ECE 207 – FIRST ORDER RC CIRCUITS – INVESTIGATION 14
STEP AND PULSE RESPONSES

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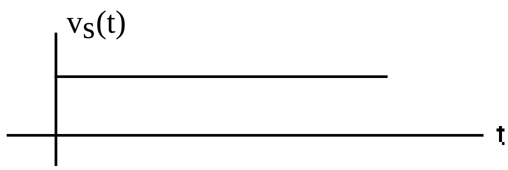
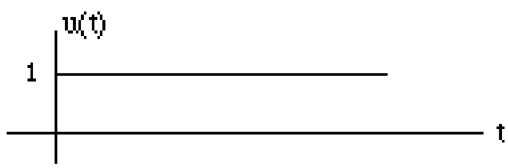
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

From the last two investigations we know how to analyze first order RC circuits with constant inputs that contain switches. The objective of this investigation is to see what happens when the "constant" inputs of our circuits are switched ON and OFF.

1. We start with the case of circuits that are initially at "rest" with zero initial conditions when their constant inputs are switched "ON" as follows



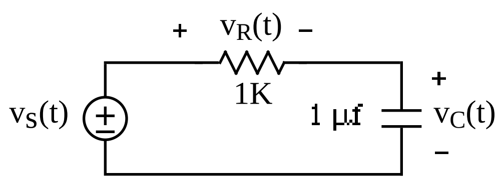
We refer to such signals as step functions since they "step" from zero to a constant value. We define the **unit step u(t)** to be a step function of magnitude one as follows



and the **unit step response s(t)** of a circuit to be the response when

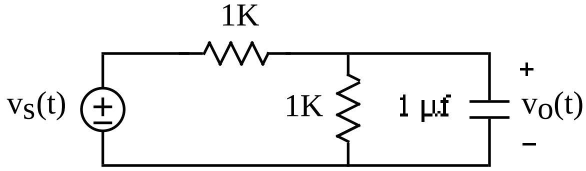
(i) The input is the **unit step u(t)**
(ii) All initial conditions are **zero** at time t = 0- just before the step turns ON

Memorize forever the definition of the unit step response s(t). And then find and sketch the unit step response of $v_C(t)$ and $v_R(t)$ in the following circuit

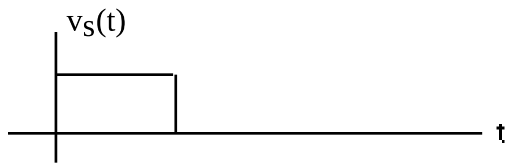


Hint - make use of the results in the last investigation to find $v_C(0+)$ - the value of $v_C(t)$ just after the source switches ON.

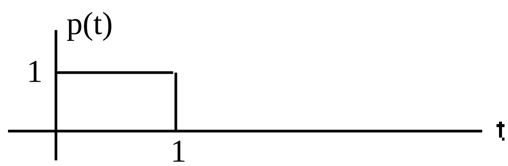
2. Find and sketch the unit step response of $v_O(t)$ the following circuit



3. We now consider the case of circuits initially at "rest" with zero initial conditions when their "constant" inputs are switched "ON" and then "OFF" as follows



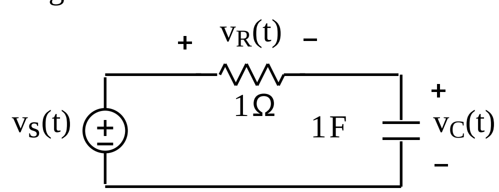
We refer to such signals as pulses. We define the **unit pulse p(t)** to be a pulse function of magnitude one and duration one as follows



and the **unit pulse response** of a circuit to be the response when

(i) The input is a **unit pulse p(t)**
(ii) All initial conditions are **zero**

Memorize forever what we mean by the unit pulse and the unit pulse response. Now suppose we have the following circuit with zero initial conditions and unit pulse input p(t)



a. Draw a picture to illustrate what the equivalent positive charges are doing when the pulse is ON and the capacitor is charging up. And then draw another to illustrate what's going on when the pulse turns OFF - when p(t) has returned to zero and the capacitor is discharging.
b. Make use of your results in part (a) to sketch what you expect for the unit pulse response of $v_C(t)$.
c. Draw the circuit and find $v_C(t)$ during the time $0 \le t \le 2$ sec when the pulse is ON
d. Draw the corresponding circuit and find $v_C(t)$ for the time $t > 2$ sec after the pulse turns OFF. Make sure that the initial value of your $v_C(t)$ at time $t = 2$ sec is equal to the value of $v_C(t)$ in part (c) when the pulse turns OFF. Express your result for $t > 2$ sec in the form $Ke^{-a(t-2)}$.
e. Make use of your results in parts (c) and (d) to plot the unit pulse response of $v_C(t)$. Make sure it agrees with your result in part (b).
f. Now make use of your results to find and sketch the unit pulse response of $v_R(t)$.
g. Draw sketches to show how increasing the pulse width would affect the pulse responses of $v_C(t)$ and $v_R(t)$