Current Transformer Lab (CTL)

You are going to look at various aspects of the current transformer:

- Rise and Droop time
- Volts per Amps
- Single windings versus multiple windings
- Common mode noise

While going through the experiments, you will write down your results with enough detail that you can later recover exactly what you have done. For example, log the following items:

- Who are your team mates?
- What instruments did you use?
- What are the instrument settings?
- How many times did you wound the wire around the toroid?
- What are you measurement results (include pictures/drawings)?

The instructions might not exactly match with the instruments you are using, if you have questions ask the instructor.

First, you will check out the instruments without the transformer. This will help you familiarize yourself with the instruments. If you are not familiar with instruments like a waveform generator and oscilloscope or digitizer, take your time getting to know the instrument.

You should have a variety of color-coded wires, connectors, and cables available to you. Pay attention to these colors as they guide you in your experiments setup.

CTL Experiment #1: Setup of equipment

First, you will get familiar with your setup, in this case, the waveform generator and the digitizer (scope). Each can often operate at different impedances and this will affect your measurement. The configuration is shown in figure 1.1.

Setup:

- Set the waveform generator to a square pulse of 10usec and an output voltage of approx. 1 Volt with a rep rate of 1 Hz.
- Set Ch1 of the scope/digitizer to a range near 5 Volts and a 20usec range
- Set the trigger system to look at Ch1 and set the trigger level such that the trace of Ch1 is synchronized.
- Connect the output of the signal generator directly to the digitizer with a short BNC cable as shown in the figure 1.1 below

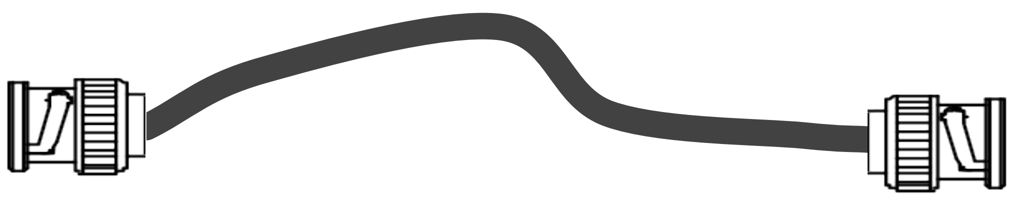

Figure 1.1 The CTL1 Configuration.

CTL1.1 Switch the digitizer impedance to 50 Ohms. Switch the impedance between 50 Ohms and 1 MOhms of the waveform generator and write down the differences. Zoom in to where the pulse changes levels to see possible differences.

CTL1.2 Switch the waveform generator impedance to 50 Ohms. Switch the impedance of the digitizer between 50 Ohms and 1 MOhms and write down the differences.

CTL1.3 Explain the differences (In case of the waveform generator impedance switch, you might not see one).

CTL1.4 Set both the waveform generator and the scope to 50Ohm impedance. Measure the rise-time of the pulse using the 10-90% method. Estimate your accuracy.

CTL Experiment #2: Rise time and Droop time

You are going to measure the rise time and droop time of your own homemade transformer. A waveform generator will simulate the beam signal. The waveform signal should be a square pulse with as small of a rise time you can make to least affect the measurement. The length of the pulse should be long enough to make the pulse droop to 10%. This means that depending on your transformer's attributes, you should adjust the pulse length. For this experiment you will make your own transformer by winding the primary and secondary windings around a core. The basic setup is sketched in the diagram below in Figure 2.1. Many of the setup values do not have to be set exact but are rather a helpful hint towards a successful setup.

Setup:

- Make two windings for the primary coil and five windings for the secondary coil.
- Set the waveform generator to a pulse of ~1 μsec, a repetition rate of ~10Hz, a 0 volt baseline with a ~4 volt peak, and ~5% duty factor. Use the resistor in series to avoid drawing too much power from the waveform generator.
- Set the Ch1 of the digitizer/scope to a range setting of ~100mV full scale and ~20 μsec horizontal range.
- Connect the secondary winding of the transformer to the Ch1 of the scope
- Set the trigger system to use Ch1 of the scope and adjust the trigger level until the scope syncs with the pulse.

