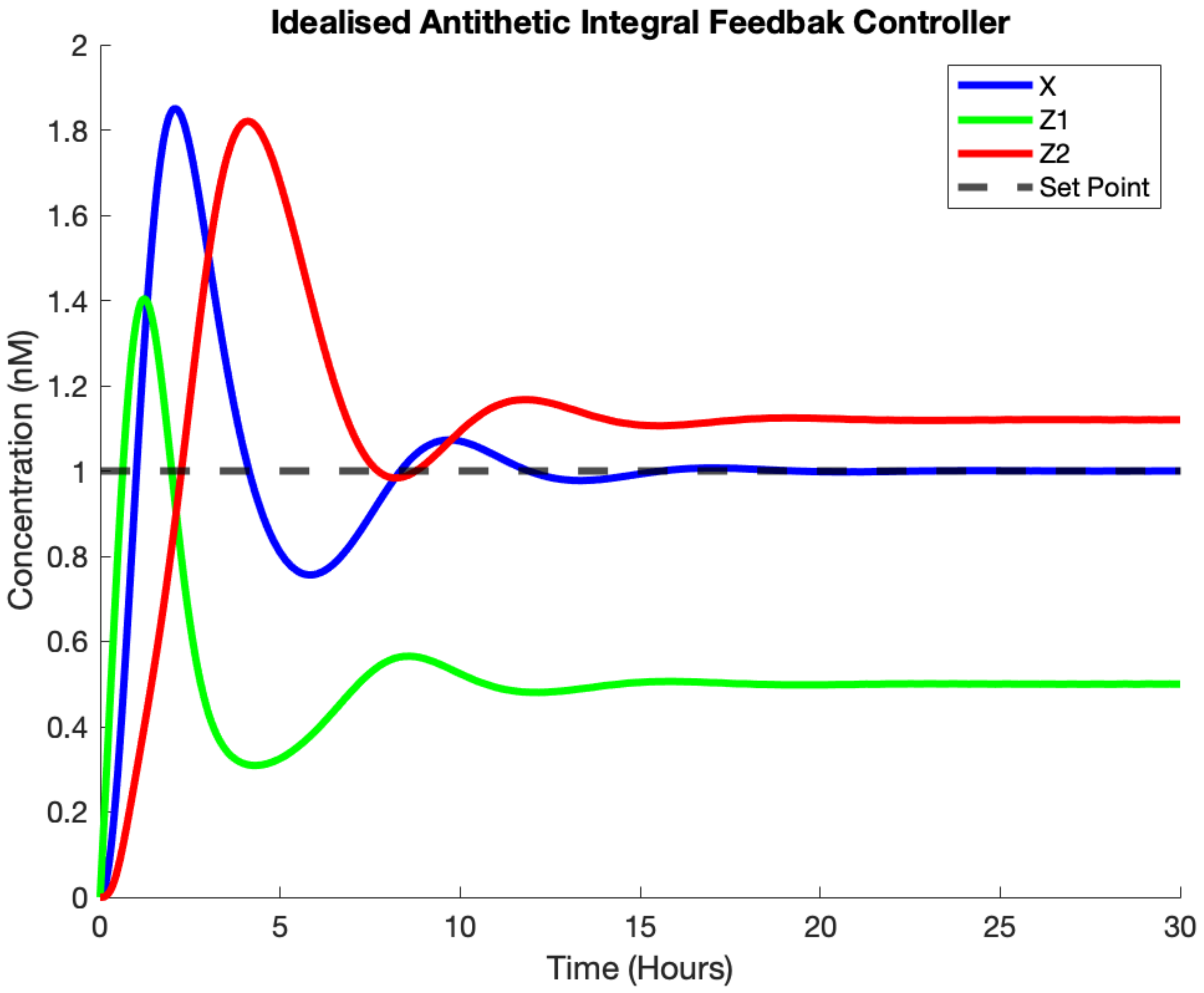
Antithetic

$$\frac{dZ_1}{dt} = \mu - \eta Z_1 Z_2 - \delta Z_1$$

$$\frac{dZ_2}{dt} = \theta X - \eta Z_1 Z_2 - \delta Z_2$$

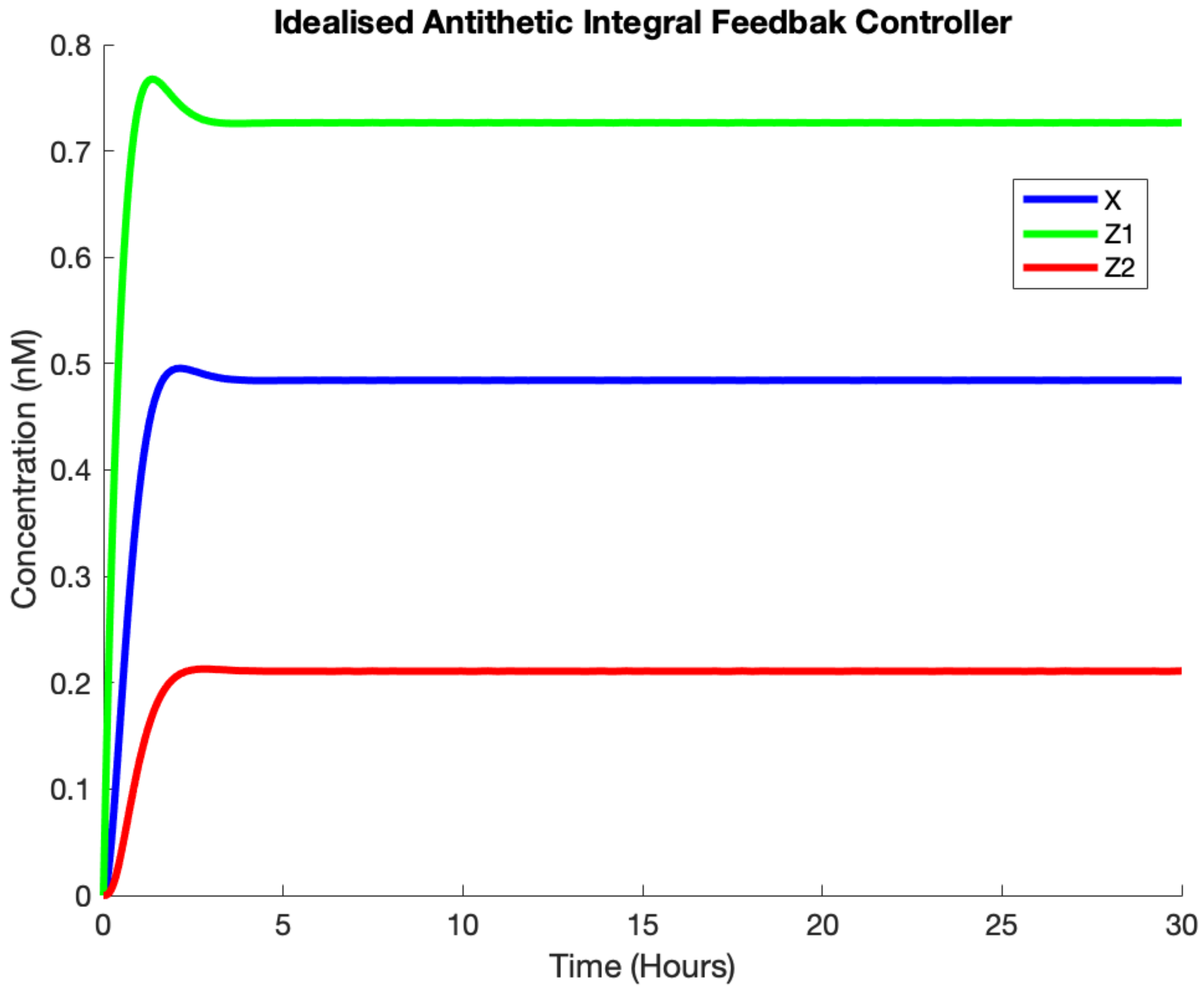
$$\frac{dX}{dt} = \mathrm{k} Z_1 - (\gamma + \delta) X$$

