

Final Design Project Report

Advanced Systems and Synthetic Biology: 424 Bioengineering

Sample Template

You have the option of doing one of the following projects:

1. Design and simulate a synthetic network which many involve genetic, protein and/or metabolic systems but does not have to include all these types (eg it could be just a genetic network). The design should include at least three identifiable modules. A module is defined as a system with a well defined function that contains **more** than one gene. Thus at minimum your design would contain at **least** six genes.
2. Design an in vitro or in vivo synthetic network based on RNA and/or protein technology. The design should contain at least two identifiable modules where a module must contain more than one RNA strand.
3. Design a library of basic modules that can carry out elementary operations, e.g summers, multipliers, oscillators, switches, filters etc. You should design a minimum of 6 modules. In each case you should show by simulation that the module operates as expected. In addition you should write up a formal spec sheet for each module indicating its characteristics, see section below for details). Provide one example (**without** simulations) of how the 6 modules might be used (not matter how contrived!).

In each case the project should be written into a final report (see below for details) and a short 10min PowerPoint (or beamer) presentation (The power point presentation will not be graded but without the presentation now grade will be awarded at all).

In the written report, a minimum font size of 10pt should be used. Any standard font is acceptable except script or ornamental fonts. Make consistent use of font types and sizes in your report. Make sure sections, subsections etc are clearly marked. Text should use single spacing and all pages should be numbered. The final report should be provided in electronic form as a **PDF file** in the dropbox.

The structure of your final report is described as follows:

Title Page:

Title of Project

Author Names and the name of your startup company together with company logo.

Example Title:

The Design of a Switchable Oscillator Circuit.

Sections should include the following:

1. Abstract

2. Introduction

An introduction to Synthetic Biology: up to two pages, one page will be adequate. Highlight the scope of the field and its possible impact in both pure and applied sciences.

3. Overview of the project: Up to one page (1/2 will be adequate)

4. Product Design Specification

This section will describe what the synthetic circuit(s) is(are) intended to do. In a real-life engineering project, the product design spec would ensure that the product meets the needs of the end user. This description may be quite short in this project, but complex projects may have quite lengthy design specifications.

5. Internal Design Specification

This section, in two parts (see below), will describe in the detail the internal workings of the proposed synthetic network(s). If the design is composed of multiple modules, then each module should be described separately. If you are building a complete systems made from multiple modules, the then you should also provide an overview of the system in terms of the modules.

A. Overall design view. This section should give the overview of the design without reference to detailed component parts (i.e what parts you would **actually** use in the fabrication) or kinetics. The design can be given as text but should also include figures illustrating the design. This section will also include a description of any modules in the design.

B. Specification of the proposed kinetic responses, that is whether some steps will be assumed to be mass-action, hyperbolic, sigmoid etc.

The length of this section will depend on the complexity of your proposed design but should be no less than one page.

6. Computer Simulation Test Implementation.

This section will take the internal design spec and translate it into a working computer simulation to illustrate the operation of the proposed design. If the design includes modules (which it will), individual modules should be simulated to show their operation. If you're designing a complete system then it should be modeled and the input/output characteristics

given to show that the design satisfies the product design specification (If building a library, then each library module should be characterized). All model codes should be provided in the report so that a third-party can also carry out the simulations. Code should be supplied in some suitable format such as Jarnac, SBML, Matlab, TinkerCell File. If a human readable script like Matlab or Jarnac is used, the code should be heavily documented and all parameters commented. In addition, if the model is supplied in Matlab format (or any other non-Jarnac like reaction input format), the rate equations **MUST** be separated from the differential equations. This will allow the model to be converted to other formats if necessary. If you submit the model in other formats such as R or Python (including Matlab), **DETAILED** instructions on how to test the model **MUST** be given. If you are using anything other than Matlab you should provide instructions on where to obtain the software and what version you used.

