|  |  |
| --- | --- |
| Name: | **Jared Fowler** |
|  |  |
| Date: | April 20, 2018 |
| Class: | Engr M20/L – Moorpark College |
| Instructor: | Hadi Darejeh |

Lab 5: Second Order Circuits

|  |  |
| --- | --- |
| Lab Partners: | Roland Terezon  Daniel Alaya |

**Objective**

Analyze second-order circuits using standardized methods and PSPICE, and compare the theoretical results with those found in the lab experiment.

**Theory**

Note: Theories, concepts, and proofs heavily quoted from “Fundamentals of Electric Circuits” 5th edition & Wikipedia.

**Second-Order Circuits**

A circuit which is characterized by a second-order differential equation. It consists of resistors and the equivalent of two energy storage elements.

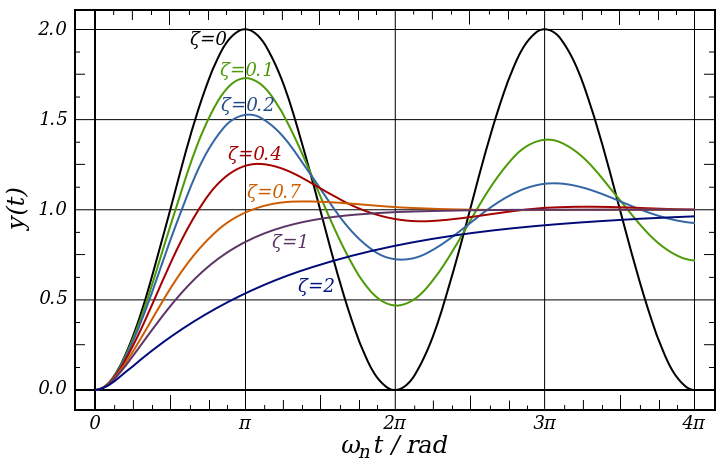
**Capacitor, C**

Device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator. The voltage across a capacitor in respect to time: , and the current in respect to time: .

**Inductor, L**

Device that stores energy in a magnetic field when electric current flows through it. An inductor typically consists of an insulated wire wound into a coil around a core. The voltage across an inductor in respect to time: , and the current in respect to time: .

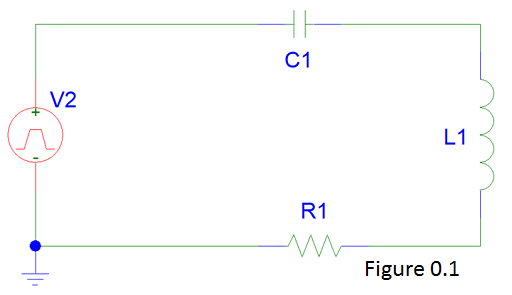
**Damping Ratio**

Dimensionless measure describing how oscillations in a system decay after a disturbance. The value is denoted by ζ (zeta, z), which can vary from undamped (z=0), underdamped (z<1), critically damped (z=1), and overdamped (z>1).

Damping is caused by the resistance in the circuit. It determines whether or not the circuit will resonate naturally (that is, without a driving source). Circuits which will resonate in this way are described as underdamped and those that will not are overdamped.

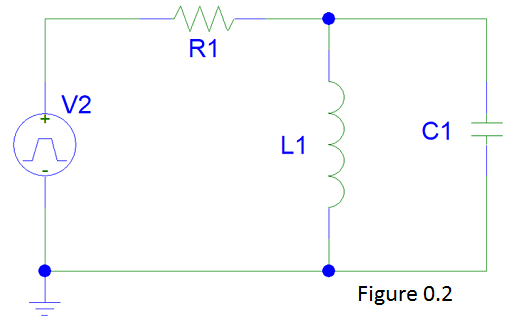
|  |  |  |
| --- | --- | --- |
|  | | |
|  |  |  |
|  |  | **EQ 0.1** “Critical Damping” |
|  |  |  |
|  |  | **EQ 0.2** “Over-Damped’ |
|  |  |  |
|  |  | **EQ 0.3** “Under-Damped” |
|  |  |  |
|  |  | **EQ 0.4** “Un-Damped” |

**Capacitor and Inductor in Series**

The circuit shown in Figure 0.1 is analyzed in this lab. In this circuit, a capacitor, inductor, and resistor are in series. A square wave pulse is used for the input voltage. The pulse’s high and low times are large enough to allow a complete charge and discharge of the system over the course of one period. The voltage across the resistor is derived below. Note that the waveform will depend upon the damping ratio as seen in EQ 1.4.

