GIET UNIVERSITY JOURNAL, 2025, VOL. 5, NO. 1, PP. 68-74
Manuscript received 20th January, 2025; revised 20th May, 2025; Accepted 18th June, 2025

ISSN: 2583-5955

Simulation of RC Parallel Circuit using Proteus Software

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Abstract: This study investigates how frequency affects a light-emitting diode (LED) connected in series with an RC parallel circuit, comprising a resistor (R) and capacitor (C). By applying alternating current (AC) at varying frequencies, we analyze the resulting waveform changes across the LED and their influence on luminous output. Our findings indicate that lower frequencies produce a more stable light output, while higher frequencies lead to increased waveform distortion and reduced average current. The capacitor's charging and discharging behavior alters the LED's response time, affecting brightness and color perception, and can even cause the LED to turn off. Additionally, the RC time constant plays a vital role in shaping the waveform and influencing the LED's efficiency. This research highlights the importance of understanding frequency interactions in LED applications, particularly for dimming control and signal modulation, suggesting that optimizing RC parameters can enhance LED performance in lighting and display systems.

Keywords— Light emitting diode, Resistor, Capacitor, Alternating current.

1. Introduction: The simulation of RC parallel circuit using proteus and the change in frequency across the led and application of circuit. An RC parallel circuit is typically used for filtering, timing, and signal shaping applications. In such a circuit, the resistor (R) and capacitor (C) are connected in parallel, allowing the circuit to manage how quickly it responds to changes in input signals. This configuration can effectively filter out certain frequencies, allowing for smooth voltage levels or timing delays in various electronic circuits.

RC parallel circuit can be used in a wide area it can be used as

1. Filtering
2. Timing Applications
3. Signal Shaping
4. Oscillation

An RC parallel circuit with an LED can be used for various applications, such as timing circuits or signal processing. In this setup, the resistor (R) limits the current flowing through the LED, ensuring it operates within its safe parameters. Additionally, the capacitor (C) charges and discharges, which can create a delay in the LED's illumination or regulate the brightness depending on the design. This configuration can work in flashing circuits, dimming applications, or for creating a specific response time in reactive circuits. The frequency response of a parallel RC circuit exhibits a characteristic behaviour where the impedance changes with frequency. At low

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frequencies, the behaviour is dominated by the capacitor, which acts as an open circuit, leading to a higher impedance. As the frequency increases, the capacitor charges and discharges more rapidly, allowing more current to pass through, which decreases the impedance of the circuit. The output voltage across the capacitor decreases as frequency increases, leading to a -20 dB/decade roll-off at high frequencies after reaching the cut-off frequency. This is a typical low-pass filter behaviour. In a parallel RC circuit, the current through the capacitor leads the voltage by 90 degrees, while the current through the resistor is in phase with the voltage. The total current in the circuit is the vector sum of these two currents, resulting in an overall current that leads the voltage by an angle that depends on the values of the resistor and capacitor.

2.Literature Review: RC circuits are fundamental components in electronics, used in various applications such as filters, timers, and signal processing. The collected data were analysed to determine the time constant and to plot voltage versus time graphs for both charging and discharging phases. The results demonstrated a clear exponential rise in voltage during the charging phase and an exponential decay during the discharging phase by M. S. Lima et al. [1]. This research introduces a better criterion for determining the discharging time in RC circuits, enhancing the accuracy of measurements and the understanding of circuit behaviour. The proposed method offers significant improvements over traditional approaches, making it a valuable tool for engineers and researchers working with RC circuits. Future studies may focus on applying this criterion to a broader range of electronic components and systems by J. G. King and A. P. French et al. [2]. The findings reveal a direct relationship between the time constant and the frequency response of RC circuits. Specifically, as the time constant increases, the cutoff frequency decreases, indicating that circuits with slower response times correspond to lower frequencies. This relationship was consistently observed across different circuit configurations. The paper highlights how this understanding can aid in the selection of components for specific applications, such as in filter design and signal processing by A. A. Moya, Universidad de Jaén et al. [3]. An innovative switched-capacitor circuit-based digitizer that enhances the interfacing of parallel R-C sensors. By improving sampling speed and energy efficiency, the proposed solution paves the way for more effective data acquisition systems in a variety of applications. Future investigations may focus on refining the design for broader sensor compatibility and exploring additional optimization techniques by Vijayakumar Sreenath, Boby George et al. [4]. This refers to the development and growth of wireless technology and applications based on RC circuit and design of circuits. Results from simulations or experiments are probably presented to demonstrate the effectiveness of the proposed RC filter designs in real-world WPT applications by Constantinos Psomas, Ioanni Krikidis; et al. [5].

