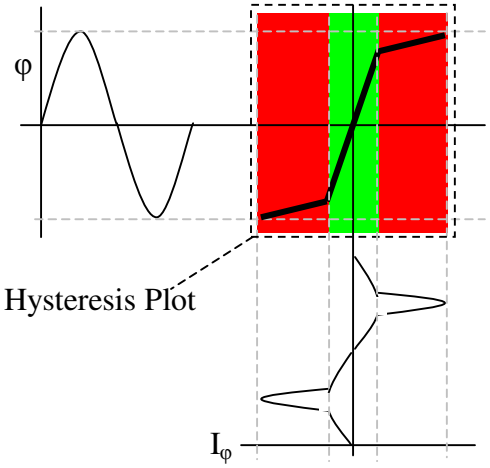
Using KCL:

$$I_1 = I_2 + I_\phi \quad \text{and} \quad I_\phi = I_C + I_m$$

I_φ in this diagram is the excitation current. This is the current required to set up the flux in the transformer's core and thus create the voltage on the secondary. It also includes the core losses of the transformer, the hysteresis and eddy current loses. For a given transformer I_φ should be relatively constant when the load is varied, this is because R_C and X_m are large compared to typical transformer loads and thus draw a small current.

Saturation and Flux:

As voltage is increased the transformer's core will enter saturation. Looking back to the magnetics lab it was observed that voltage is proportional to the time derivative of flux, because of this a higher magnitude voltage (at the same frequency) would necessarily create a larger magnitude flux. Also remember that a certain volume of iron can only handle so much flux before it saturates. Combining these two facts it can be seen that increasing the voltage across a transformer increases the flux in the core, a high enough flux in the core can cause the iron to saturate and enter the nonlinear region (the flat tails on either end) of the hysteresis curve.



This plot demonstrates the effects of saturation on the excitation current. The flux waveform shows the flux necessary to support the voltage of the transformer. In the unsaturated region the current magnitude is very low because the iron is a very good conductor of flux so a small amount of current gives a large amount of flux. Once the flux magnitude exceeds the saturation point of the iron the iron becomes a very poor magnetic conductor and a large amount of current is needed for a small flux change. This causes the large spike in current in the saturation regions.

Green = Unsaturated *Red = Saturation*