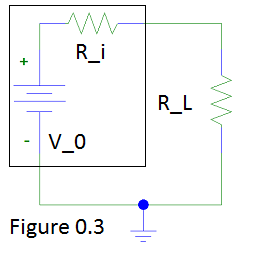
|  |  |  |
| --- | --- | --- |
|  |  | KVL |
|  |  |  |
|  |  | EQ 1.1 |
|  |  |  |
|  |  | Take Derivative. |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  | EQ 1.2 |
|  |  |  |
|  |  | EQ 1.3 |
|  |  |  |
|  |  | Because right side of ‘=’ is constant 0. |
|  |  |  |
|  |  | Differential Equations. (DE) |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  | **EQ 1.4** |
|  |  |  |
|  |  | Quadratic Equation. |
|  |  |  |
|  | | |
|  | | |
|  |  |  |
|  | | |
|  |  |  |
|  |  | Solve in terms of V across R |

**Capacitor and Inductor in Parallel**

The circuit shown in Figure 0.2 is analyzed in this lab. In this circuit, a capacitor and inductor in parallel. A square wave pulse is used for the input voltage. The pulse’s high and low times are large enough to allow a complete charge and discharge of the system over the course of one period. The voltage across the capacitor is derived below. Note that the waveform will depend upon the damping ratio as seen in EQ 2.4.

|  |  |  |
| --- | --- | --- |
|  |  | KCL |
|  |  |  |
|  |  | EQ 2.1 |
|  |  |  |
|  |  | Take Derivative. |
|  |  |  |
|  |  | EQ 2.2 |
|  |  |  |
|  |  | EQ 2.3 |
|  |  |  |
|  |  | Because right side of ‘=’ is constant 0. |
|  |  |  |
|  |  | Differential Equations. (DE) |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  | **EQ 2.4** |
|  |  |  |
|  |  | Quadratic Equation. |
|  |  |  |
|  | | |
|  | | |
|  |  |  |
|  | | |
|  |  |  |
|  |  | Solve in terms of V across L |

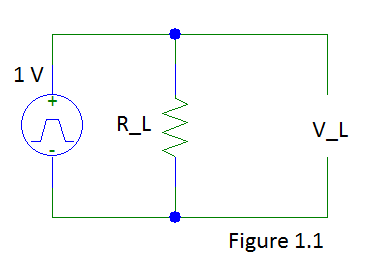
**Internal Resistance of Power Supply (Square Wave Generator)**

The square wave generator used in Figures 0.1 and 0.2 has an internal resistance. This resistance can be found by sampling the voltage across the generator when no load is present, and then again when a load is present. It’s easiest to picture the internal resistance as a resistor in series with the voltage source, which Figure 0.3 illustrates. This is mere voltage division, where V0 is the voltage with no load, and VL is the voltage across the added load, RL. The internal resistance, Ri, is derived below.

|  |  |  |
| --- | --- | --- |
|  |  | Voltage Division |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  | **EQ 3.1** |

**Procedure**

**Part 1:**

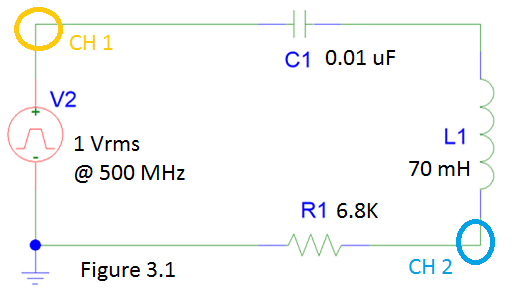
The internal resistance of the square wave generator was determined. The circuit, as seen in Figure 1.1, was constructed. The voltage across the voltage source was first measured without any load resistor, R\_L. Five additional voltage readings were taken with the load resistor connected, each time the load resistor being changed to a different value. The results can be seen in the table below.

