Incoherent Feedforward Loop as a Clock Signal for Synchronizing Signals in Biological Systems
Rongying Huang\textsuperscript{1}, Valeriia Kravchik\textsuperscript{1}, Ilan Oren\textsuperscript{1}, and Ramez Daniel\textsuperscript{1}

Abstract
Asynchronous signals in synthetic gene networks can result in fault outputs and system failure. To address this challenge and meet the growing demands for user-defined control in biomedical applications, this research proposes a clock signal to integrate input signals and generate a synchronized output. The clock signal utilizes an incoherent type-1 feedforward loop (I1-FFL) network, which exhibits stable behavior and enhanced response speed, as shown through mathematical models and simulations. Our proposed biological clock serves as a promising solution for synchronizing asynchronous inputs in synthetic gene networks, enabling temporal control over gene expression dynamics, and providing a timing reference for multi-input systems in various applications.

\textsuperscript{1}Department of Biomedical Engineering, Technion - Israel Institute of Technology, Haifa 3200003, Israel.

My name: Rongying Huang
Name of supervisor: Ramez Daniel
Academic institution: Technion - Israel Institute of Technology