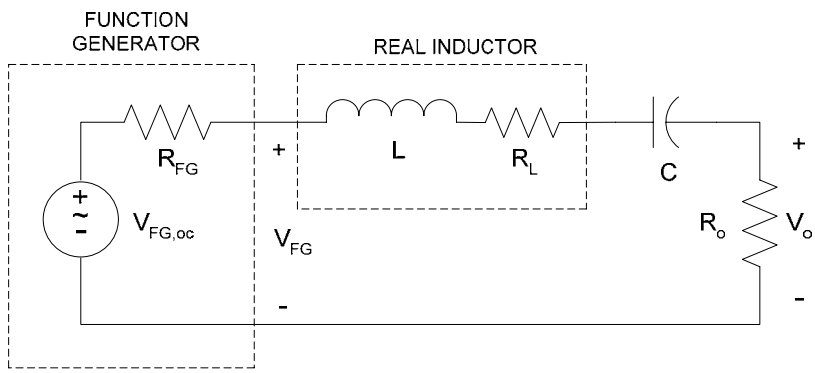
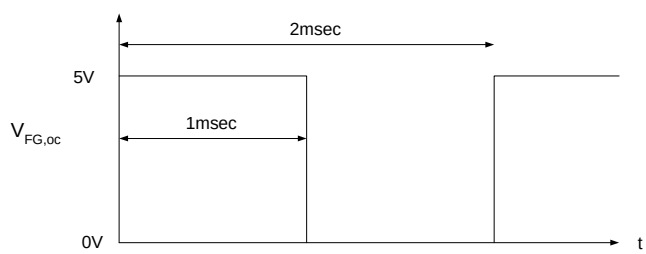
LABORATORY EXPERIMENT #3

ENGINEERING PROBLEM: Our goal is to identify unknown parameter values using step response data. You are given the following circuit setup where we will assume that we know that $R_{FG} = 50\Omega$, $L \approx 42mH$, and $R_L \approx 113\Omega$. The unknowns are C and R_o.



In order to create a step response that is periodic (so we can easily trigger on it with the scope), we will apply a square-wave with offset (like in Lab #2) whose period is long enough for the transient to subside yet not too long so the attributes of the transient are still measurable. Consider the following waveform as an adequate input



Tasks:

1. Place the circuit into the frequency domain and derive an expression for the step response $V_o(s)$ in terms of the parameters R_{FG}, L, R_L, C, and R_o assuming the step height of the input shown above.

2. Assume that you know that the response will be <u>*underdamped*</u>, complete the square in the denominator and inverse Laplace transform the result of 1. You should now have expressions for the damping factor α and the damping frequency ω_d in terms of the parameters R_{FG}, L, R_L, C, and R_o. HAVE THE INSTRUCTOR VERIFY YOUR CALCULATIONS.

3. Build the circuit on your proto-board (ensure that your function generator is set to the above waveform before applying it to your circuit). Connect the function generator output to CH1 and V_o to CH2 (trigger on CH1).

4. From the step response, estimate the oscillation period then compute the oscillation frequency in radians/sec (this is ω_d). Then estimate the time required for the transient to subside (go sufficiently close to zero). This time interval is a good approximation for $5\tau = \frac{5}{\alpha}$. From these two measurements and the result from step 2, compute estimates for C and R_o. Sketch the result. HAVE THE INSTRUCTOR VERIFY YOUR CALCULATIONS.

5. Simulate the circuit in Multisim (one period is adequate). Compare the amplitude of the first peak in the simulation with the hardware step response. Tweak the value of R_o in Multisim so that these two peak values match. Print the final circuit and output waveform.

6. Demonstrate the same circuit response in Matlab by specifying the transfer function of the above circuit (multiplied by five since Matlab automatically performs a unit step response), creating the step response, and plotting it. See the sample code below for guidance.

7. Determine a new value of C that will make the circuit response critically damped (Hint: $\omega_d = 0$). Insert this new value in the hardware circuit, create the step response, and sketch it for your report (specifically note the peak value, when it occurs, and when the transient subsides). DEMONSTRATE YOUR RESULT TO THE INSTRUCTOR.

HINTS FOR MATLAB PART

Suppose you have the transfer function $H(s) = \frac{a_2 s^2 + a_1 s + a_0}{s^3 + b_2 s^2 + b_1 s + b_0}$, the step response is determined by the following code (note, the step function is part of the control system toolbox which you do not get with the student edition)

```
>> n = [ a2  a1  a0 ];          % Assign numerator polynomial
>> d = [ 1   b2  b1  b0 ];      % Assign denominator polynomial

>> s = tf( n , d );             % Create transfer function structure

>>[ y , t ] = step(s);          % Create step response data
>> plot( t , y )                % Plot it!
```

Remember, this gives you the UNIT step response. If your step has a different height, then the numerator coefficients must be scaled by that value!