3. Figures, Tables and Equations: In figure 1 this circuit diagram appears to represent a simple electronic setup involving an oscillator, a capacitor, a resistor, and an LED indicator. This circuit is essentially used to create a visual feedback loop—where the oscillation can be viewed through the LED, indicating the operational state of the circuit. This setup is common in basic electronics

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experiments to observe the effects of oscillation and filtering in a simple circuit. In figure 2 The image depicts a digital oscilloscope interface in an electronic simulation software, likely used for analyzing waveforms in a circuit. In figure 3 the digital oscilloscope is commonly utilized in electrical engineering labs and simulations to observe and analyze waveforms from diverse electronic circuits. It's an essential tool for troubleshooting, designing, and understanding AC and DC signals in various applications. This shows the variation in wave form and the lagging of wave form.

3.1 Figures:

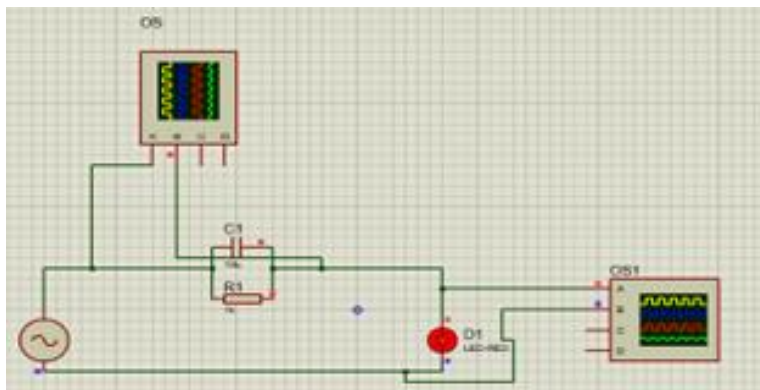

Figure 1: Circuit Diagram Made Using Proteus

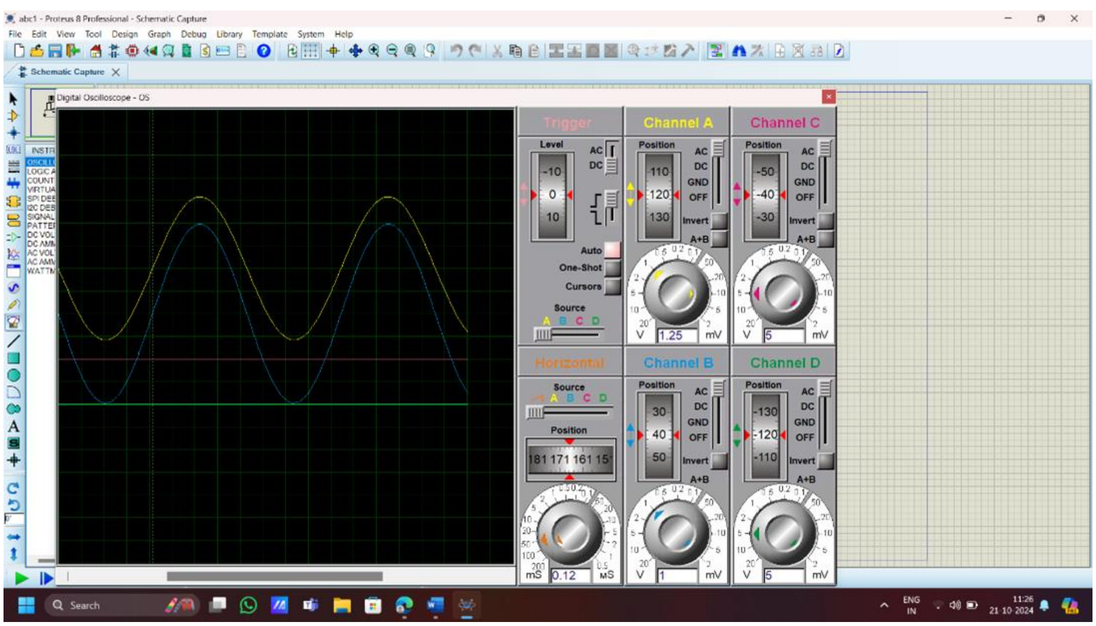

Figure 2: Oscilloscope showing AC frequency across RC