$$\text{setpoint} = \frac{\mu}{\theta}$$



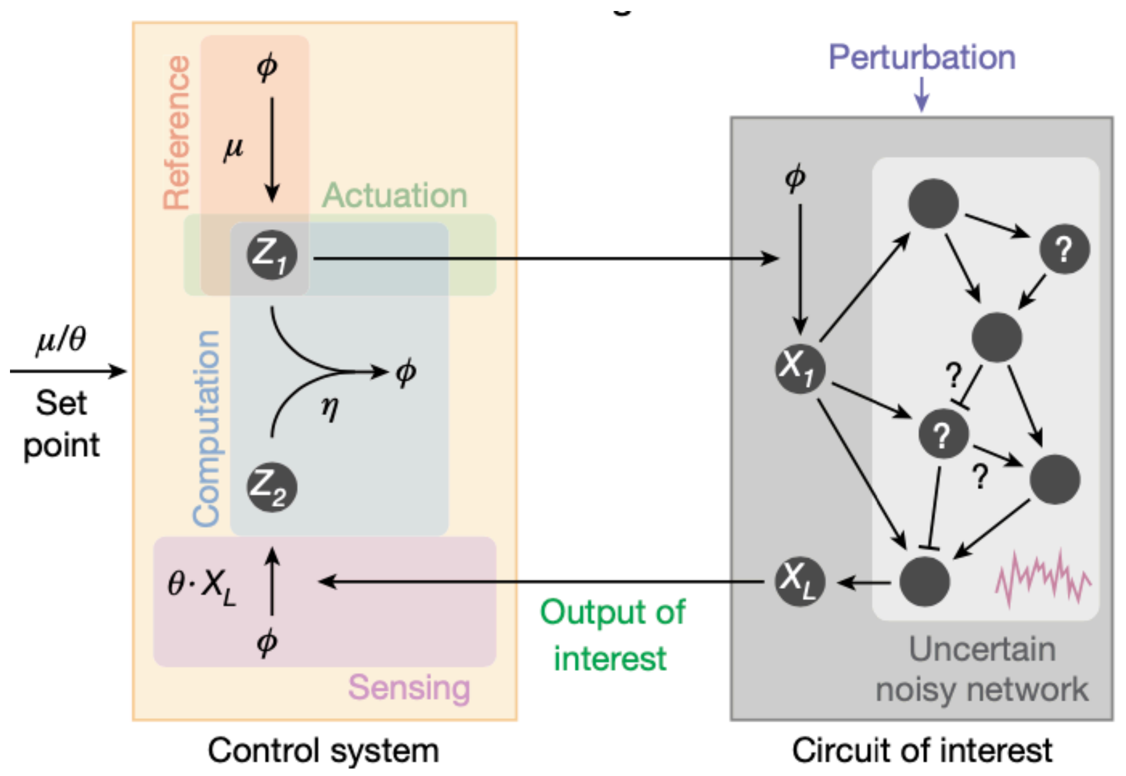
$$\mu = 0.028\ \text{nMmin}^{-1}; \eta = 0.05\ \text{nM}^{-1}\text{min}^{-1}; \theta = 0.028\ \text{min}^{-1}$$

$$\mathrm{k} = 0.028\ \text{min}^{-1}; \gamma = 0.014\ \text{min}^{-1}; \delta = 0\ \text{min}^{-1}$$



$$\mu = 0.028\ \text{nMmin}^{-1}; \eta = 0.05\ \text{nM}^{-1}\text{min}^{-1}; \theta = 0.028\ \text{min}^{-1}$$

$$\mathrm{k} = 0.028\ \text{min}^{-1}; \gamma = 0.014\ \text{min}^{-1}; \delta = 0.028\ \text{min}^{-1}$$



Antithetic with Damping

$$\frac{dZ_1}{dt} = \mu - \eta Z_1 Z_2 - \delta Z_1$$

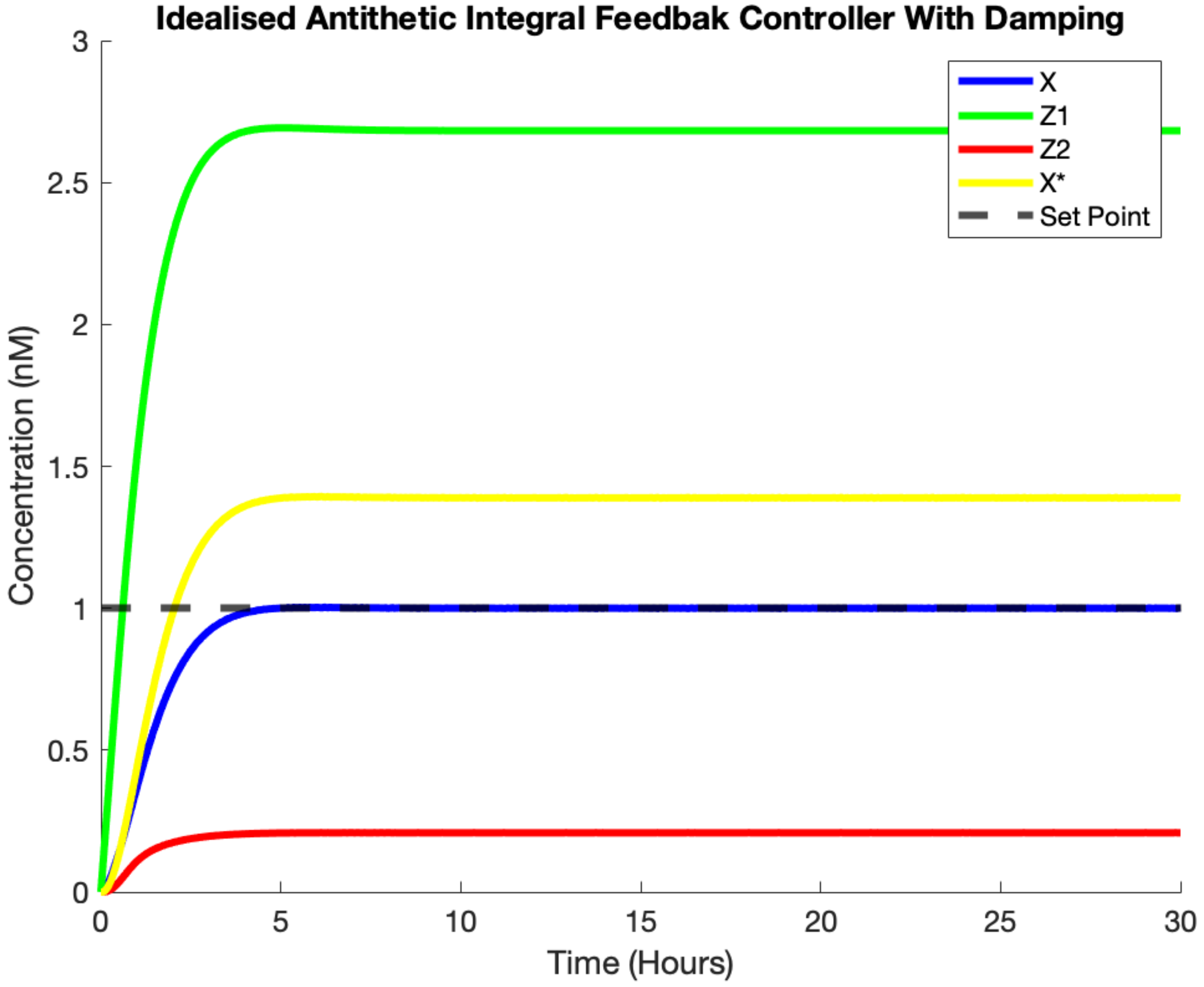
$$\frac{dZ_2}{dt} = \theta X - \eta Z_1 Z_2 - \delta Z_2$$