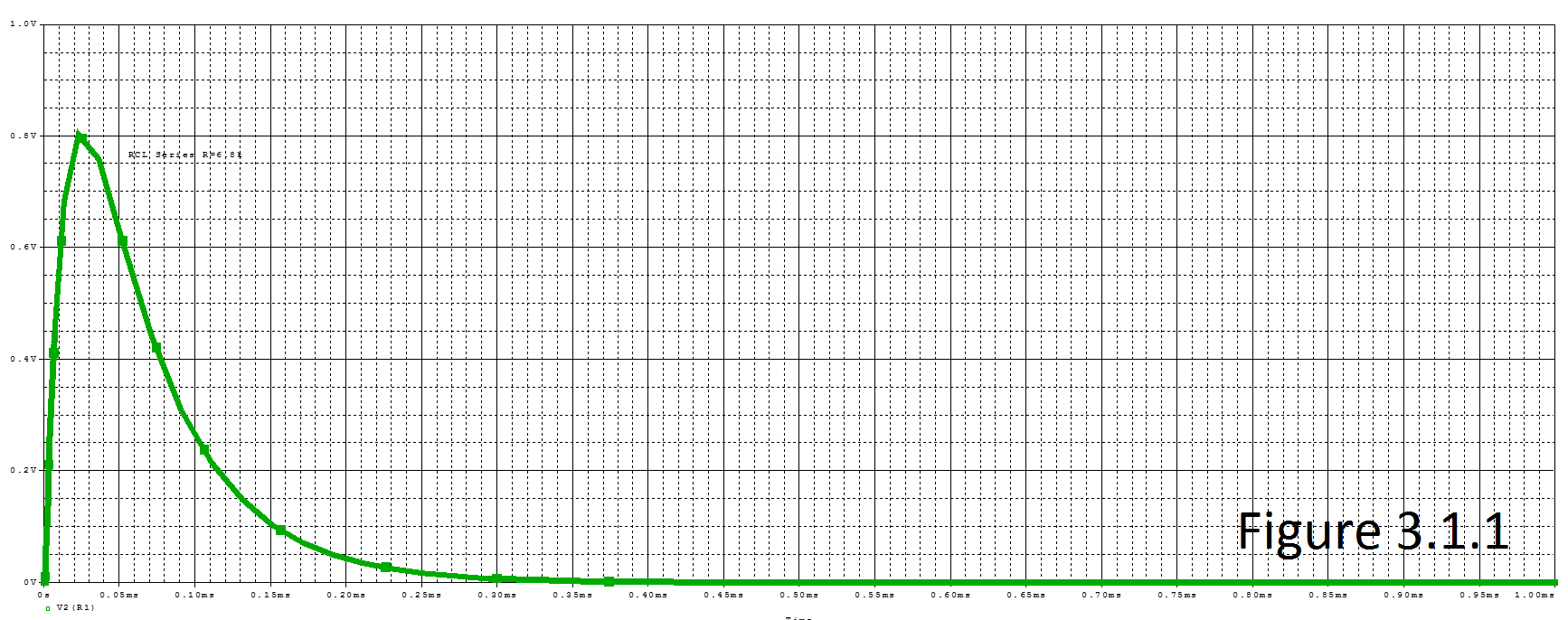
The internal resistance was found experimentally to be 50.25 Ohms. The square wave generator voltage source claims to have an internal resistance of 50 Ohms. The experimental and actual internal resistances differ by 0.5%.

