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1-Introduction

The purpose of this lab is to investigate the characteristics of a basic RLC circuit by observing its response to square wave and sinusoidal wave inputs, focusing on the behavior of the capacitor voltage. 1.327

The following circuit and the signals are given,

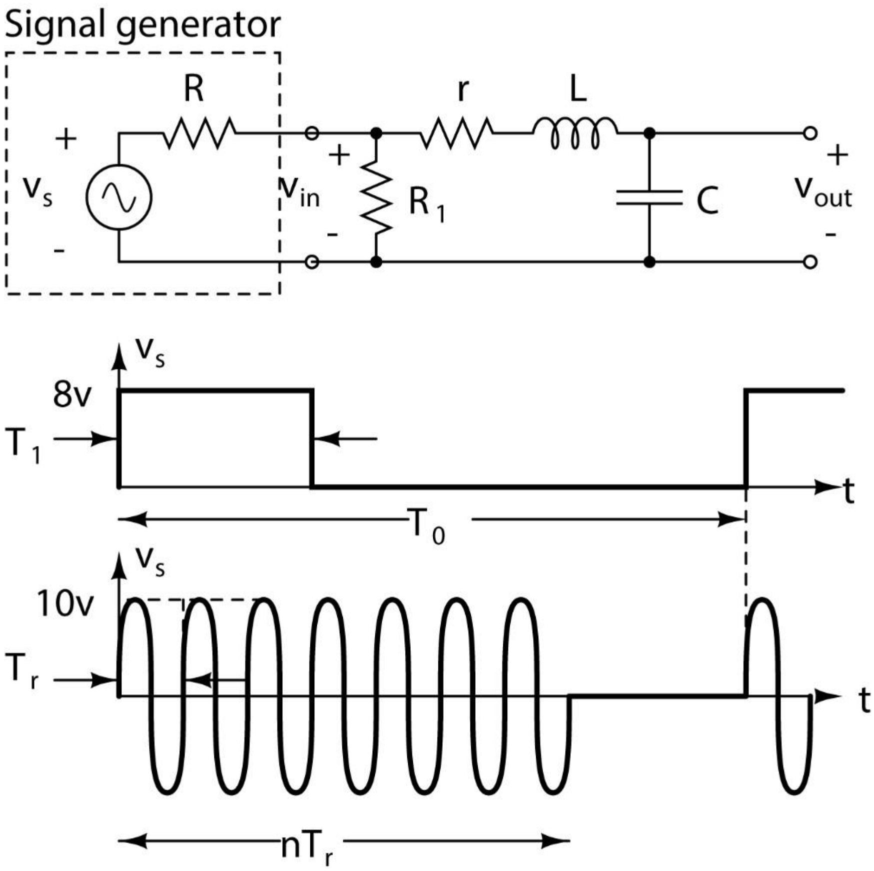

Figure.1: Given Elements

Values:

$R = 50\ \Omega$

$R_1 = 1.5\ \Omega$

$L\ =\ 100\mu H\ (There\ is\ no\ 150uH\ inductor\ in\ the\ lab)$

$r\ =\ 0.1\ \Omega$

$C\ =\ 1.5\ nF$

2. Analysis

Resonant Frequency:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

It's derived from the equality of X_L and X_C values.

$$f_r \cong 410936\ Hz$$

Quality Factor:

$$Q = \frac{\omega_r L}{R_{total}}$$

$$Q = \frac{2\pi \times 410936 \times 100\mu H}{1.556} \cong 165.937$$

A- Step Function Response

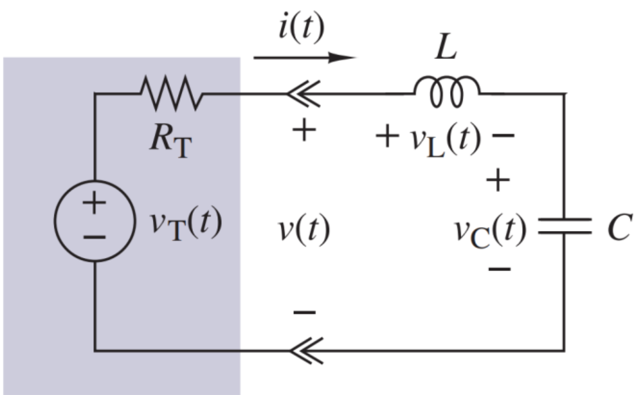

Figure.2: Simplified version of the circuit, from EE-202 Textbook

Applying KVL around the loop,

$$LC\frac{d^2 v_C(t)}{dt^2} + R_T C\frac{dv_C(t)}{dt} + v_C(t) = v_T(t)$$

$$v_L(t) \quad + \quad v_R(t) \quad + v_C(t) = v_T(t)$$

Figure.3: KVL equation of the simplified circuit, from EE-202 Textbook

The methodology of the response will be setup by using KVL. This is the differential equation and the solution of this made by the MATLAB.

```
L_val = 10e-6;
R_val = 1.56;
C_val = 1.5e-9;
V_source = 0.212;
part_value = V_source / L_val;

alpha = R_val / L_val; % Coefficient of y'
beta = 1 / (L_val * C_val); % Coefficient of y
y_steady = part_value / beta; % Steady-state solution
real_root = -alpha / 2; % Real part of roots
angular_freq = sqrt(4 * beta - alpha^2) / 2; % Angular frequency
A1 = -y_steady; % From y(0) = 0
A2 = -(real_root * A1) / angular_freq; % From y'(0) = 0

tau = 1 / abs(real_root); % Time constant
t = linspace(0, 5 * tau, 1000);

% Calculate y(t) using the general solution
y_solution = exp(real_root * t) .* (A1 * cos(angular_freq * t) + A2 * sin(angular_freq * t)) + y_steady;

% Calculate the voltage across the capacitor V(t)
V_cap = y_solution / C_val;

% Plot results
figure;
plot(t, V_cap, 'g', 'LineWidth', 1.5); hold on;
plot(t, (y_steady / C_val) * ones(size(t)), '--m', 'LineWidth', 1.5);
title('Voltage Across Capacitor V_c(t)');
xlabel('Time (seconds)');
ylabel('Voltage V_c(t) (Volts)');
grid on;
```