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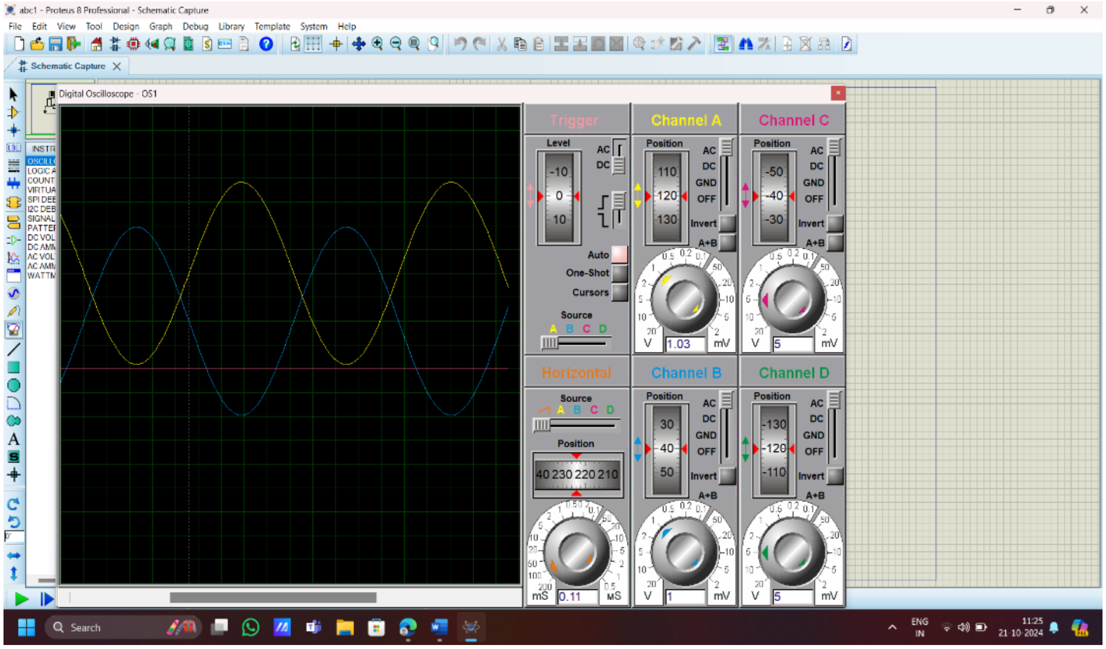

Figure 3: Oscilloscope showing AC frequency across LED

3.2. Equation: An RC parallel circuit (also known as an RC filter or RC network) is an electrical circuit consisting of a resistor R and a capacitor C connected in parallel, driven by a voltage source or current source. There are two strategies for calculating the total current and total impedance. First, we could calculate total impedance from the individual impedances in parallel (Z Total = 1/ (1/Z R + 1/Z L + 1/Z C), and then calculate total current by dividing source voltage by total impedance (I=E/Z).

$$|z| = \frac{1}{\sqrt{w^2C^2 + \frac{1}{R^2}}} \tag{1}$$

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Table 1: Table for Comparison of parameters

10 V Amplitude			
Frequency (Hz)	LED status (ON/OFF)	Capacitance for frequency (10 Hz)	Capacitance for frequency (1 Hz)
1	ON	0.1 uF =>OFF	0.1 uF=>LED BLINKING
10	OFF	0.01 uF=>OFF	0.01 uF=>LED BLINKING
20	OFF	0.001 uF=>OFF	0.001 uF=>LED BLIKING
40	OFF	1 mF=>OFF	1 mF=>LED BLINKING
50	OFF	0.1 mF=>OFF	0.1 mf=>LED BLINKING
60	OFF	0.01 mF=>OFF	0.01 mF=>LED CONTINIOUSLY BLINKING
70	OFF	0.001 mF=>SLIGHT BLINK	0.001 mF=>LED CONTINOUSLY BLINKING

