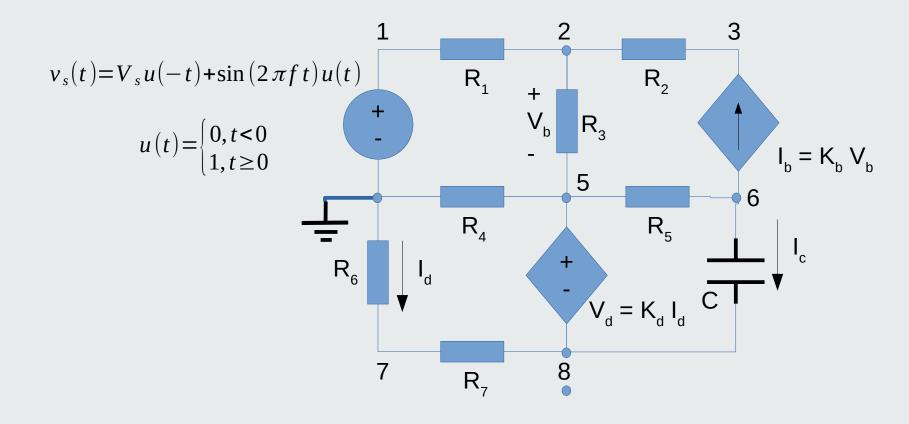


# Circuit Theory and Electronics Fundamentals

Lab 2: RC Circuit Analysis



#### The RC circuit





## **Simulation Analysis**

- 1) Simulate the operating point for t<0, to obtain the voltages in all nodes and the currents in all branches. Print a table with the results.
- 2) Simulate the operating point for  $v_s(t)=0$ , replacing the capacitor with with a voltage source  $V_x = V(6)-V(8)$ , where V(6) and V(8) are the voltages in nodes 6 and 8 as obtained in 1). Explain why you need this step. Print a table with the results.
- 3) Simulate the natural response of the circuit, using the boundary conditions V(6) and V(8) as obtained in 2) (use Ngspice directive .ic V(6)=... v(9)=...). Use Ngpice's transient analysis mode to get  $v_6(t)$  in the interval [0, 20] ms. Plot the result.
- 4) Simulate the natural and forced response on node 6 by repeating step 3) with  $v_s(t)$  as given in Fig. 1 and f=1kHz. Plot both the stimulus and the response.
- 5) Simulate the frequency response in node 6 (frequency logscale, magnitude in dB, phase in degrees) for the frequency range 0.1 Hz to 1 MHz. Plot both  $v_s(f)$  and  $v_6(f)$  in the same figure and explain how and why they differ.



## **Theoretical Analysis**

- 1) Use the nodal method to determine the voltages in all nodes and currents in all branches for t<0. Print a table with the results.
- 2) Determine the equivalent resistance  $R_{eq}$  as seen from the capacitor terminals. Suggestion: make  $V_s$ =0 and replace the capacitor with a voltage source  $V_x$ = V(6)-V(8), where V(6) and V(8) are the voltages in nodes 6 and 8 as obtained in 1); run nodal analysis to determine the current  $I_x$  supplied by  $V_x$ ; compute the equivalent resistor as  $R_{eq} = V_x/I_x$ , and the time constant. Explain why you need this procedure, and print a table with the computed results.
- 3) With the results obtained in 2), determine the natural solution  $v_{6n}(t)$ , in the interval [0, 20] ms, using the <u>capacitor voltage</u>  $V_x$  for t<0 as the initial condition. Plot the result, identifying all axes, signals displayed and units used.
- 4) Determine the forced solution  $v_{6f}(t)$  in the same interval. Suggestion: use a phasor voltage source  $V_s$ ; replace C with its impedance  $Z_c$ ; run nodal analysis to determine the phasor voltages in all nodes. Print a table with the results.
- 5) Determine the final total solution  $v_6(t)$ , converting the phasors to real time functions for f=1KHz, and superimposing the natural and forced solutions. Plot both  $v_s(t)$  and  $v_6(t)$  in the same figure in the interval [-5, 20] ms.
- 6) Determine the frequency responses  $v_c(f)=v_6(f)-v_8(f)$ , and  $v_6(f)$  (frequency logscale magnitude in dB, phase in degrees) for frequency range 0.1 Hz to 1 MHz. Plot  $v_s(f)$ ,  $v_c(f)$  and  $v_6(f)$  in the same figure and explain how and why they differ.



#### Lab report

- 1) The Python script, *t2\_datagen.m* output should be redirected to a file *data.txt* using bash's ">" facility.
- 2) The octave script should read and use the data file *data.txt*, and output a data file for Ngspice (directive .include). Use file I/O functions such as *fprintf* and *fscanf*.
- 3) Ideally, generating a new data set with a different student number and re-running the top Makefile should produce consistent results.
- 4)Produce all tables and plots required in the simulation and analysis sections
- 5)Compare Octave and Ngspice results <u>side by side</u> looking for exactness or discrepancy, and explaining both. Read the repository's README file.