## Contents



## 1. Equations

$$
\begin{aligned}
EnvZ & \quad \dot{x}_1 = k_{ad}x_2 - k_{ap}x_1RL + k_{d2}x_4 - k_{b2}x_5x_1 - k_{b3} * x_6x_1 + k_{d3}x_7 \\
EnvZ - P & \quad \dot{x}_2 = k_{ap}x_1RL - k_{ad}x_2 + k_{d1}x_3 - k_{b1}x_6x_2 \\
EnvZ - P.OmpR & \quad \dot{x}_3 = -(k_{d1} + k_{pt})x_3 + k_{b1}x_6x_2 \\
EnvZ.OmpR - P & \quad \dot{x}_4 = k_{pt}x_3 - (k_{ph} + k_{d2})x_4 + k_{b2}x_5x_1 \\
OmpR - P & \quad \dot{x}_5 = k_{d2}x_4 - k_{b2}x_5x_1 \\
OmpR & \quad \dot{x}_6 = k_{d1}x_3 + k_{d3}x_7 - k_{b3}x_6x_1 - k_{b1}x_6x_2 \\
EnvZ.OmpR & \quad \dot{x}_7 = k_{ph}x_4 - k_{d3}x_7 + k_{b3}x_6x_1 \\
lacZ_{mRNA} & \quad \dot{x}_8 = \alpha_M \frac{\left(\frac{x_5}{K5}\right)^{n_l}}{\left(1+\frac{x_5}{K5}\right)^{n_l}} - \gamma_M x_8 \\
\beta - Galactosidase & \quad \dot{x}_9 = \alpha_B x_8 - \gamma_B x_9 \\
dye & \quad \dot{x}_{10} = \alpha_A x_9
\end{aligned}
$$

## 2. Parameters

| Parameter | Value | Unit | Name | Source |
|---|---|---|---|---|
| $k_{ap}$ | 0.1 | $\frac{1}{s}$ | EnvZ autophosphorelation rate | [1] |
| $k_{ad}$ | 0.001 | $\frac{1}{s}$ | EnvZ dephospholeration rate | [1] |
| $k_{b1}$ | 0.5 | $\frac{1}{s}$ | binding rate EnvZ-P & OmpR | [1] |
| $k_{d1}$ | 0.5 | $\frac{1}{s}$ | unbinding rate EnvZ-P.OmpR | [1] |

| Parameter | Value | Unit | Name | Source |
|---|---|---|---|---|
| $k_{b2}$ | 0.05 | $\frac{1}{s}$ | binding rate EnvZ & OmpR-P | [1] |
| $k_{d2}$ | 0.5 | $\frac{1}{s}$ | unbinding rate EnvZ.OmpR-P | [1] |
| $k_{b3}$ | 0.5 | $\frac{1}{s}$ | binding rate EnvZ & OmpR | [1] |
| $k_{d3}$ | 5 | $\frac{1}{s}$ | unbinding rate EnvZ.OmpR | [1] |
| $k_{ph}$ | 0.05 | $\frac{1}{s}$ | dephosphorelation rate EnvZ.OmpR-P | [1] |
| $k_{pt}$ | 1.5 | $\frac{1}{s}$ | phosphotransfer rate | [1] |
| $K1$ | 5 | nM | response param. OmpR-P,lacZ | guessed |
| $\alpha_M$ | $\frac{0.997}{60}$ | $\frac{nM}{s}$ | max transcription rate lacZ | [2] |
| $\alpha_B$ | $\frac{1.661e-5}{60}$ | $\frac{1}{s}$ | max translation rate lacZ | [2] |
| $\alpha_A$ | $\frac{20}{60}$ | $\frac{1}{s}$ | enzymatic reaction rate | [2] |
| $\gamma_M$ | $\frac{0.411}{60}$ | $\frac{1}{s}$ | degradation lacZ mRNA | [2] |
| $\gamma_B$ | $\frac{8.331e-4}{60}$ | $\frac{1}{s}$ | degradation $\beta$-Galactosidase | [2] |

## 3. Initial Data

| Name | Variable | Initial Value | Comment | Source |
|---|---|---|---|---|
| $EnvZ$ | $x_1$ | $\frac{3500}{0.60221}$ | 3500 molecules per cell | [1] |
| $EnvZ-P$ | $x_2$ | 0 | | |
| $EnvZ-P.OmpR$ | $x_3$ | 0 | | |
| $EnvZ.OmpR-P$ | $x_4$ | 0 | | |
| $OmpR-P$ | $x_5$ | 0 | | |
| $OmpR$ | $x_6$ | $\frac{100}{0.60221}$ | 100 molecules per cell | [1] |
| $EnvZ.OmpR$ | $x_7$ | 0 | | |
| $lacZ_{mRNA}$ | $x_8$ | 0 | | |
| $\beta-Galactosidase$ | $x_9$ | 0 | | |
| $dye$ | $x_{10}$ | 0 | | |

## 4. Simulation

TBD

## 5. Attribution

The red light sensor was modeled according to the paper "Hysteretic and graded responses in bacterial two-component signal transduction"[1]

The Expression of lacZ is an adaption of the model given by "Dynamics and bistability in a reduced model of the lac operon"[2]

## References

[1] Oleg A Igoshin, Rui Alves, and Michael A Savageau. Hysteretic and graded responses in bacterial two-component signal transduction. *Mol Microbiol*, 68(5):1196–215, Jun 2008.

[2] N Yildirim, M Santillan, D Horike, and MC Mackey. Dynamics and bistability in a reduced model of the lac operon. *CHAOS*, 14(2):279–292, JUN 2004.