4.Methodology: The RC circuit is designed using Proteus, a software that helps us to design and test circuits. We first load the components used to make the circuit into the software, and using those components, we design the circuit and bring it to working condition. We connect the AC source to the parallel combination of a resistor and capacitor and connect an LED in series with the parallel combination of the resistor and capacitor (C). Then, we connect two digital oscilloscopes—one across the parallel combination of the resistor and capacitor and the other across the LED. After the circuit is completed, we test it with multiple sets of values to check whether the LED is switching on or off. First, we set the frequency to 1 Hz and the amplitude to 8 V and check the LED status. Next, we change the value of capacitance and check whether the LED is working or not. We simulate the circuit using different values of capacitance and check whether the LED is glowing from table 1. Then, we change the frequency value and check again for different values of capacitance. We repeat this process multiple times with different values of frequency and capacitance, checking for the LED switching on or off. Initially, we check the LED status by keeping the frequency at 1 Hz and observing the blinking or switching on of the diode. Then, we set the voltage at a constant 10 volts and check whether the LED is blinking. The LED blinks and shows a red light. We then take different values of frequency and check the status of the LED. First, we change the frequency from 1 Hz to 10 Hz and continue the process to check the status of the LED up to 20,000 Hz. After reviewing the data, we select 1 Hz and 10 Hz as both points act as threshold points for the LED to switch on or off from table 1. Next, we change the capacitance value by reducing it and check the LED status to see if it is on or off. We also increase the capacitance value and check the status of the LED. We repeat the above process until the LED blinks. Finally, we enter the data into a table and check the waveform of the signal, varying the amplitude to achieve a proper variation in frequency response waveform.

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5. Result Analysis: In the experiment, when we increase the frequency, the LED goes into off mode, and with a decrease in capacitance, it starts glowing again. At a frequency of 10 Hz, the LED consistently turns off at higher capacitance values. However, if we slightly vary and reduce the capacitance to nearly 0.001 µF, the LED blinks slightly. We then set the frequency to 1 Hz and test each value of capacitance. The LED blinks continuously for very low capacitance values, such as 0.001 µF. For frequencies greater than 10 Hz, the LED turns off, and with variations in capacitance, it remains in the off state. We study the graph shown by the oscilloscope and infer that there is a phase difference of nearly 90 degrees when the current passes through a parallel RC circuit. This experiment is generally performed in labs, but in this virtual software, we can easily modify and make changes according to our requirements. The output demonstrates the frequency variation, showcasing the characteristics of an RC parallel circuit. In the experiment, we vary and check the frequency range from 1 Hz to 20,000 Hz and observe the status of the LED, whether it is on or off. Up to 10 Hz, the LED blinks and shows some response, but after 10 Hz and up to 20,000 Hz, there is no response from the LED.

The waveforms shown by the two oscilloscopes represent the waveforms of the AC signal at a particular amplitude. The current lags the voltage due to the capacitor taking time to charge and discharge, which shows a lag of a phase difference of 90 degrees. This lagging waveform further proves that the circuit is a capacitive circuit, as the current lags the voltage by 90 degrees. The use of this RC circuit is relevant in a vast field of engineering and technology. RC circuits can be used to create time delays, such as in timers and oscillators. The time constant ($\tau = R \times C$) determines how long it takes for the voltage across the capacitor to charge or discharge. RC circuits are frequently used in filter applications, including low-pass and high-pass filters. They allow certain frequency components of a signal to pass while attenuating others, which is crucial in audio processing, radio communications, and more. In analog signal processing, RC circuits can be configured to serve as integrators or differentiators, modifying the shape of input signals for various applications. In power supply circuits, RC filters smooth out the rectified AC voltage to produce a steady DC output. RC circuits also help in shaping and maintaining the integrity of signals in transmission lines and communication systems.

Conclusion: The RC parallel circuit using Proteus software is evaluated and the change in frequency is observed with phase difference of 90 degrees. The circuit is in on state at frequency of 1 Hz and with an amplitude of 10 V and capacitance 1 uF.

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