7. Implementation Details.

Provide a detailed list of all parts that would be required to build the product (Genes, RBS, Terminators, Promoters, Operators etc). In a real specification you would give actual parts (i.e catalog entries etc), however since we currently have limited characterized parts in synthetic biology, this may not be possible. I expect you to however use at least **four** real parts in your description and to provide the corresponding BioBrick Id for reference.

By assuming average sizes for genes, promoters, terminators and RBS sites, give estimates for the final size of the genomic material that will be required to build the network. By assuming a cost of 50c per base, give an estimated cost for synthesizing the design by a DNA fabrication company.

Cite any references at the end in a separate references section.

In an appendix provide the following information:

8. Assume it is the year 2025 you will sell this device to other companies and that your company employs a design team of 12 people at an average salary of 120K each. Assume that your other fixed costs (renting building, etc) are 1 million dollars per year. Also assume that the cost of manufacturing the device is negligible (The manufacturing plant is in Outer Mongolia because labor costs in China in 2025 are too expensive). From these numbers, and with an estimated market size of 1000 units per year, what should you price your device at in order to break even?

9. Design Spec Sheets

Design spec sheets should be provided with the project write up. If you chose option one or two, then you should provide a single spec sheet, up to three pages, for the final network including details of the internal design in the form of schematics. If you chose option three (module library) then you should provide a spec sheet for each module, up to one page per module.

I spec sheet should include details of (Total points 25 out of 100):

1. [3] General description (two or three sentences)

2. [10] Schematic diagram(s)
3. [12] The input/output response of the system (in the form of graphs)

For option three, you should provide at least one design that illustrates how the modules might be used, not matter how contrived. Do not provide simulations of this example.

Grading

Abstract: [3]

Introduction: [11]

Overview: [3]

Product Design Spec: [10]

Internal Design Spec: [15]

Computer Simulation Tests: [20]

Implementation Details: [10]

Design Spec Sheet(s): [25]

Appendix: [3]

Example Design

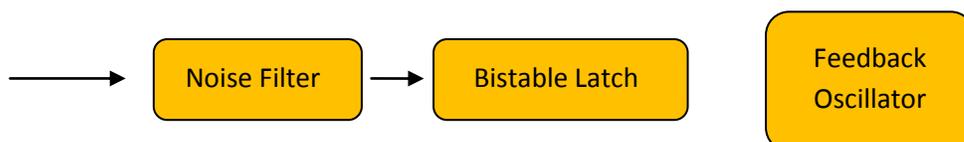
Title: The Design of a Switchable Oscillator Circuit.

4. Product Design Specification

The proposed design is intended to act as a noise immune switchable oscillator. Users of the network will be able to apply a pulse to the input of the circuit which, in turn, will permanently switch on an oscillator. The circuit will not be susceptible to transient signals or noise at the input which could inadvertently switch on the oscillator.

5. Internal Design Specification

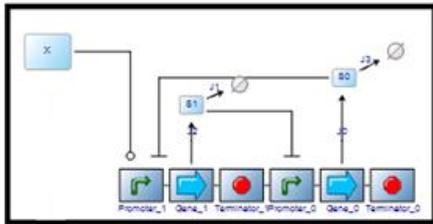
A. The design of the network comprises of three modules. An overview of the network is given in the figure below:





Follow this with a description of each module.

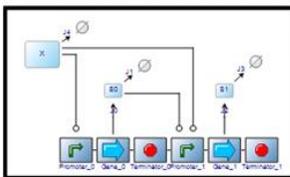
Noise Filter



The noise filter is composed of....and operates on the principle of....etc

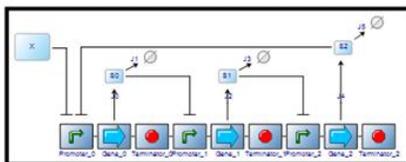
Bistable Switch

The bistable switch is composed of.....etc



Feedback Oscillator

The feedback oscillator is composed of.....etc



B. Description of the design kinetics.

6. Computer Simulation Test Implementation.

Describe each module in turn. Show that the noise filter, bistable latch and feedback oscillator work as expected. Combine all three and show that the entire system works as expected.

7. Implementation Details