Development of Network Analysis kits

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Abstract: To simplify a complex electrical circuit, there are various network reduction techniques. These techniques include star delta conversion, series parallel conversion, source transformation, Kirchoff law. Network theorem etc. The network theorems not only reduce or simplify the networks but also helps in calculating the network parameters.

Reciprocity theorem and RC series network are both part of syllabus engineering of course, network analysis of semester 4 of electrical program. Both these kits are developed, tested and are ready to use for laboratory purpose. These kits are developed at Rajeev Electricals. The industry expert Mr. Damle guided us in preparing the two kits. This experiential learning helped us getting the technical experience and also gave us industry exposure which definitely helped us understand the expectation of industry from a budding engineer.

The reciprocity theorem [1] is a fundamental principle in electrical engineering and physics that establishes a relationship between the electrical behaviour of two circuits. (Source and load). It states that the effect of a current in one circuit on the electric field in another circuit is the same as the effect of the same current in the second circuit on the electric field in the first circuit.

The RC series circuit is a fundamental electrical circuit consisting of a resistor and a capacitor connected in series across a voltage source. When a voltage is applied, the capacitor charges up gradually. The time it takes for the capacitor to charge is determined by time constant, which is RC that is the product of the resistance and capacitance in the circuit. When the voltage source is removed, the capacitor begins to discharge through the resistor.
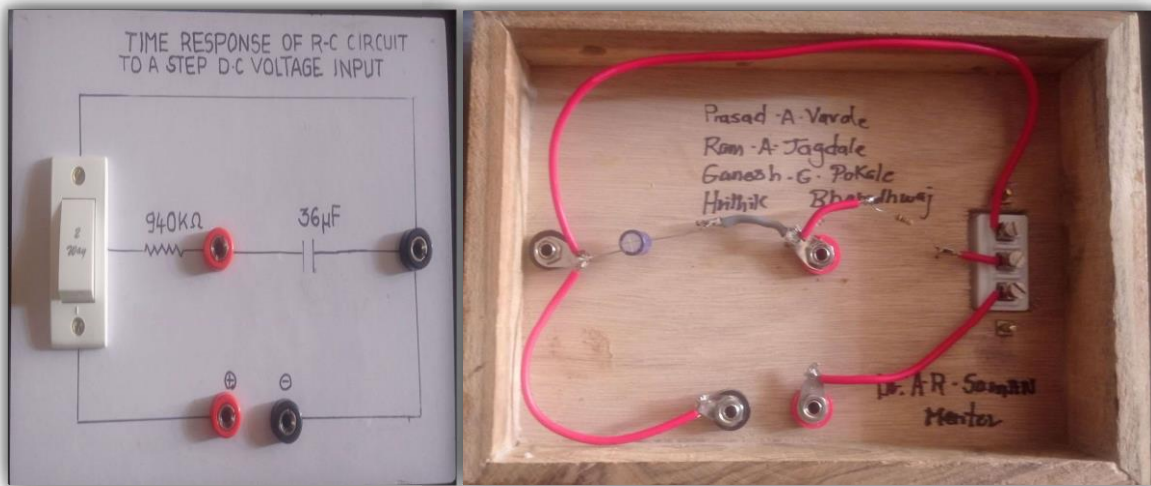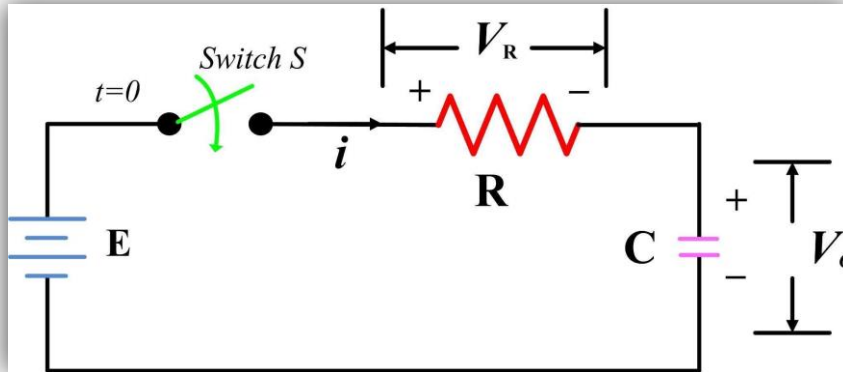
I.   RC SERIES CIRCUIT

