Controllable switching between stable modes in small network of pulse-coupled chemical oscillators

Pavel S. Smelov, Ivan S. Proskurkin, and Vladimir K. Vanag

Centre for Nonlinear Chemistry, Immanuel Kant Baltic Federal University, Kaliningrad, 236041, Russia

Description of the algorithm written in the program LabView.

Figure ESI-1. The block scheme of the LabView software for unidirectional inhibitory pulse coupling with time delay and external inhibitory pulses.

Analog signals from the photodiode receivers, PD1 - PD4, are converted to the digital E1 - E4 signals, respectively. The module “Threshold analyzer” defines the excess signal \( E \) of the PD receiver over the threshold value \( E_{th} = 8 \) V and works as a trigger for the next module. “1/0” means digital line. The module “Timer \( \tau \)” is responsible for the time delay \( \tau \) between the operations of modules “Threshold analyzer” and “Timer \( \Delta t^{(ext)} \)”. The module “Timer \( \Delta t \)” is responsible for the duration of the internal injection \( \Delta t \), while the module “Timer \( \Delta t^{(ext)} \)” is responsible for the duration of the external pulse injection, \( \Delta t^{(ext)} \). SP1 - SP4 are digital inputs which operate syringe pumps of the A3 type. “Virtual buttons” is used for controlling external pulses manually. Logical “1” is a constant signal that can be given to the input of a needed channel of module “Timer \( \Delta t^{(ext)} \)” by pressing the corresponding virtual button.
Four lines in each module from top to bottom correspond to oscillators #1 - #4, respectively. Each line in the modules works separately. Let us describe how our algorithm works for the \( j \)th oscillator \((j = 1, 2, 3, 4)\) and corresponding \( j \)th channel. Signal \( E_j \) of the PD_\( j \) comes to the input of the “Threshold analyzer”. If \( E_j \) exceeds the threshold value \( E_{th} = 8 \) V, the digital output of the “Threshold analyzer” is equal to “1”, and “0” otherwise. Note that the threshold value \( E_{th} \) can be equated to any value between 5 V and 9 V. The module “Timer \( \tau \)” starts to count \( \tau \) seconds (time delay), if its input is equal to logical “1”. During this time (time of counting), the “Timer \( \tau \)” cannot read any input signals. When the counter reaches \( \tau \) seconds, the value of the \( j \)th output of the “Timer \( \tau \)” switches from logical “0” to logical “1”. As soon as the input of the next module “Timer \( \Delta t \)” changes from “0” to “1”, this module starts to count \( \Delta t \) seconds. During this time of counting, the \( j \)th output of the module “Timer \( \Delta t \)” is equal to logical “1” and the model cannot read any new \( j \)th input. Since we use unidirectional coupling on the ring, the \( j \)th output of the “Timer \( \Delta t \)” is connected to the input of a syringe pump SP_\( j+1 \) (if \( j = 4, j + 1 = 1 \)). The module “Timer \( \Delta t^{(ext)} \)” is designed to create short external pulses that can be controlled manually by “virtual buttons”. If the virtual button in the \( j \)th line is pressed, what is equivalent to setting logical “1” to the \( j \)th input of the module “Timer \( \Delta t^{(ext)} \)”, this module starts working by the same manner as module “Timer \( \Delta t \)” but with its own time \( \Delta t^{(ext)} \), which can be changed from one to another experiment.