Binding Process Analysis of Bacterial-based AND Logic Gates

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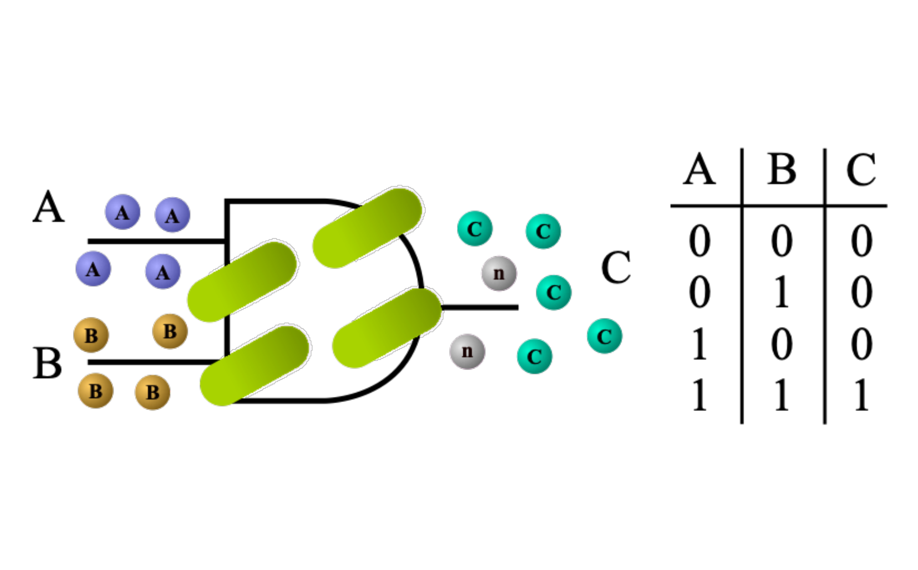
RATIONALE



MOTIVATION

Analog electronics can be applied as *in silico* representation of bacteria-based biocomputing systems' processes.

The analysis of the molecular binding using analog electronics can optimize the cellular membrane engineering for biocomputing applications.

IMPACT

We believe this work will contribute to the development of molecular communications devices based on engineered bacterial populations for the precise use of herbicides and theranostics applications in humans, animals and plants.

Introduction

Analog and digital electronics have been utilized in the past to model the operation of biological circuitry. Similarly, researchers have been able to apply the bacterial communications capabilities on the design of synthetic biology systems that use *Quorum Sensing* molecules as information in a system known as **Molecular Communications**.

Here we contribute to this field by investigating the bacterial internal signal processing using analog electronics. Our circuit represents the chemical reactions at the population level related to this bacteria-based molecular computing and investigates the impact of the molecular binding on the bacterial signal process.

Materials and Methods

Our model is an analog electronics description of the cellular processes utilized by the bacteria to sense, process and emit molecules, such as the binding/unbinding of molecular signals. This is achieved by mapping the biological process involved in the bacterial signal processing into analog circuit components. For example, the degradation, transcription and translation of molecules are represented as resistors, while bacterial receptors are modelled as capacitors. Please note that the diodes will be considered as short circuits (small signal analysis) and will not be mapped to any biological process.