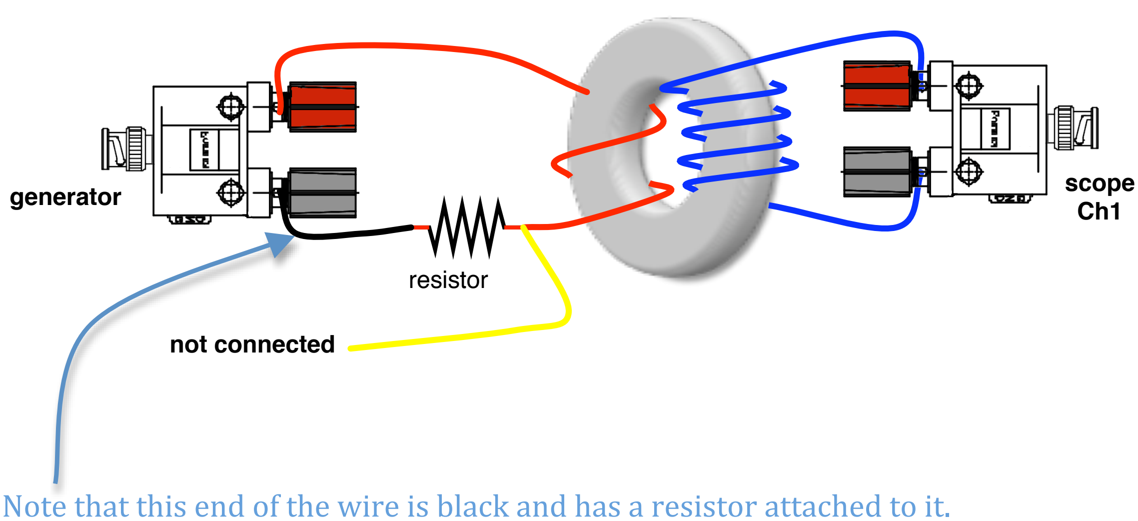

Figure 2.1 The CTL2 Configuration.

CTL2.1 There is a 50 Ohm resistor in series with the wire through the toroid. What is its purpose?

CTL2.2 Look at the signal on the scope, zoom in to the rising sloop until you can see the slope of the signal in detail. (if you slope is falling that is ok too, either reverse your polarity of the scope Ch1 hookup or continue). Measure the rise time.

CTL2.3 What formula should you use to compensate for the rise-time of the waveform generator? Apply that formula to calculate the rise-time.

CTL2.4 Measure the droop-time of the transformer. Increase the pulse length if the pulse doesn't droop far enough. Should we have measured the droop time of the waveform generator?

CTL Experiment #3: Bandwidth

You are going to measure the bandwidth of the transformer. You will use the sine wave function of the waveform generator to do this exercise. The setup is the same as in CTL2, see also figure 3.1, but you will be using a sinewave (sinusoid) signal from the waveform generator. You will vary the frequency to find the pass band and the fall off points at 3db. An example of the signal strength as a function of frequency is given in figure 3.2.

Setup:

- Set the waveform generator to generate a sinewave instead of a pulse.
- Set the waveform into a burst mode of 20 waveforms (if possible, otherwise skip step)
- Set the sinewave frequency to 1Mhz

