Example circuits - Context Project 2011/2012
June 6, 2012

1 Introduction

You have implemented a working biological circuit designer. And now you are provided with several example circuits, which you can use to test designer functionality and simulation correctness. You can expect that similar circuits will be used to evaluate your applications in the final demo.

2 New library

A new library of Coding Sequences (CDS), AND and NOT promoters has been generated to enable designing more complex circuits. Reaction rate, transcription rate and translation rate constants of the new library contain less variation compared to the original library provided to you. This leads to slower accumulation of noise in the output signal and enables construction of circuits consisting of many gates. Note that input concentrations that you used in circuits constructed using BioBricks from the previous library may no longer be suitable for the new library due to the change in rate constants.

The new library contains 13 coding sequences, 58 AND promoters and 13 NOT promoters. Note that only a fraction of all possible AND promoters is present in the library.

The library consists of (i) AND and NOT promoters generated specifically to enable construction of the example circuits discussed below, and (ii) randomly generated promoters. Its design makes sure that there exist at least 7 different Transcription Factor (TF) assignments for every example circuit.

The library is provided in the format as before - CDS, AND promot2ers and NOT promoters are stored in `cds.csv`, `and.csv` and `not.csv` Comma Separated Files (CSV) respectively.

3 Example circuits

Four example circuits are available for the purpose of testing your application: (i) an OR gate; (ii) a XOR gate; (iii) a 1-to-2 multiplexer; (iv) an SR-latch. These are briefly discussed in the following subsections. Every circuit is accompanied by (i) a schematic representation, (ii) simulation output for a given combination of inputs, (iii) TFs used to obtain the simulated output, (iv) an CSV file describing the change of input signal(s) in time (see Section 3.1).

3.1 Input signal specification

Input is provided in a CSV file with columns specifying time and input names (not to be confused with protein/TF names), and rows specifying presence or absence of input signal (i.e. binary 0-1 values) and exact times when the signal changes. Time can be a floating point value and signal can be either 0 or 1. An example file for two inputs `A` and `B` can be seen below:

```
t,A,B
0,0,0
70,1,0
100,0,1
140,1,1
```

Any input signal file contains at least two rows. The first row is always a header row and the second row always specifies inputs for $t_1 = 0$. Every next line $i + 1$ specifies input signal that is used starting from time $t = t_i$ (and until $t = t_{i+1}$ or the end of the simulation).

Note that 0-1 input signals have to be translated into appropriate TF concentrations prior to simulating circuits.

3.2 OR gate

An electrical OR gate can be constructed by combining several AND and NOT gates. In the case of biological circuits this translates to combining several AND and NOT promotors as shown in Figure 1. Its simulation for input values given in file `or-input.csv` and TFs from Figure 1 is plotted in Figure 2.

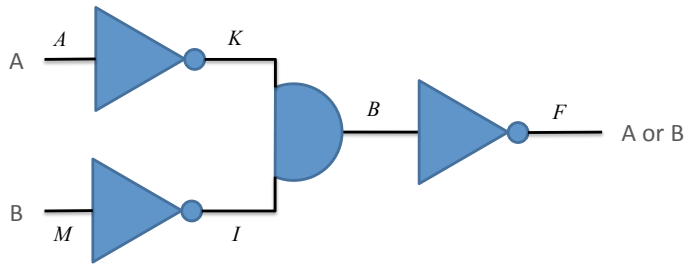

Figure 1: Schematic representation of the OR gate. Connections are labeled with names and/or TFs used to simulate this circuit.

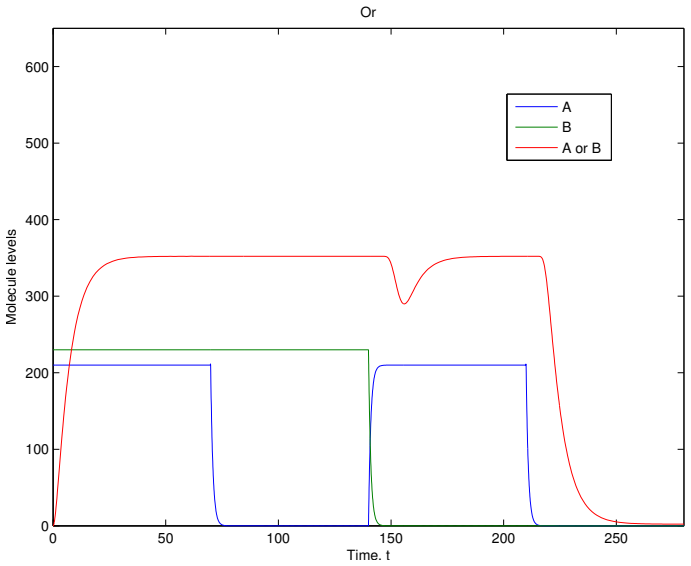

Figure 2: Simulation plot of an OR gate using TFs from Figure 1.