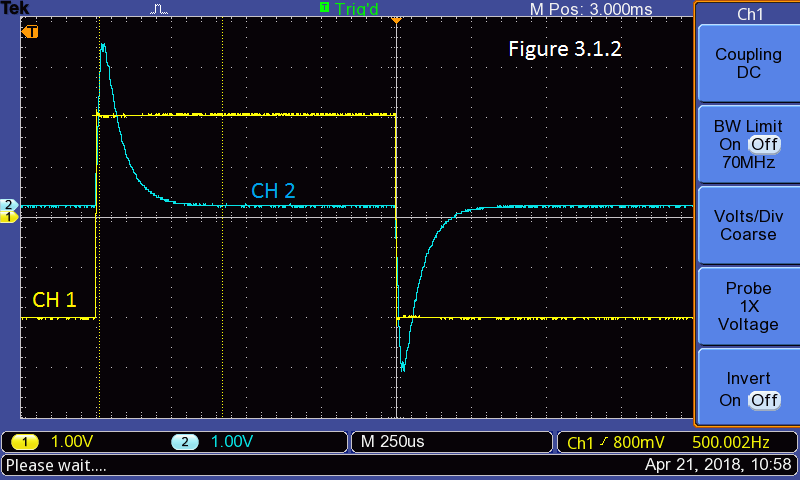
|  |  |  |  |
| --- | --- | --- | --- |
| **Vin** | **Resistance (R)** | **Vout** | **Internal Resistance (Ri) – See (Calculation 1.1)** |
| 1 VRMS | OPEN | 2.01 | - |
| 1 VRMS | 300 | 1.72 | 50.58 |
| 1 VRMS | 200 | 1.60 | 51.25 |
| 1 VRMS | 100 | 1.34 | 50.00 |
| 1 VRMS | 50 | 1.00 | 50.50 |