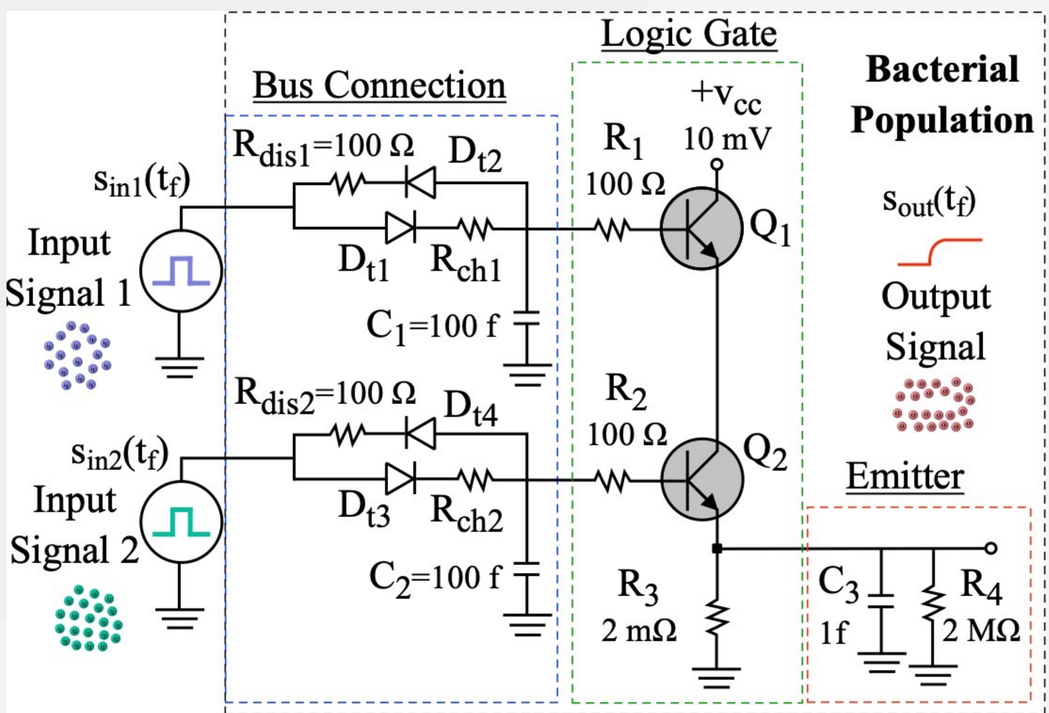


Figure 1. The electronic circuit representation of molecular signaling process (AND gate) performed by engineered bacterial populations.

Results

By increasing/decreasing tenfold the charging resistance in respect to the discharging one we obtain a decrease of 0.43% and an increase of 2.07% on the emitted signal levels, respectively. Note that the increase on the input signal 2, produce a smaller emitted signal for the proposed analog circuit.

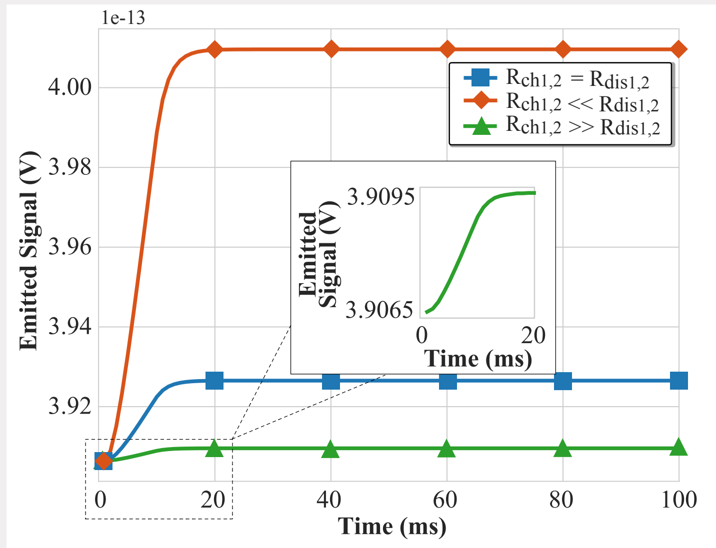


Figure 2. Signal emitted by the electronic circuit (measured in volts) when considering equal and unequal values of signal input charging/discharging (i.e., binding/unbinding) process.

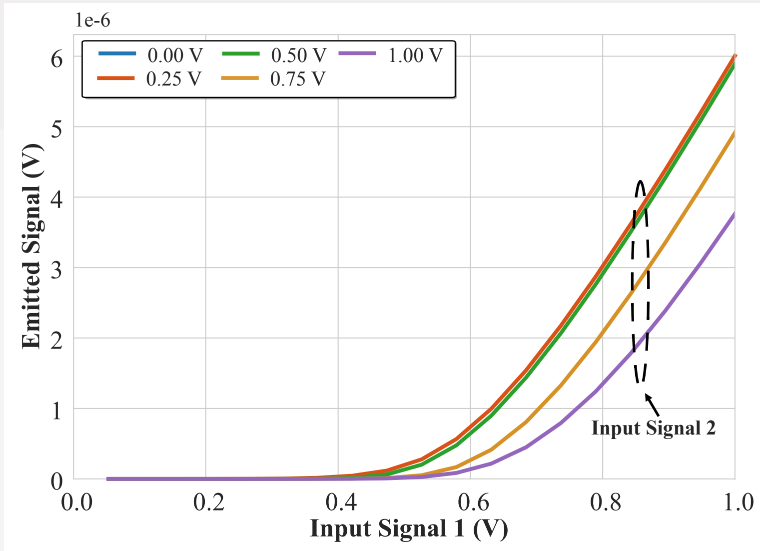


Figure 3. Signal emitted by the electronic circuit when considering continuous input signals. In this case, the charging resistance is tenfold smaller than the discharging resistance.

Discussion

Our analog circuit analysis shows the impact of the molecular binding on the signal concentration produced by the engineered bacterial population. Our results shows that a minimal decrease on the charging resistance result in a major improvement on the bacterial signaling process performance

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