Figure.4: MATLAB simulation code

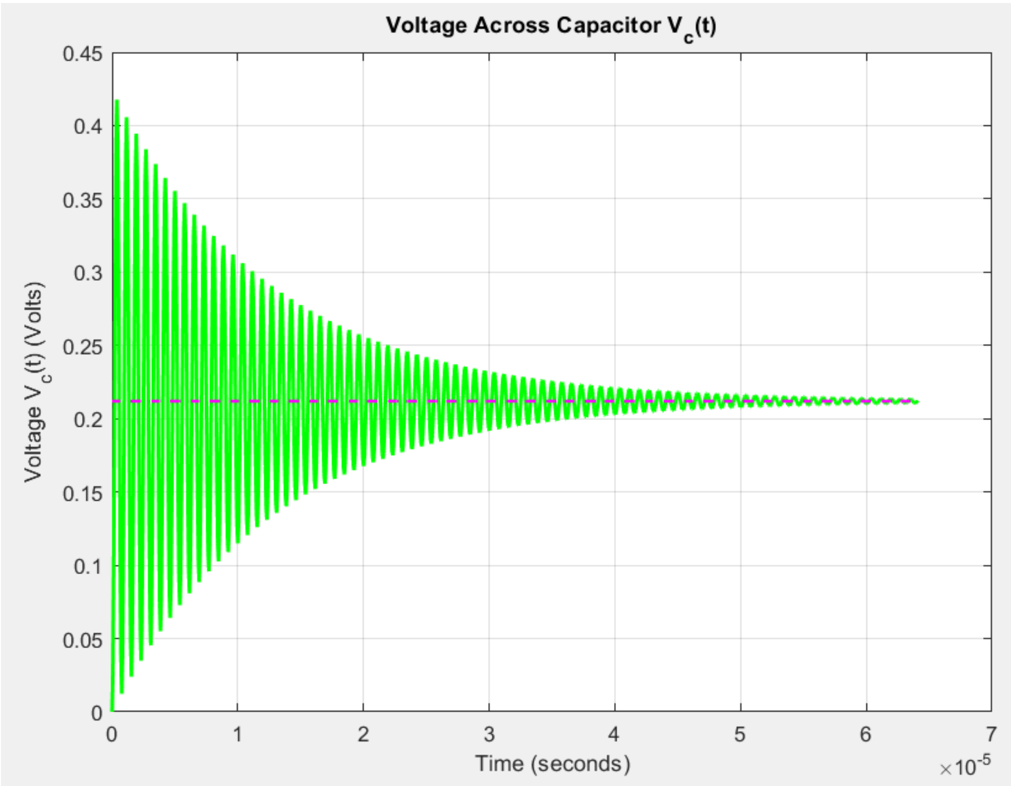

Figure.5: MATLAB plot

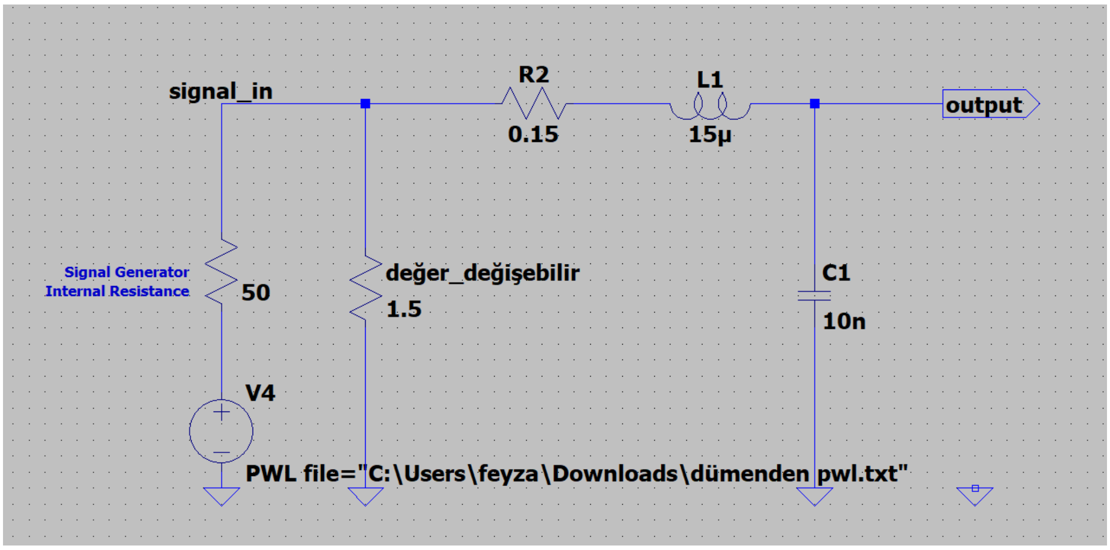

Figure.6: LTspice schematic of the circuit

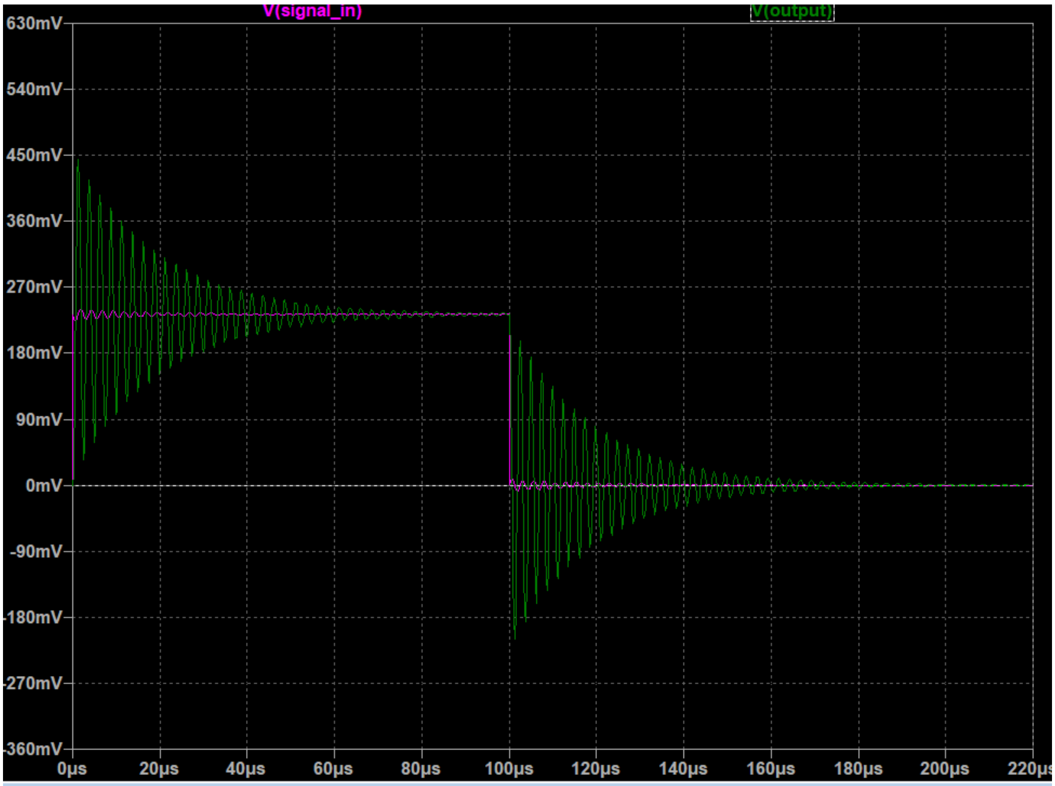

Figure.7: Step Function Response of the Capacitor, LTspice simulation

B- Sinusoidal Wave Response

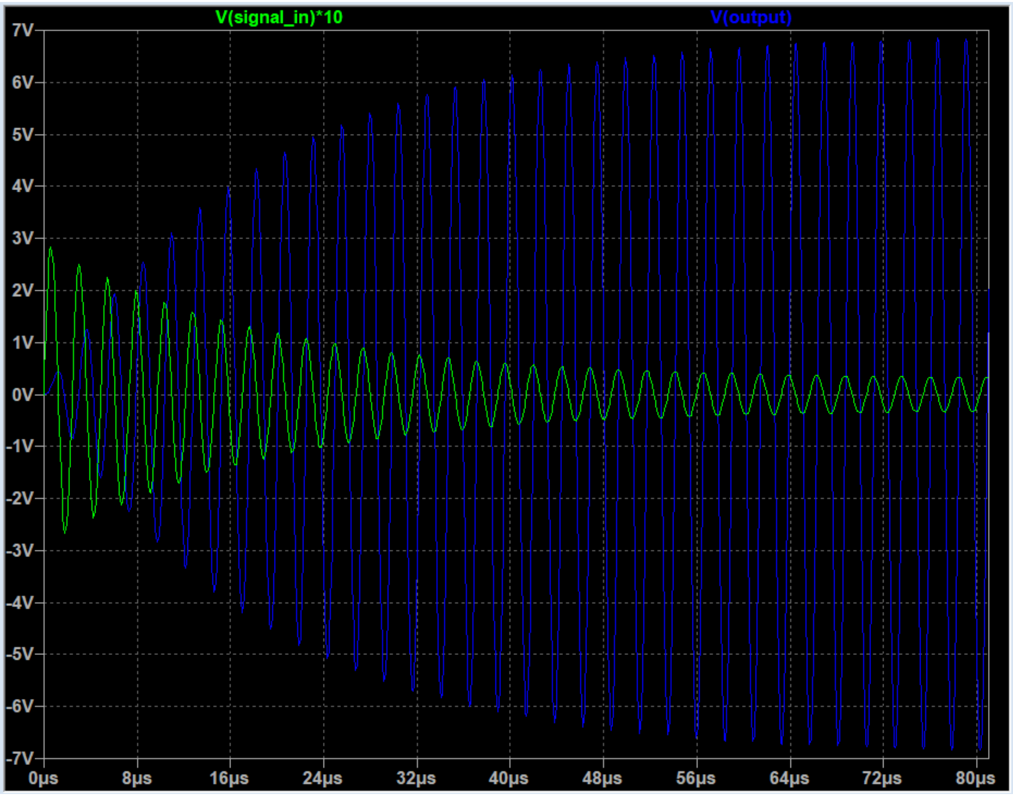

Figure.8: Sinusoidal Wave Response of the Capacitor, LTspice simulation

3. Conclusion

This preliminary study explored the behavior of RLC circuits at resonance, focusing on the interplay of inductance (L) and capacitance (C). The circuit's response to an 8V step function and a 10V sinusoidal input was examined and simulated. Needed outputs of the circuit plotted in MATLAB and simulated in LTspice. Additionally, the steady-state response of the circuit was observed, revealing that the capacitor voltage generally stabilizes over time.