3.3 XOR gate

Similar to an OR gate, a biological equivalent of a XOR gate can be constructed from several AND and NOT promotors as shown in Figure 3. Its simulation for input values given in file `xor-input.csv` and TFs from Figure 3 is plotted in Figure 4.

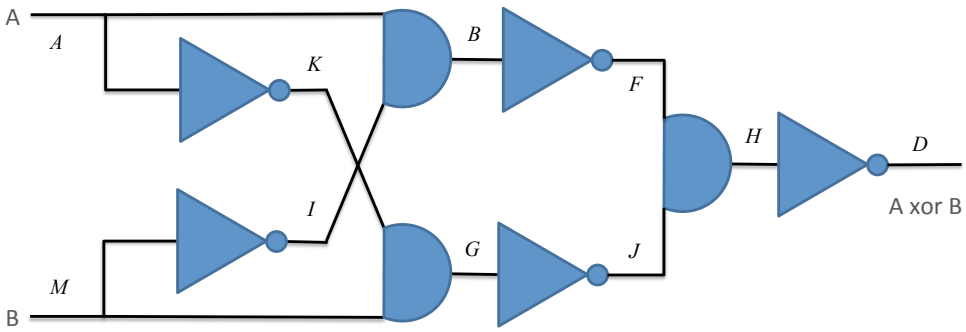

Figure 3: Schematic representation of a XOR gate.

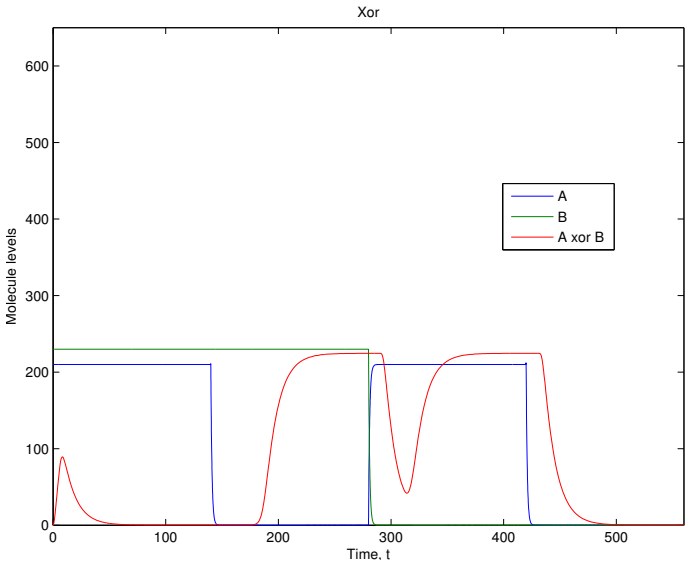

Figure 4: Simulation plot of an XOR gate using TFs from Figure 3.

3.4 1-to-2 multiplexer

In electronics a multiplexer is a device that selects one of several input signals and forwards it to one of several output lines. A 1-to-2 multiplexer has forwards a single input signal to one of the output lines based on a selector signal. A biological equivalent of a 1-to-2 multiplexer can be implemented by combining AND and NOT promotors as shown in Figure 5. Its simulation for input values given in file

`1-to-2-multiplexer-input.csv` and TFs from Figure 5 is plotted in Figure 6.

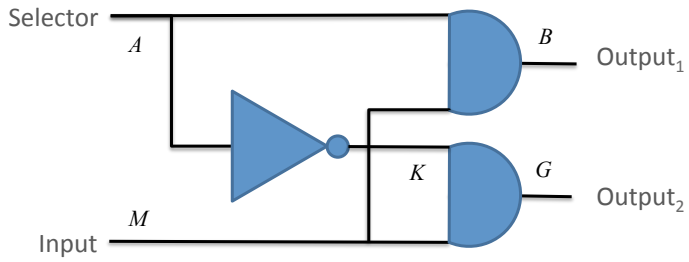

Figure 5: Schematic representation of a 1-to-2 multiplexer.