Current in RC Series Circuit:
The current flowing through the circuit is the same in both the resistor and the capacitor since it connected in series. The current from voltage source flows through the resistor, and then through the capacitor.

Voltage Distribution: -
The voltage across the resistor V_R and the voltage across capacitor V_C may differ due to their individual characteristics and respective component values (R and X_C). The voltage across the resistor can be calculated by Ohm's Law ($V = I \times R$), where V is the voltage [2], I is the current, and R is the resistance.

The voltage across the capacitor depends on its charging or discharging behaviour, which is influenced by the time constant ($\tau = R \times C$). The RC series circuit configuration allows for the interaction of the resistor and capacitor, leading to unique electrical properties and behaviour.

As shown in fig.(a) Fig.(a)RC Series Kit

III. OBSERVATIONS IN CHARGING AND DISCHARGING CIRCUIT

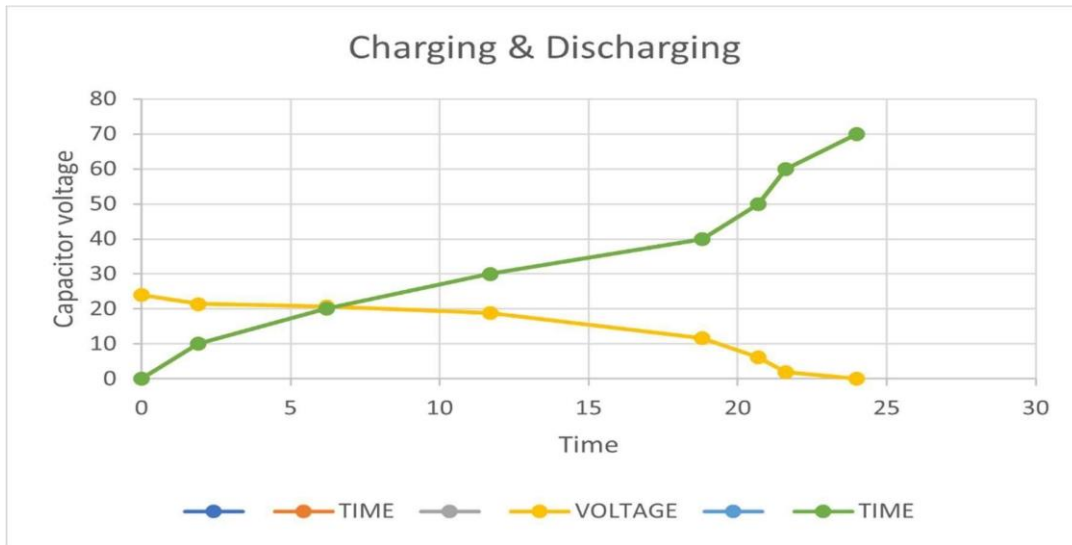| Charging		Discharging	
Time	Vc	Time	Vc
0	0	0	24
10	2	10	21.6
20	5.9	20	20.7
30	10.2	30	18.8
40	15.6	40	11.7
50	17.7	50	6.2

Fig.(b) Graph of Vc & t

IV.   DEVELOPMENT OF RECIPROCITY THEOREM KIT

According to the reciprocity theorem, firstly we apply supply to the one side and check current to other side. After that we apply the supply to the other side and check current to the one side. Thus, [3]it concludes that the reciprocity theorem gets proved by the same current to both sides.