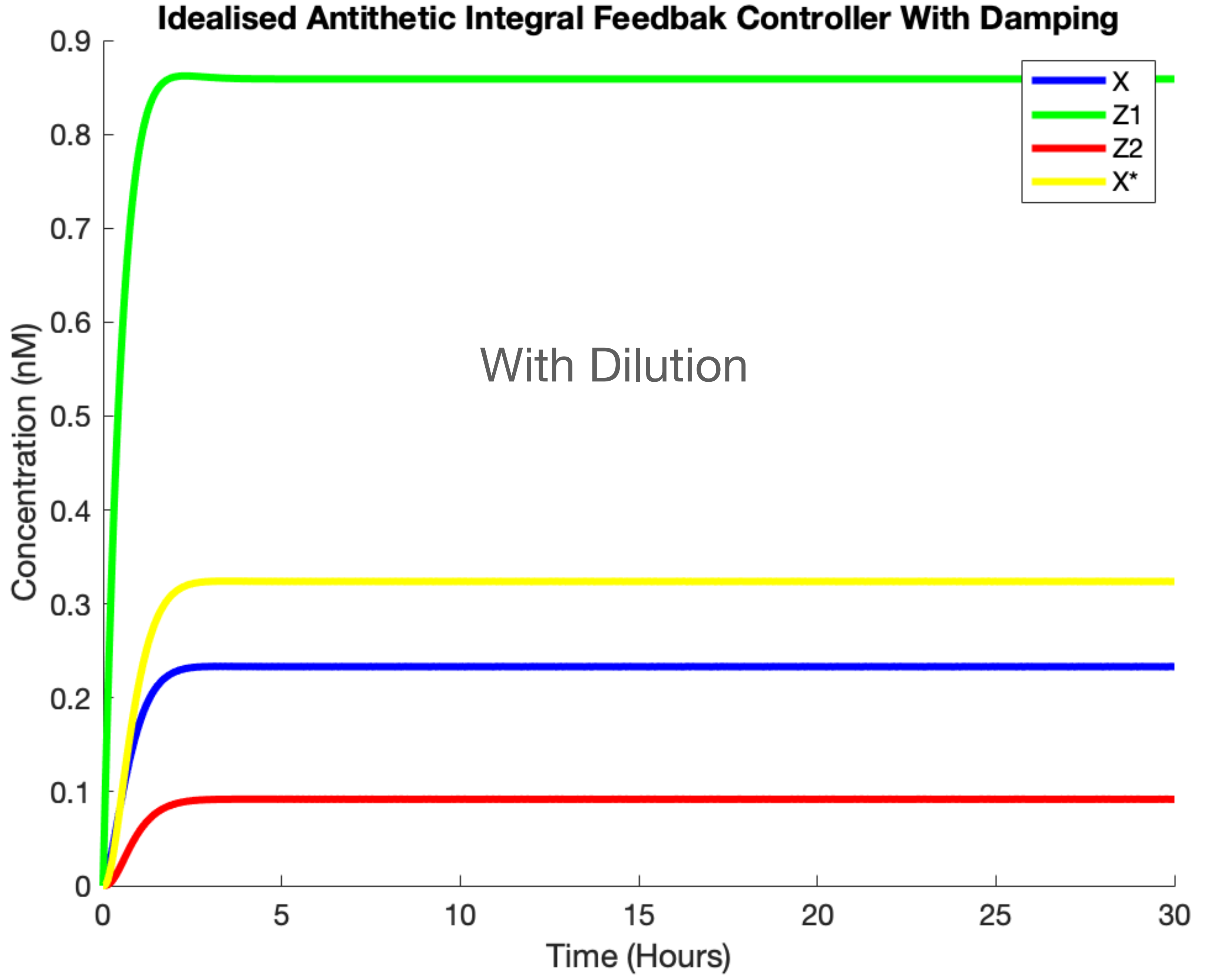
$$\frac{dX}{dt} = \mathrm{k} Z_1 - (\gamma + \delta)X - \alpha_1 X + \alpha_2 X^*$$

