

Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second Year)

Subject: Physics

Paper Code: PYS 101

Paper Title: NETWORK ANALYSIS

Unit: 3 Response of RL, RC, and RLC circuits to DC and AC

Module Name: Transients – An Introduction

Module No: 14

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Notes

The term '**transient**' refers to the phenomena of transition of an electrical or mechanical system from one stable state to another. In case of electrical circuit transient phenomenon can be observed when circuit elements like inductors, capacitors or both in addition to resistors are included in a circuit. On switching ON (or OFF) the voltage source, the steady value (or zero steady value) of the current is not reached in the circuit instantly but takes some time, the change of switch position results in sudden change in the circuit structure where a transient process begins as the circuit readjusts itself towards a steady state. The presence of capacitor, inductor or both makes the circuit dynamic i.e its behaviour is a function of time and described by differential equations. It has a transient response as well as a steady state.

The transient response is a temporary state which lasts from the instant the switch changes state to the instant the steady state is reached. The current so produced is called transient current.

The important fact to keep in mind is that the capacitor voltage and inductor current cannot change suddenly to a new steady state.

Types of transients. There are single-energy transients and double-energy transients. Single-energy transients are those in which only one form of energy, either electromagnetic (RL circuit) or electrostatic (RC circuit) is

involved. Double-energy transients involve both form of energy electromagnetic and electrostatic (RLC circuit)

Transients are further classified as Initiation transients (energised from zero steady state), Subsidence transients (deenergised from a steady state to zero steady state), Transition transients (between energised states), Complex transients (produced in a circuit which is subjected simultaneously to two transients due to two independent disturbances or when the disturbing force producing the transients is itself variable). and Relaxation transients (which occurs cyclically towards states, which when reached becomes unstable themselves)

Transient analysis is the analysis of the circuits during the time it changes from one steady state condition to another steady state condition. It is important as it enables us to understand when and how voltages and currents evolve or changes with time during the transient period. To get such time responses, the mathematical models should necessarily be a set of differential equations.

In Transient circuit analysis we focus on three critical time instants and concepts involved in each time instant which is very essential to the solution of transient circuits. a) $t = 0^-$, the instant before the switch changes position. b) $t = 0^+$, the instant immediately after the switch changes position.

c) $t > \infty$, after the switch has been changed for a long time.

a) $t = 0^-$ is useful in determining the initial condition needed to solve the transient circuit problem. At this instant the circuit is in a steady state, i.e voltages and currents are not varying with time, There is no current flowing across capacitor and no voltage across inductor, capacitors are considered open circuit $V_C(0^-)$, and inductors are considered short circuit $I_L(0^-)$.

b) $t = 0^+$ Starting point of transient process, the initial condition for the differential equation corresponding to the transient process. The value of $V_C(0^+)$ or $I_L(0^+)$ needs to be obtained for the solution of the differential equation. In case of second order transient circuits its derivative at 0^+ is also needed.

Transition from $t = 0^-$ to 0^+

Sudden change in the switch position, causes a change in the circuit structure, which forces the circuit to rebalance itself and begin a new steady state through a transient process, during which time the voltage and current evolve towards their new steady values. Since the voltage across capacitor and

current through the inductor cannot change suddenly, we get the initial conditions of voltage and current $V_C(0+)$ and $I_L(0+)$ which is identical to $V_C(0-)$ and $I_L(0-)$

The continuity of these two quantities makes it possible for us to determine initial conditions.

In case of second order circuits, derivatives of $V_C(0+)$ or $I_L(0+)$ needs to be obtained from $V_C(0+)$ and $I_L(0+)$

c) $t > \infty$ new steady state (final conditions), all voltages and currents are again stabilised, capacitors are considered open circuit and inductors short circuits. The value of V_C or I_L at $t > \infty$ is obtained by circuit analysis.