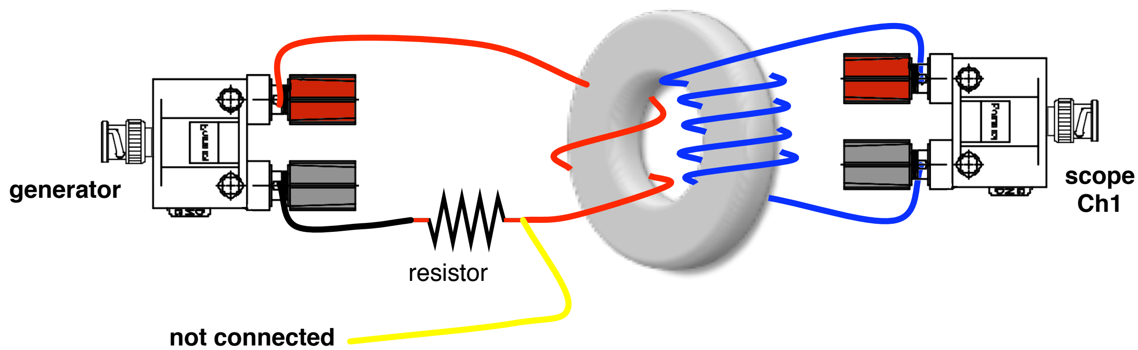

Figure 3.1. Configuration of the CTL3 experiment.

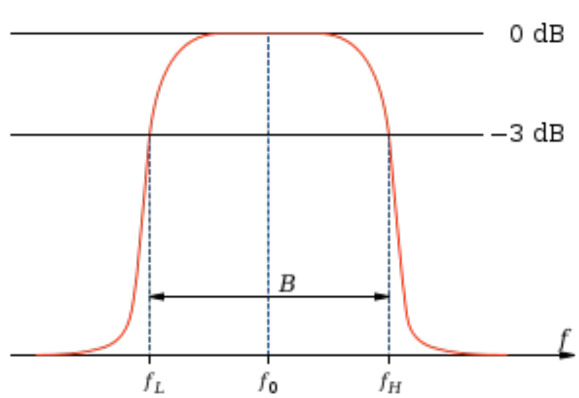

Figure 3.2. Definition of bandwidth in terms of 3dB.

CTL3.1 Measure the peak-to-peak voltage. (maximum-minimum of the sinewave)

CTL3.2 Change the sinewave frequency up and down and find the maximum peak-to-peak voltage.

CTL3.3 By what factor should you multiply the maximum peak-to-peak voltage to obtain the 3db point?

CTL3.4 Find the lower and upper 3dB points and write down these two frequencies.

CTL3.5 Compare these 3dB frequencies with the rise-times and droop-times you found in CTL2. (Convert the rise/droop times to F_L and F_H).

CTL Experiment #4: Volts per Amp

You are going to measure the volts per amp. You will use the sinewave signal once again. But the setup is slightly modified from CTL4. You will now connect the voltage over the resistor to the second channel of the scope (digitizer).

Setup:

- Set the sinewave frequency to the middle of the bandwidth $(F_H - F_L)/2$
- Hookup the second channel of the scope as shown in Figure 4.1. Pay attention to how you wired the red wire from the resistor, it is possible to ground the generator through the ground of the scope.
- Activate the second scope channel so you can see the trace, adjust the voltage range so you can see the sinewave clearly.