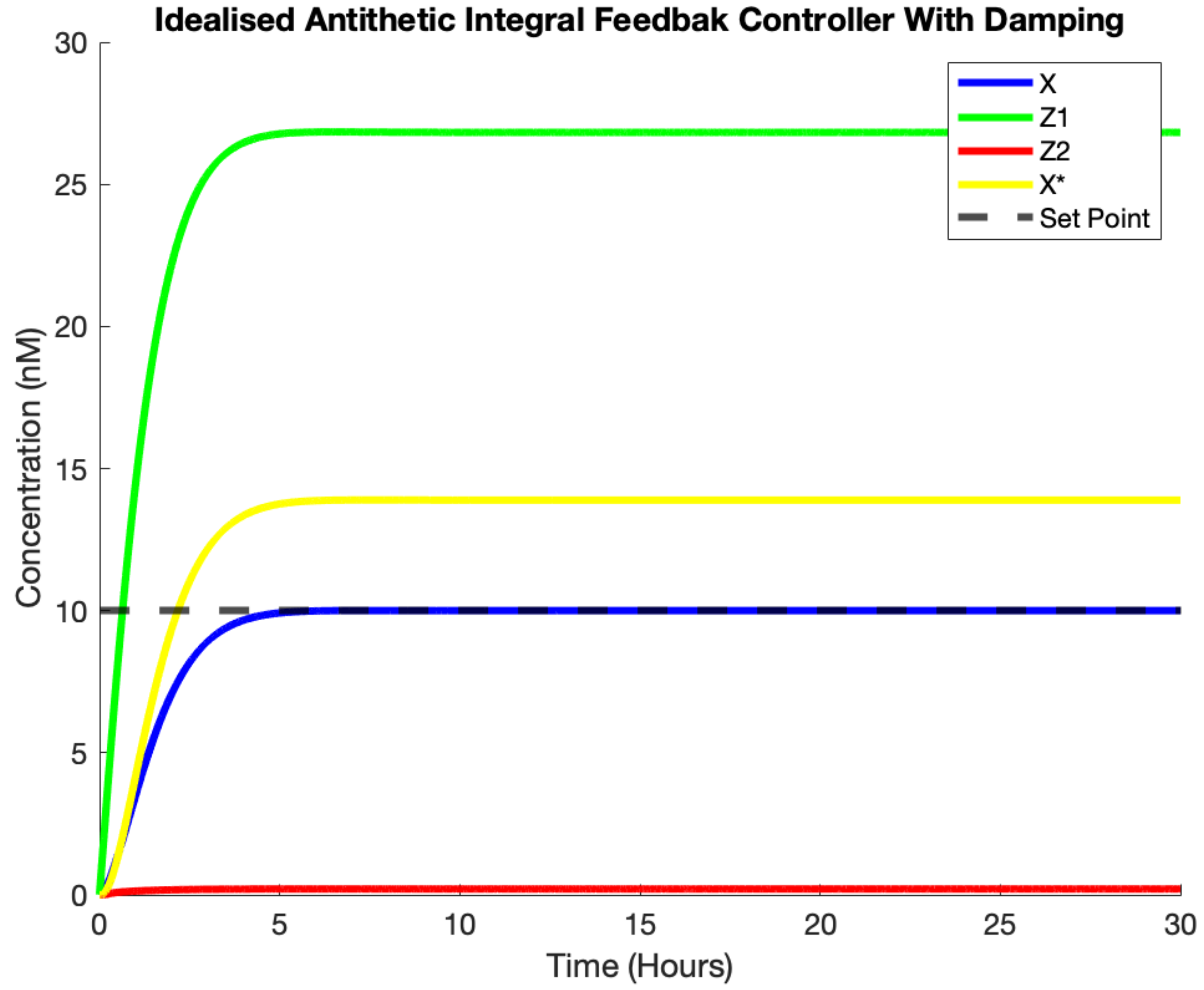
$$\frac{dX^*}{dt} = \alpha_1 X - \alpha_2 X^* - \gamma_* X^*$$

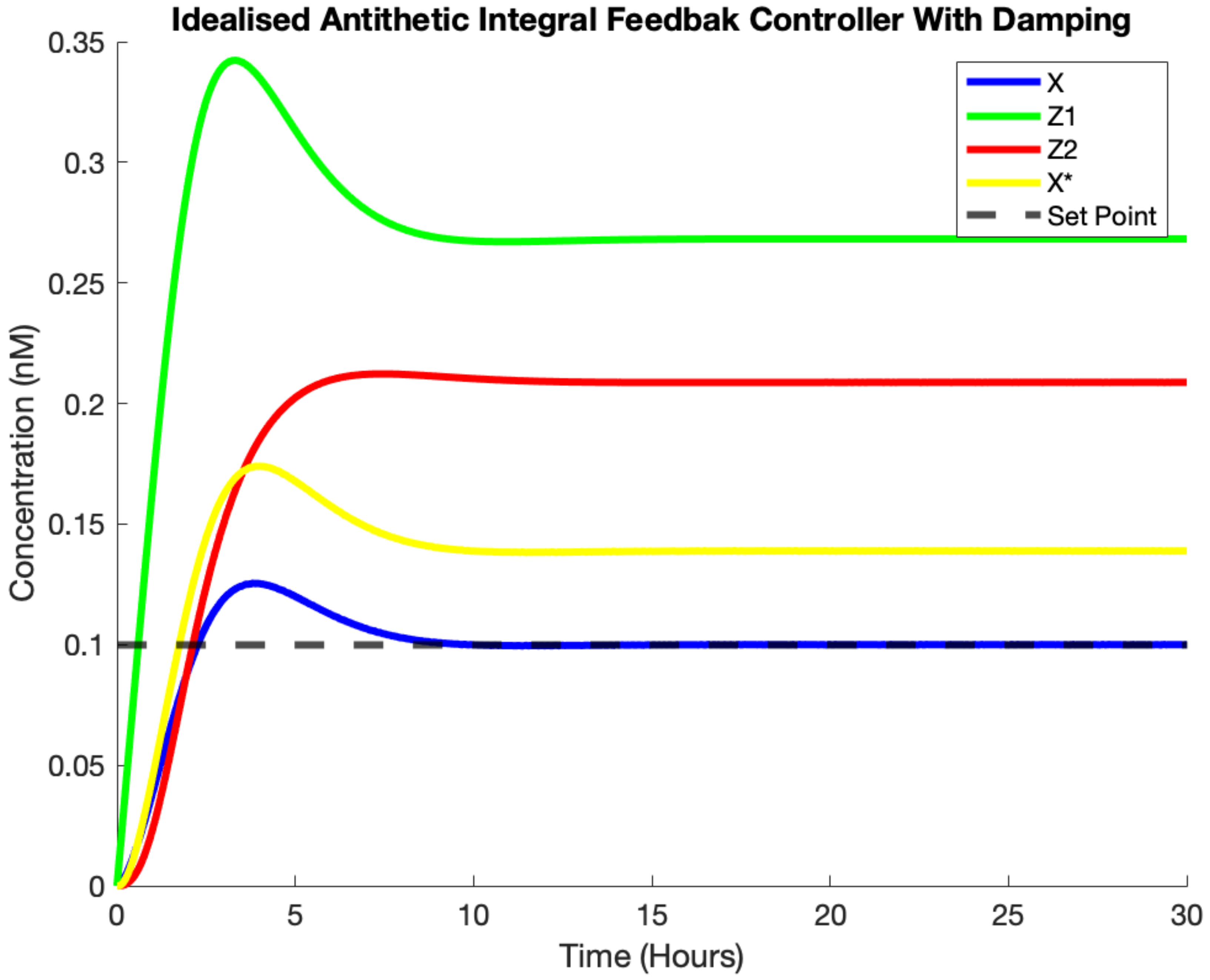
$$\text{setpoint} = \frac{\mu}{\theta}$$