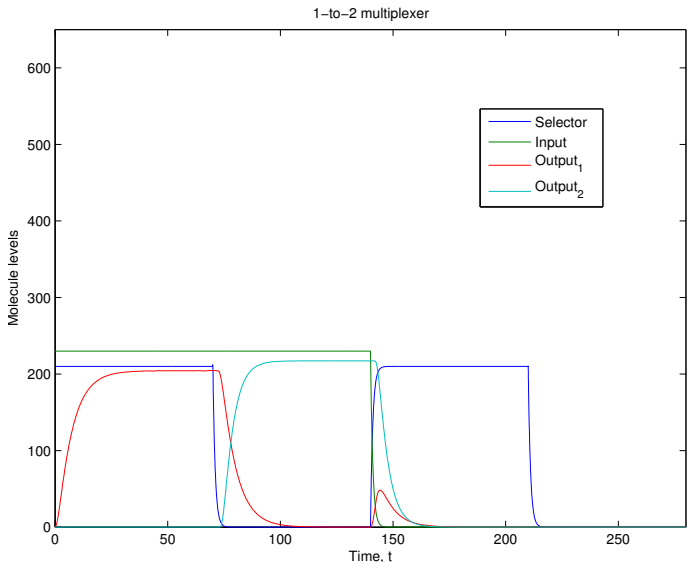

Figure 6: Simulation plot for a 1-to-2 multiplexer using TFs from Figure 5.

3.5 SR-latch

In electronics a latch (also called flip-flop) is a device or circuit that has two stable states and can store state information. An SR-latch (SR stands for set-reset) is a particular type of a latch. An SR-latch can be implemented as a biological circuit using AND and NOT promotors, and feedback loops as shown in Figure 7. This

makes it a particularly interesting test case. Simulation of an SR-latch for input values given in file `sr-latch-input.csv` and TFs from Figure 5 is plotted in Figure 6.

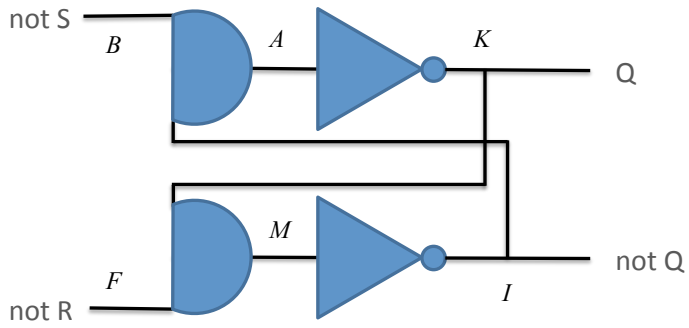

Figure 7: Schematic representation of an SR-latch.

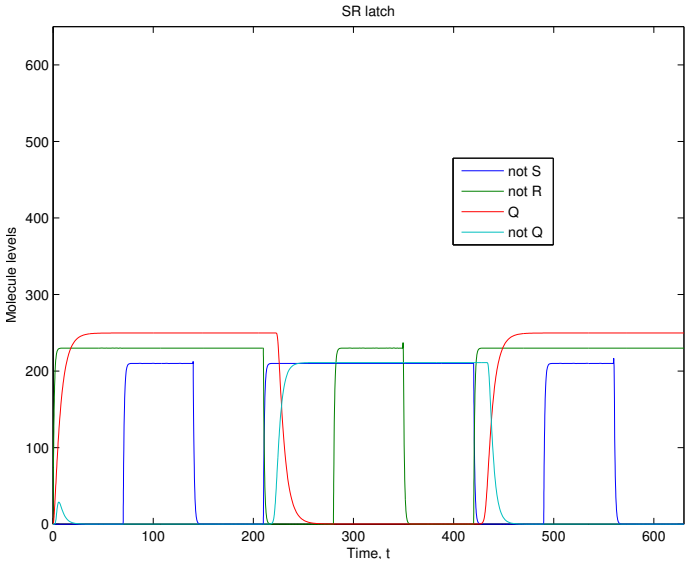

Figure 8: Simulation plot for an SR-latch using TFs from Figure 7.