| 1 VRMS | 25 | 0.68 | 48.90 |
|  |  |  |  |
| **Average:** | | | 50.25 |
| **(Theoretical Value: 50 Ohms) -> % Error:** | | | 0.5% - See (Calculation 1.2) |

**Part 2:**

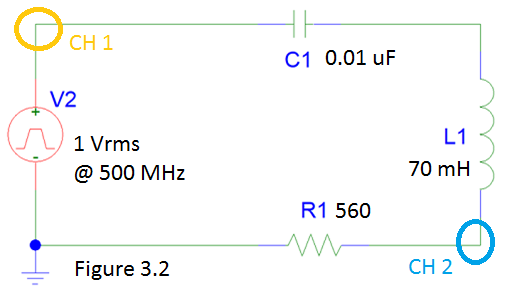
**Part 3a:**

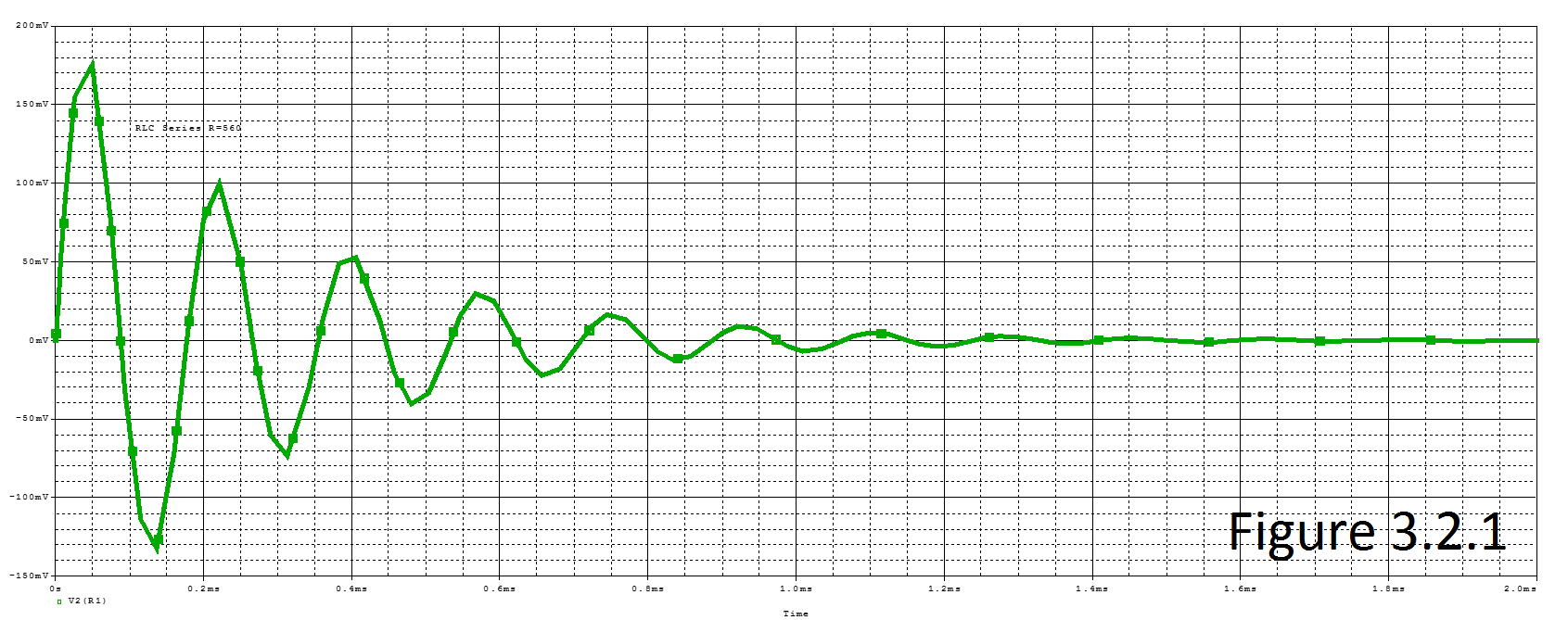
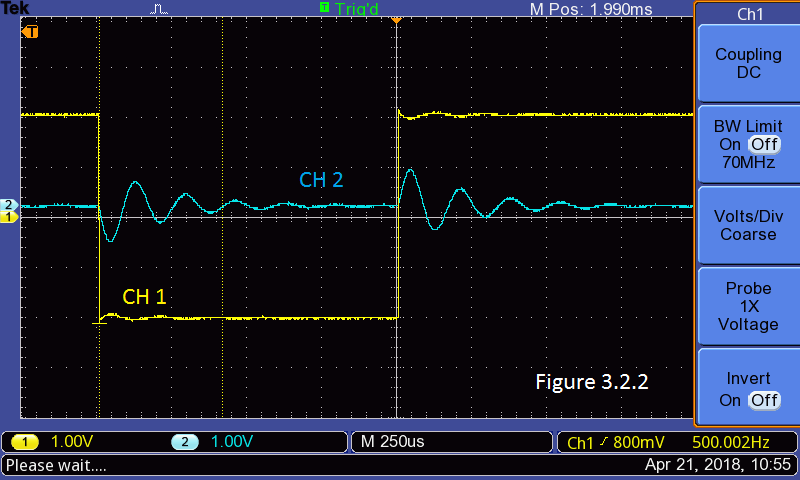
****