Verification of Reciprocity Theorem: -
The reciprocity theorem holds true for linear and me invariant circuits, such as the RC series circuit. Nonlinear or me-varying elements may not satisfy the reciprocity theorem. The reciprocity theorem provides a valuable tool for understanding and analysing the RC series circuit.
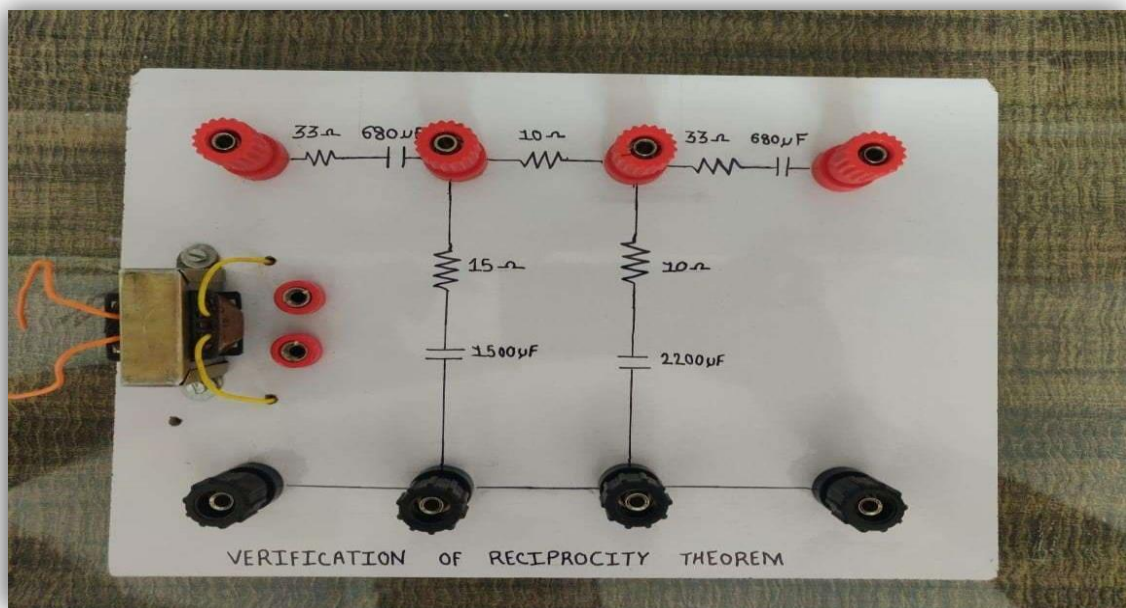

Fig.(c) Reciprocity

V.   APPLICATIONS OF RC SERIES CIRCUITS & RECIPROCITY THEOREM RC SERIES CIRCUITS

A)   RC Series Circuits

• RC series circuits are applicable in numerous applications in various fields of electrical and electronic engineering.
• RC series circuits are widely used as timing circuits in electronic devices.
• RC series circuits are used as basic building blocks for different types of filters.
• For instance, in audio equalizers, RC series circuits are used to boost or a attenuate specific frequency bands, enhancing the overall audio quality.

B)   Reciprocity Theorem
• The reciprocity theorem is a valuable tool in electrical engineering with practical applications in circuit analysis and design [4].
• The reciprocity theorem simplifies the analysis of complex circuits by allowing us to interchange the positions of sources and receivers.

VI. CONCLUSION

• Understanding RC series circuits is essential for engineers and practitioners in electrical and electronic engineering.
• It forms the basis for circuit analysis, enables the design of precise timing and signal processing systems, and contributes to stable and efficient circuit operation.
• With the knowledge of RC series circuits, engineers can effectively utilize them in a wide range of applications, ensuring reliable and optimal performance in electronic systems
• The reciprocity theorem is a fundamental principle in electrical engineering that offers valuable insights and benefits in circuit analysis and design.
• Understanding and applying the reciprocity theorem enhances the efficiency, accuracy, and optimization on of electrical systems.

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