Class 424 Advanced Systems and Synthetic Biology

Due date: 19 Feb, 2010, 11.45pm

Small Perturbations Simulation Assignment

On page five of the Small Signal Response notes you will see the linearized equation (2) that describes the rate of change of a perturbation in δs and/or δp. Below equation (2) you will also see the three different combinations of perturbations. Your task is to study each combination of perturbation by way of a numerical simulation of a linearized system.

Use the following two step model in your study:

$$\longrightarrow s \longrightarrow$$

where the first reaction has the rate law $v_1 = k_1 X_o - k_2 s$ and the second reaction the rate law, $v_2 = \text{Vm } s/(\text{Km} + s)$.

Study perturbations with respect to s and Vm. You will need to derive a similar equation to (3) then solve this numerically. You will need to provide three plots in your assignment, one plot for each combination of perturbation. The figure below shows one example of such a perturbation from the example model in the notes. Note the initial state is at zero, that is I started the simulation at steady state by running the full model first to determine what the steady state value of s was (i.e there was not initial perturbation). At time 5 the perturbation is applied to the linearized model (about 20% of the steady state value) and the change recorded. The Jarnac script that was used to generate the plot is given below but one could equally use Matlab or other tool to do the same simulation.

Answer the following questions

[20] **1.** Compute the steady state for the full non-linearized model.

[30] **2.** Linearize the model and show your working.

[25] **3.** Apply the three different perturbations to the linearized model and provide plots and simulation code (state what tool you used if no code is available).

[25] **4.** In each case give an explanation for the behavior you observe.
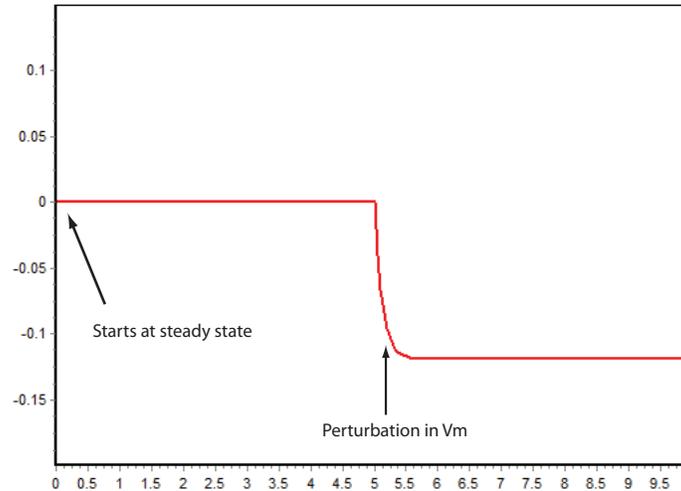
Figure 1: Perturbation in Vm

```
p = defn cell
      // Have to use the name sss because ss is a reserved name
      // $x means x is fixed.
      $x -> s; -(s*Vm*Km/(Km + sss)^2 + dVm*sss/(Km + sss));
end;


p.Vm = 5.5;
p.Km = 0.5;
p.sss = 0.0851064; // Steady state value computed in non-linearized model
p.dVm = 0;
p.s = 0;

// Simulate for a little while
m1 = p.sim.eval (0, 5, 100, [<p.time>, <p.s>]);
// Then make the perturbation
p.dVm = p.Vm * 1.5;
// Simulate the effect of the perturbation
m2 = p.sim.eval (5, 10, 100, [<p.time>, <p.s>]);

// augr is a method for combining matrices row wise.
graph (augr (m1, m2));
```

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