Electric Circuits

Hani Mehrpouyan,

Department of Electrical and Computer Engineering,
Boise State University
Lecture 14 (Singularity Functions)
Nov 9th, 2015

Overview

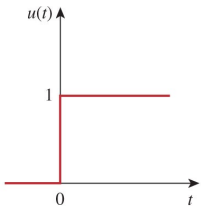
- This chapter examines RC and LC circuits' reaction to switched sources.
- The circuits are referred to as first order circuits.
- Three special functions, the unit step, unit impulse, and unit ramp function are also introduced.
- Both source free and switched sources are examined.

Singularity Functions

- Before we consider the response of a circuit to an external voltage, we need to cover some important mathematical functions.
- Singularity functions serve as good approximations to switching on or off a voltage.
- The three most common singularity functions are the unit step, unit impulse, and unit ramp.

The Unit Step

- A step function is one that maintains a constant value before a certain time and then changes to another constant afterwards.
- The prototypical form is zero before *t=0* and one afterwards.
- See the graph for an illustration.



The Unit Step

- Mathematically, the unit step is expressed as:

$$u(t)=\begin{cases}0, & t<0\\ 1, & t>0\end{cases}$$

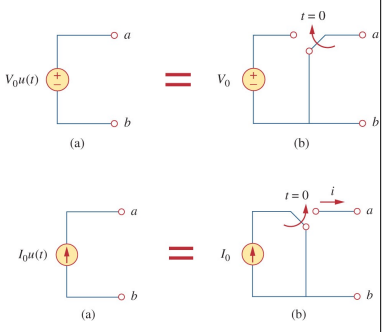
- The switching time may be shifted to $t=t_0$ by:

$$u(t-t_0)=\begin{cases}0, & t<t_0\\ 1, & t>t_0\end{cases}$$

- Note that this results in a *delay* in the switch.
- The unit step function is written as *u(t)*

Equivalent Circuit

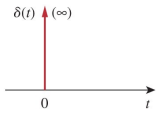
- The unit step function has an equivalent circuit to represent when it is used to switch on a source.
- The equivalent circuits for a voltage and current source are shown.



The Unit Impulse Function

- The derivative of the unit step function is the unit impulse function.
- This is expressed as:

$$\delta(t) = \begin{cases} 0 & t < 0 \\ \text{Undefined} & t = 0 \\ 0 & t > 0 \end{cases}$$



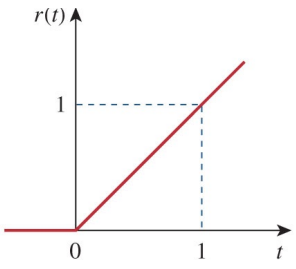
- Voltages of this form can occur during switching operations.

The Unit Ramp Function

- Integration of the unit step function results in the unit ramp function:

$$r(t) = \begin{cases} 0, & t \le 0 \\ t, & t \ge 0 \end{cases}$$

- Much like the other functions, the onset of the ramp may be adjusted.



Solved Problem

Solved Problem

Solved Problem