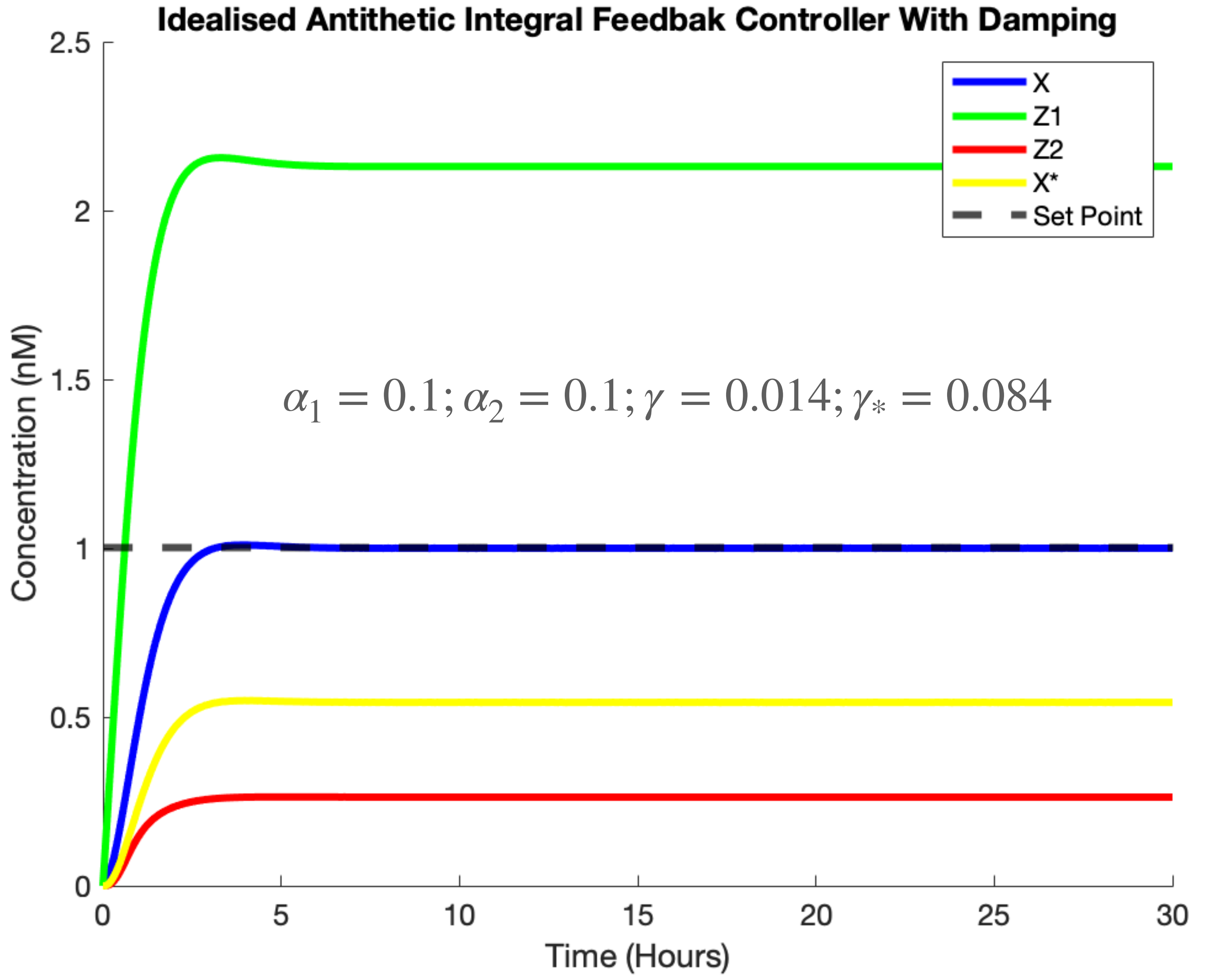
$\alpha_1 = 0.2; \alpha_2 = 0.1; \gamma = 0.014; \gamma_* = 0.044$



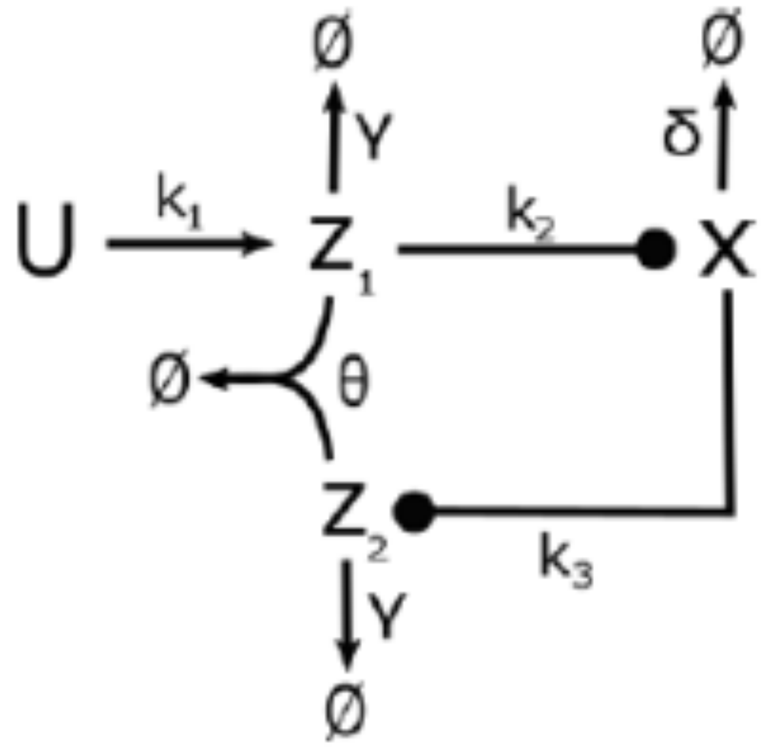








Antithetic sRNA Implementation



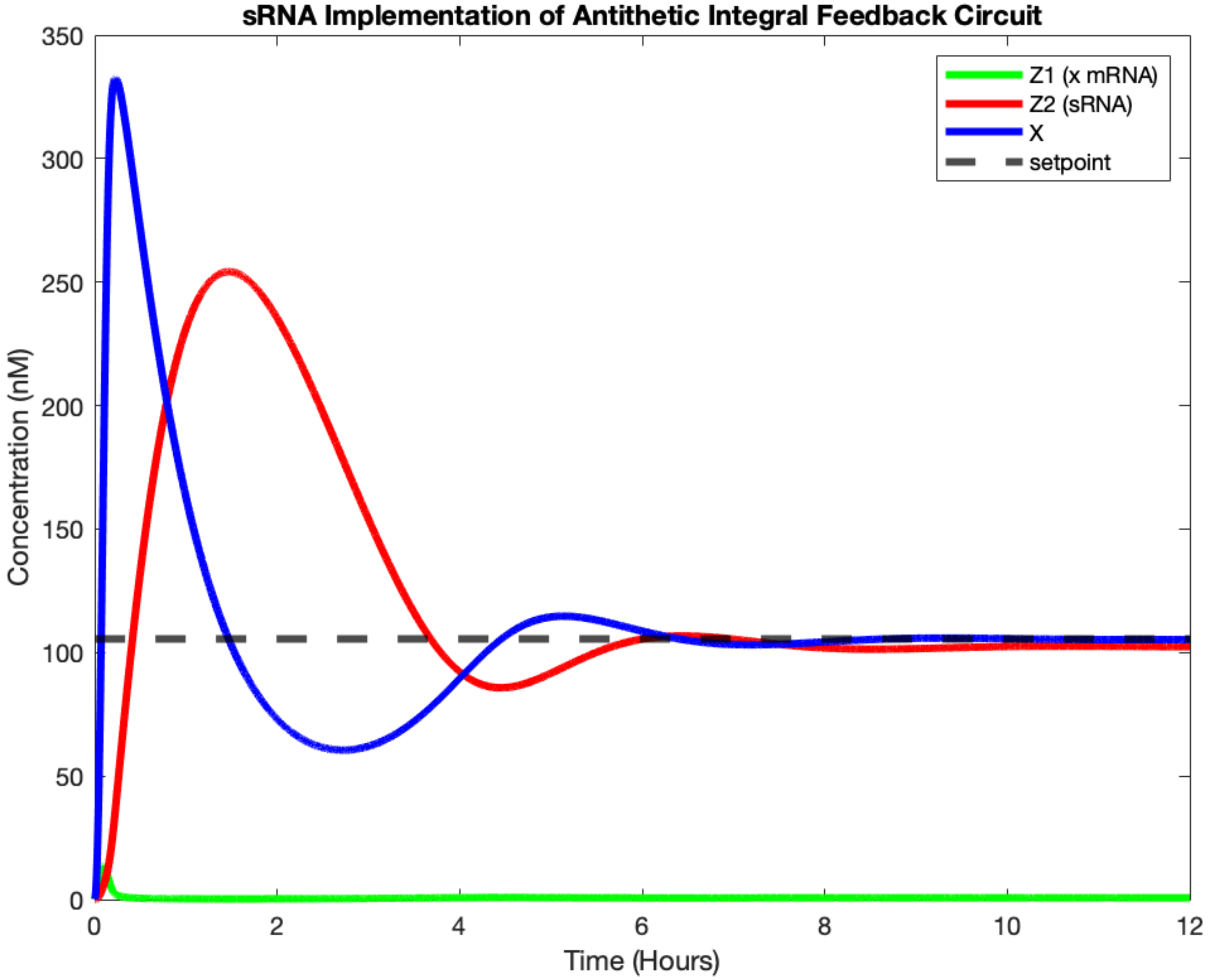
$$\frac{dZ_1}{dt} = \tau_1 + \frac{k_1 U}{K_U + U} - \gamma_m Z_1 - \theta Z_1 Z_2$$

