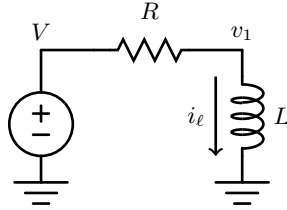# Numerical Analysis

Homework 13. Solving a Simple RL Circuit

Due: June 9, 2015

In this homework, the following simple RL circuit will be solved using different ODE methods.

For this homework, we have that R is 1 Ω, L is 1×10^{-9} Henry. And at $t = 0$, $V(t) = v_1(t) = 1$ Volt and $i_\ell(t) = 1$ Ampere; while $V(t) = 0$ Volts for $t > 0$.

1. Assuming the only system variable is i_ℓ, formulate the system equation for $t > 0$ in the following form, where f is a function of $i_\ell(t)$ and $V(t)$.

$$\frac{\mathrm{d}i_\ell}{\mathrm{d}t} = f(i_\ell, V, t). \tag{13.1}$$

2. Using forward Euler method with time step of $h = 2 \times 10^{-11}$, solve for $i_\ell(t)$, $0 <= t <= 5 \times 10^{-9}$. Plot $i_\ell(t)$ for $0 <= t <= 5 \times 10^{-9}$. List the values of $i_\ell(t)$ for $t = 0$, 10^{-9}, 2×10^{-9}, 3×10^{-9}, 4×10^{-9}, and 5×10^{-9}.

3. Using backward Euler method with time step of $h = 2 \times 10^{-11}$, solve for $i_\ell(t)$, $0 <= t <= 5 \times 10^{-9}$. Plot $i_\ell(t)$ for $0 <= t <= 5 \times 10^{-9}$. List the values of $i_\ell(t)$ for $t = 0$, 10^{-9}, 2×10^{-9}, 3×10^{-9}, 4×10^{-9}, and 5×10^{-9}.

4. Using trapezoidal rule with time step of $h = 2 \times 10^{-10}$, solve for $i_\ell(t)$, $0 <= t <= 5 \times 10^{-9}$. Plot $i_\ell(t)$ for $0 <= t <= 5 \times 10^{-9}$. List the values of $i_\ell(t)$ for $t = 0$, 10^{-9}, 2×10^{-9}, 3×10^{-9}, 4×10^{-9}, and 5×10^{-9}.

5. Please compare the solutions obtained in the previous questions. If possible, please plot out the errors obtained by each method against the analytic solution.

Notes.

1. For this homework you need to turn in a set of `C++` source codes. That includes `hw13.cpp`, which solves question 3 above, `MAT.h`, `MAT.cpp`, `VEC.h` and `VEC.cpp` files.

2. A `pdf` report file is also needed. Please name this file `hw13a.pdf`.

3. Submit your files on EE workstations. Please use the following command to submit your homework 13.

```
$ ~ee407002/bin/submit hw13 hw13a.pdf hw13.cpp MAT.h MAT.cpp VEC.h VEC.cpp
```

where `hw13` indicates homework 13.

4. Your report should be clearly written such that I can understand it. The writing, including English grammar, is part of the grading criteria.