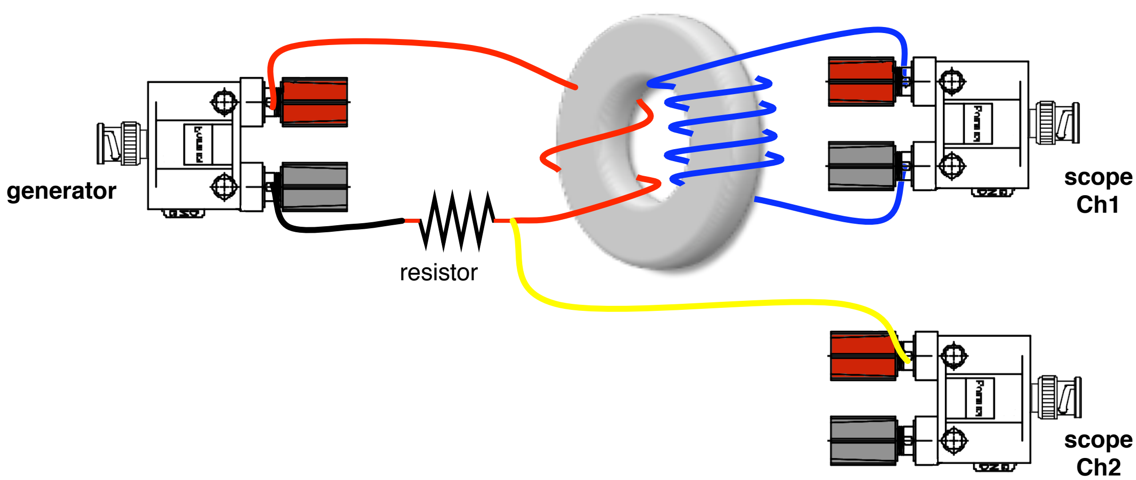

Figure 4.1. Configuration of the CTL4 experiment.

CTL4.1 Measure the peak-to-peak voltage of Ch1. What is the current going through the scope Ch1?

CTL4.2 Measure the peak-to-peak Voltage of Ch2 What is the current given that the resistor value is 49.9 Ohms?

CTL4.3 Use your previous results to calculate the Volts per Amp.

CTL4.4 Was the scope set to 50 Ohms?

CTL Experiment #5: Modify the windings

You will now look at the effect of adding a secondary winding. Use the initial setup configuration of experiment CTL3.

Setup:

- Set the sinewave frequency to the middle of the bandwidth $(F_H - F_L)/2$

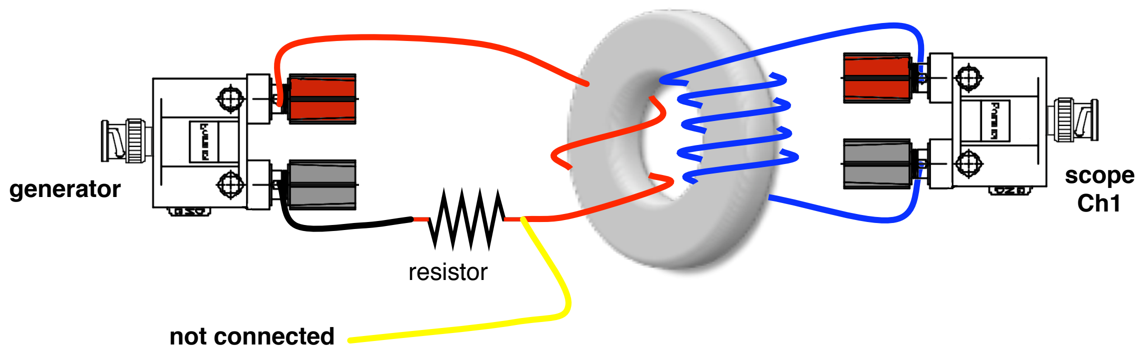

Figure 5.1 The CTL5 Configuration.

CTL5.1 Measure the peak-to-peak voltage.

- Add one turn to the secondary winding

CTL5.2 Measure the peak-to-peak voltage. Did the voltage increase or decrease? How do you explain this?

- Set the scope/digitizer impedance to 1MOhm

CTL5.3 Measure the peak-to-peak voltage.

- Remove one turn from the secondary winding

Measure the peak-to-peak voltage. Did the voltage increase or decrease? How do you explain this?

CTL Experiment #6: Measure your transformer's torus

For your homework, you will calculate the permeability of your transformer's torus material but you will need to measure the torus during the lab.

CTL6.1 Measure the physical dimensions of the torus. Write these down on a separate paper (you have to hand in your lab notes) as well as your droop or bandwidth measurements and the number of turns at which you obtained those measurements. For your homework calculate the permeability given your bandwidth or droop time constant measurement.