$$\frac{dZ_2}{dt} = \tau_2 + \frac{k_3 X}{K_X + X} - \gamma_s Z_2 - \theta Z_1 Z_2$$

$$\frac{dX}{dt} = \tau_3 C + k_2 Z_1 - \delta X$$

$$\frac{dC}{dt} = \theta Z_1 Z_2 - \delta_C C$$

Without Dilution/Degradation



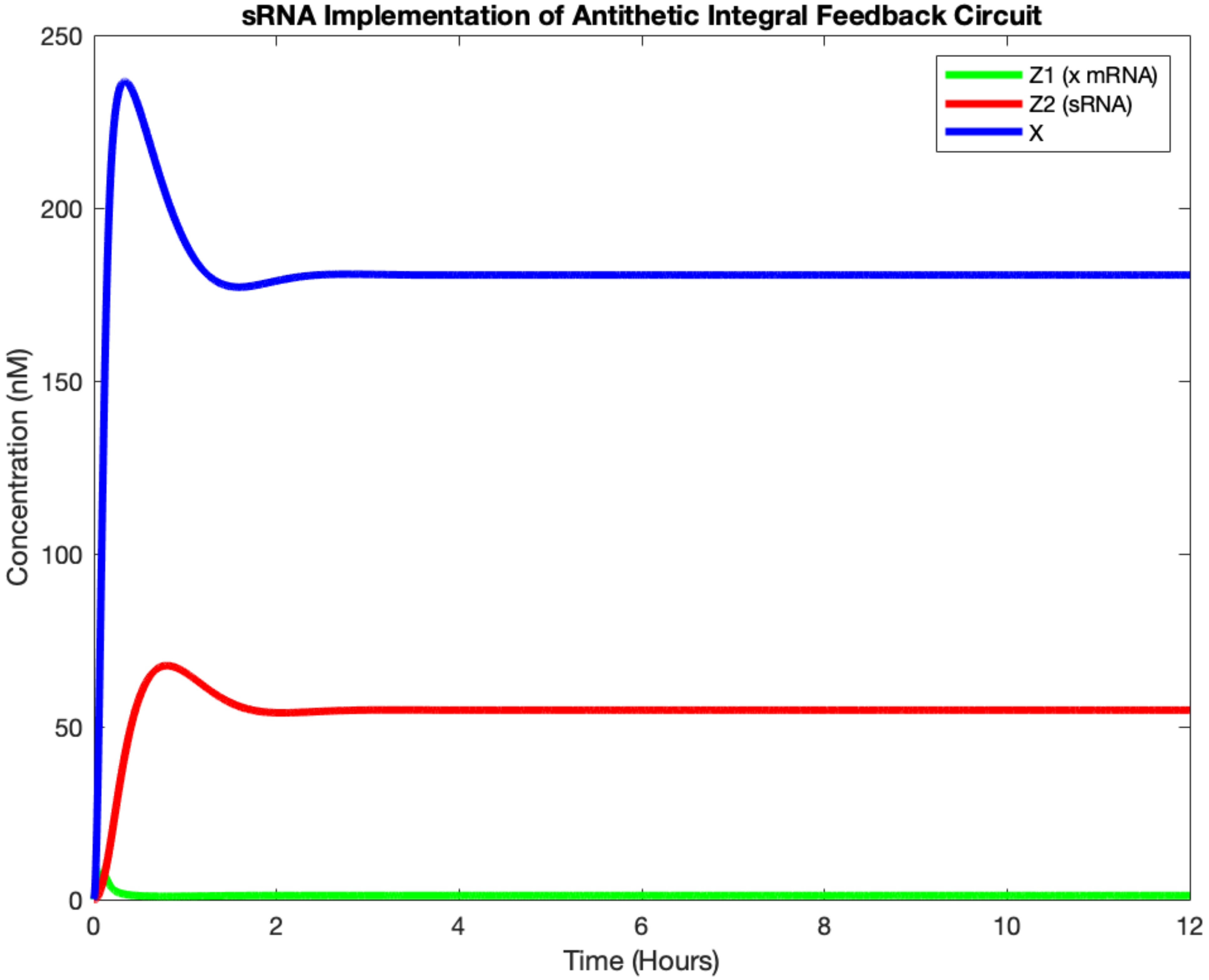
$\tau_1 = 0; \tau_2 = 0; \tau_3 = 0; \gamma_m = 0; \gamma_s = 0$

$k_1 = 0.1$ nMs^{-1}; $k_2 = 0.06$ s^{-1}; $k_3 = 1.5$ nMs^{-1}

$\theta = 0.05$ nM^{-1}s^{-1}; $\delta = 0.00039$ s^{-1}; $\delta_C = 0.0041$ s^{-1}