****

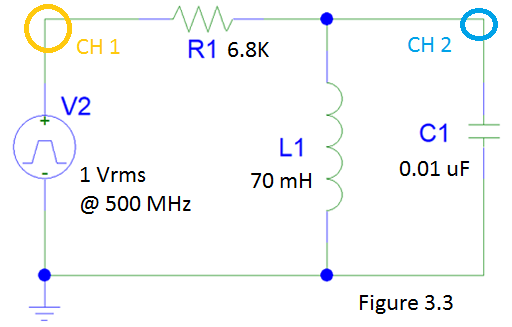
****

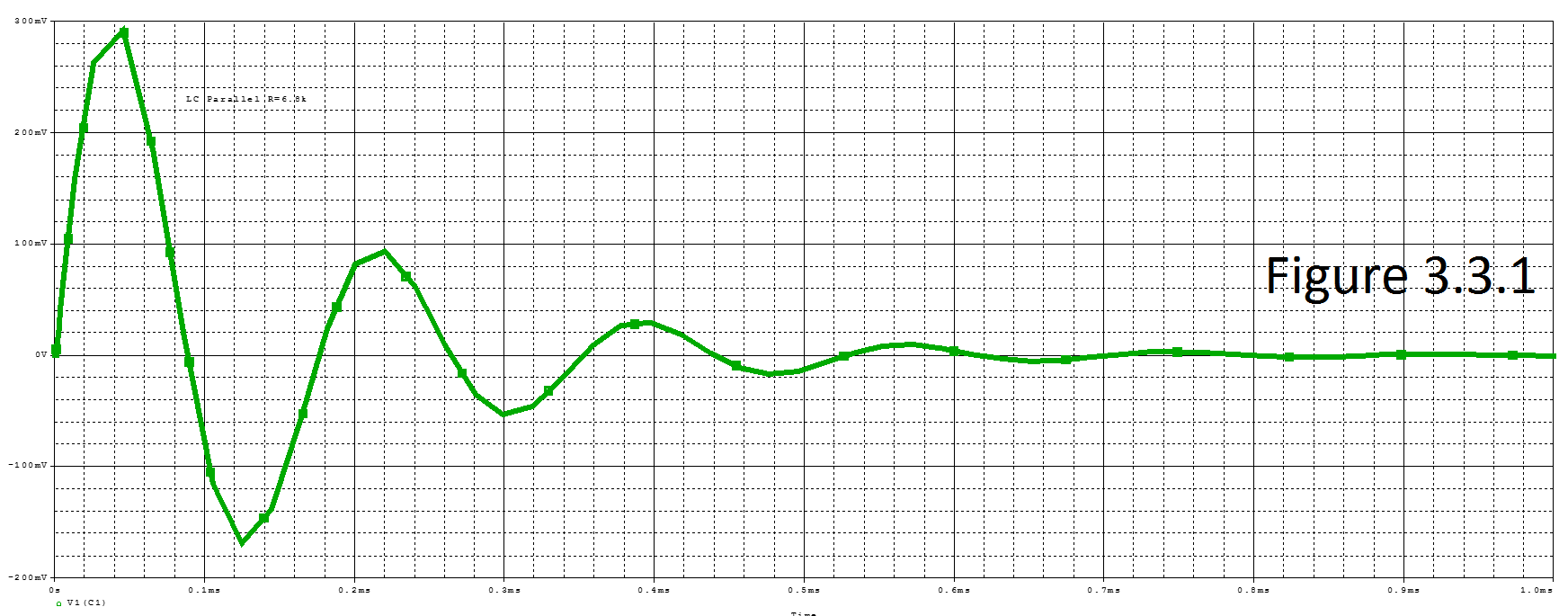
**Part 3b:**

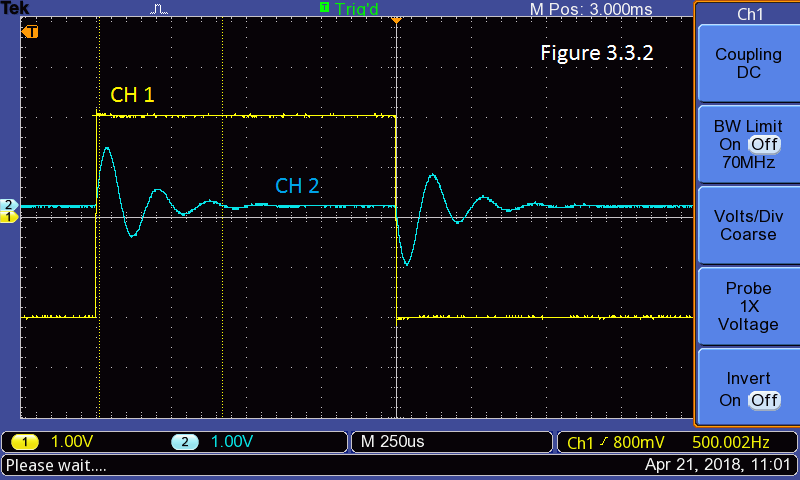
****

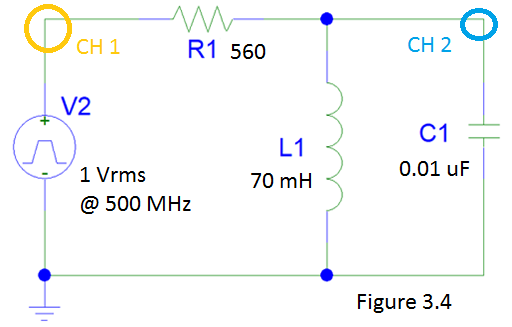
****

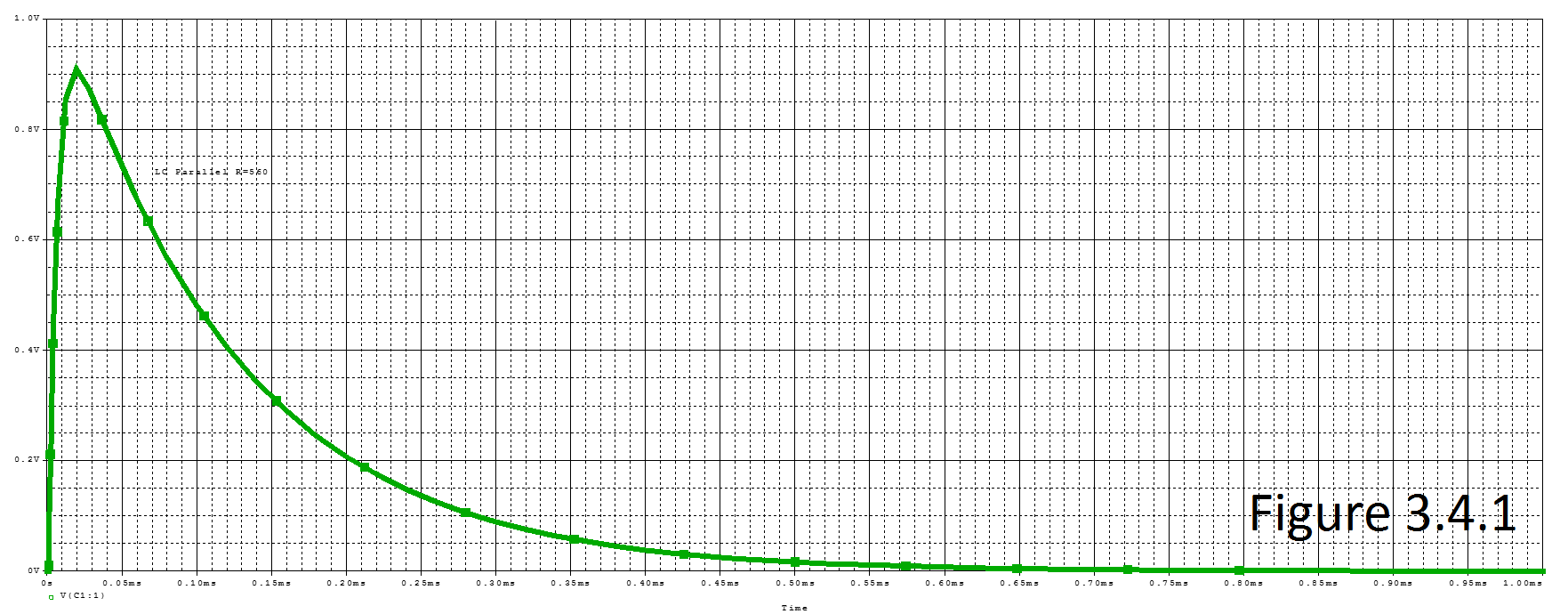
**Part 3c:**

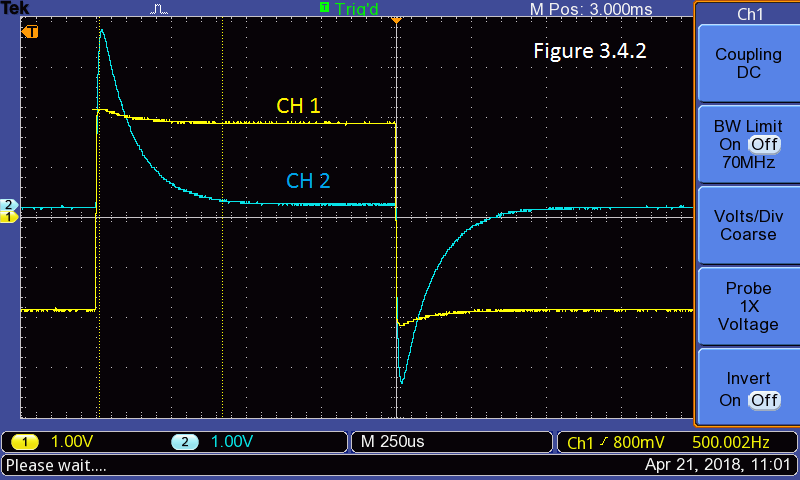
****

****

****

**Part 3d:**

****

****

**Data & Calculations**

**Calculation 1.1**

|  |  |  |
| --- | --- | --- |
|  |  | Use EQ 3.1 |
|  |  |  |
|  |  | Plug in known values. |
|  |  |  |
|  |  | Solve for each scenario…  **Example: Load resistor is 300 Ohms** |
|  |  |  |
|  |  |  |

**Calculation 1.2**

|  |  |  |
| --- | --- | --- |
|  |  | Definition of % error. |
|  |  |  |
|  |  | Plug in actual resistance and averaged experimental resistance. |
|  |  |  |
|  |  | Solve |

**Discussion of Results**

**Part 1:**

**Appendix**