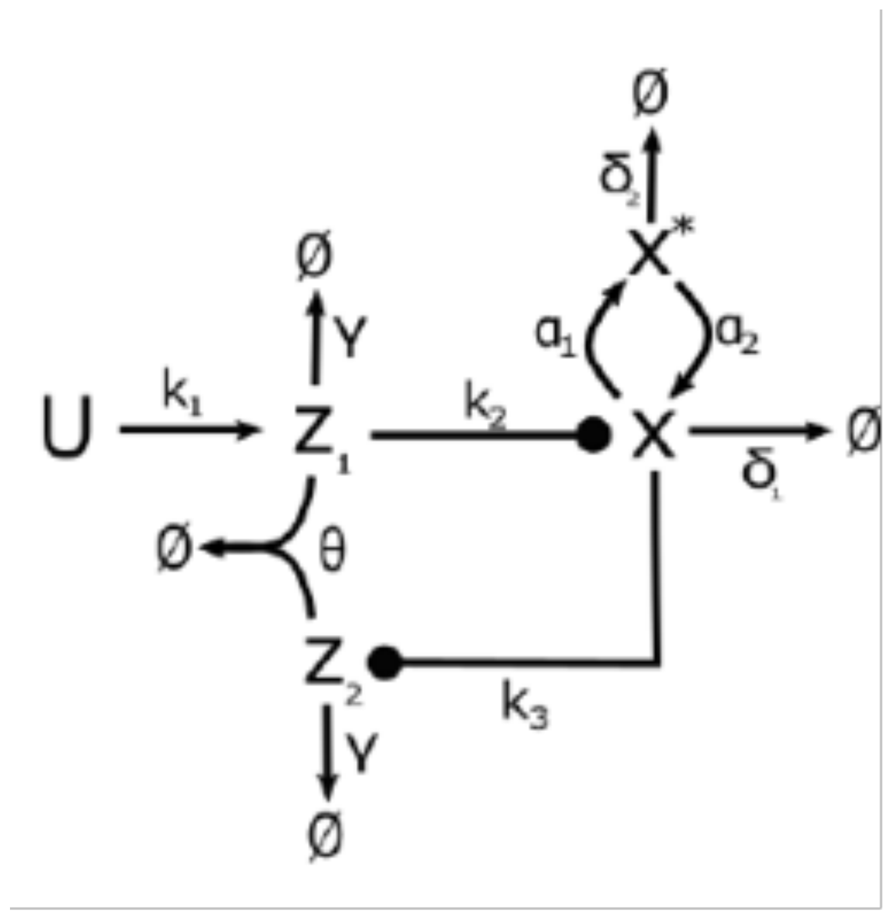
$K_U = 178000$ nM; $K_X = 2600$ nM

With Dilution/Degradation



$\gamma_m = 0.0041$ s^{-1}; $\gamma_s = 0.0008$ s^{-1}

Antithetic sRNA Implementation with Damping



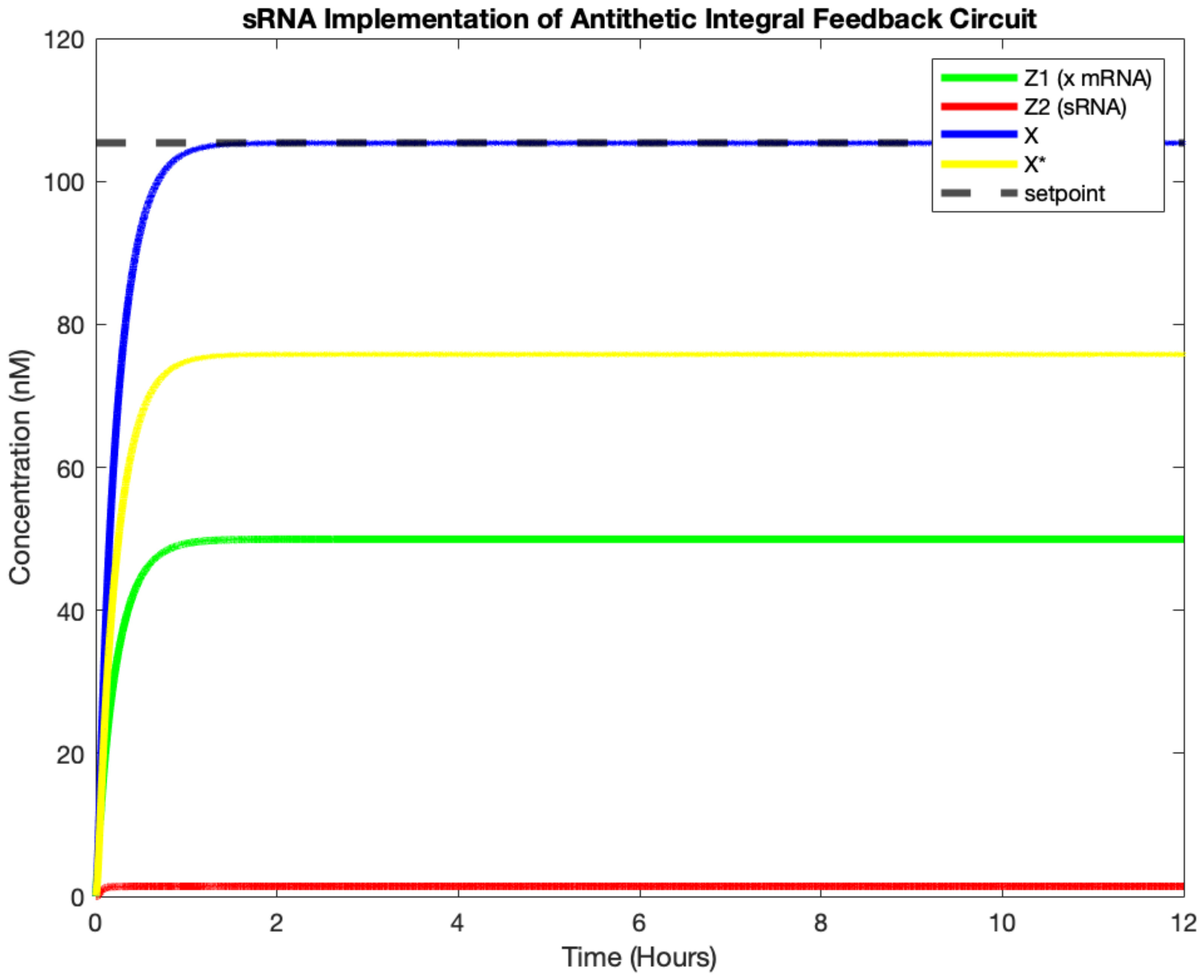
$$\frac{dZ_1}{dt} = \tau_1 + \frac{k_1 U}{K_U + U} - \gamma_m Z_1 - \theta Z_1 Z_2$$

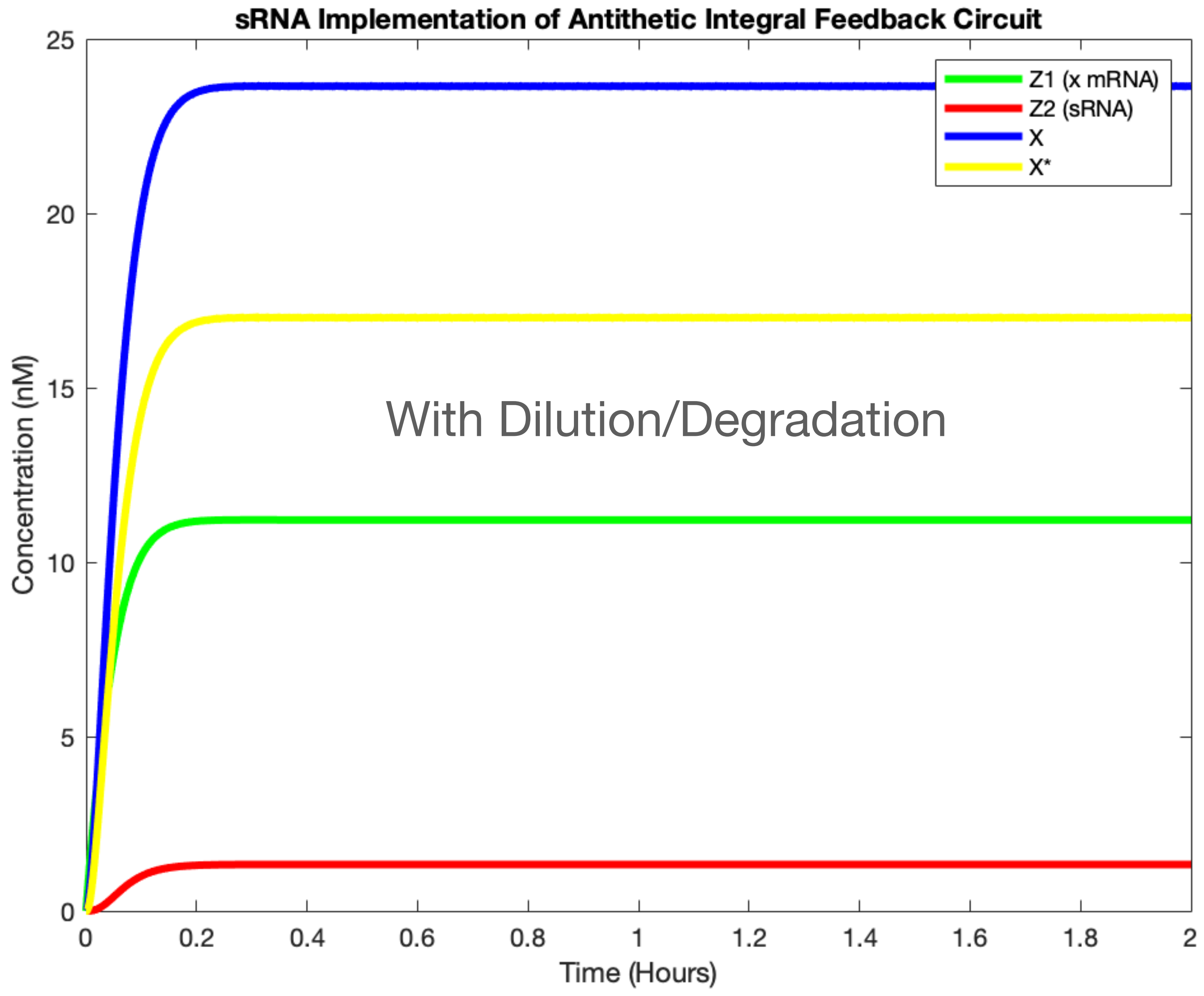
$$\frac{dZ_2}{dt} = \tau_2 + \frac{k_3 X}{K_X + X} - \gamma_s Z_2 - \theta Z_1 Z_2$$

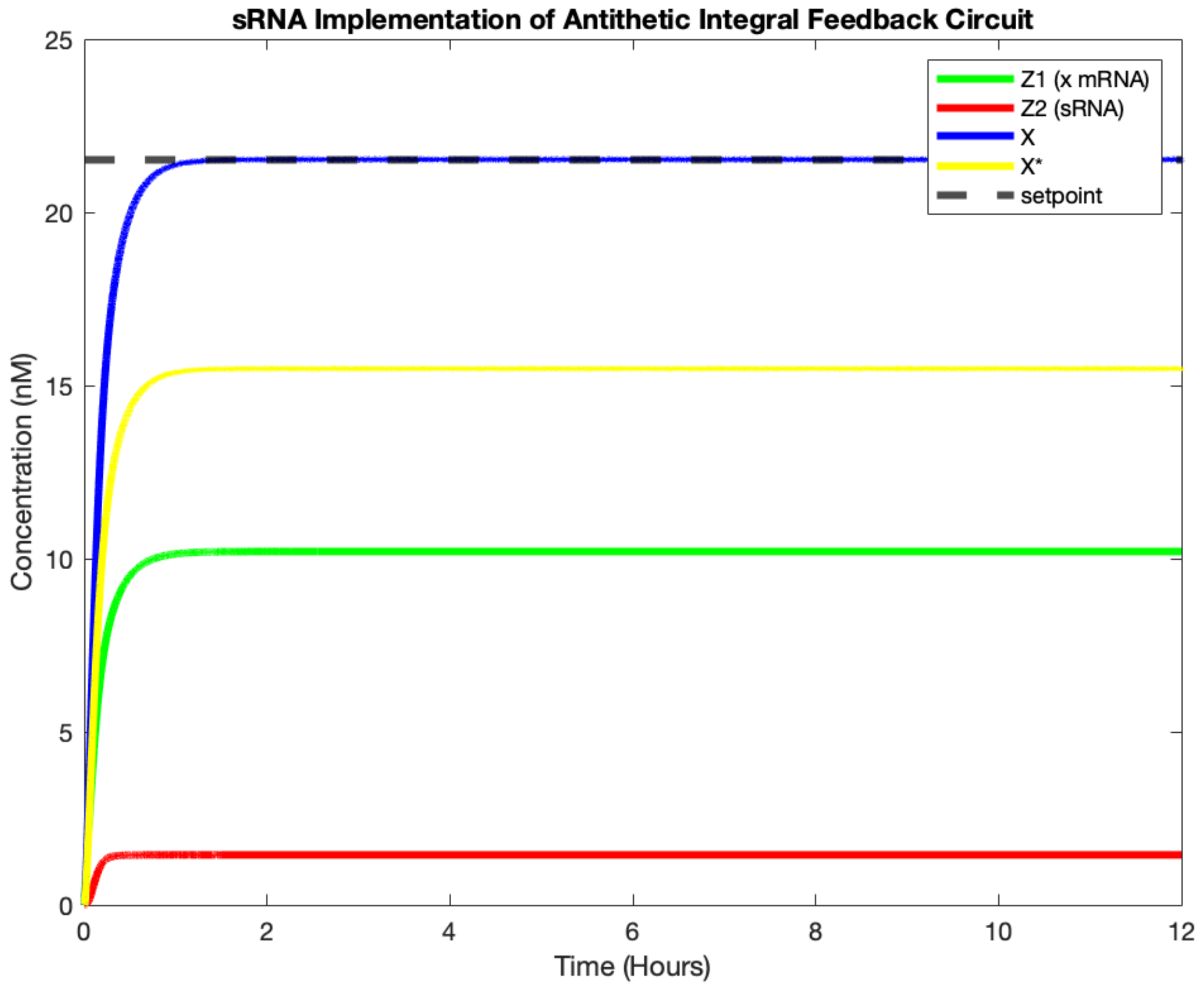
$$\frac{dX}{dt} = \tau_3 C + k_2 Z_1 - \delta X - \alpha_1 X + \alpha_2 X^*$$

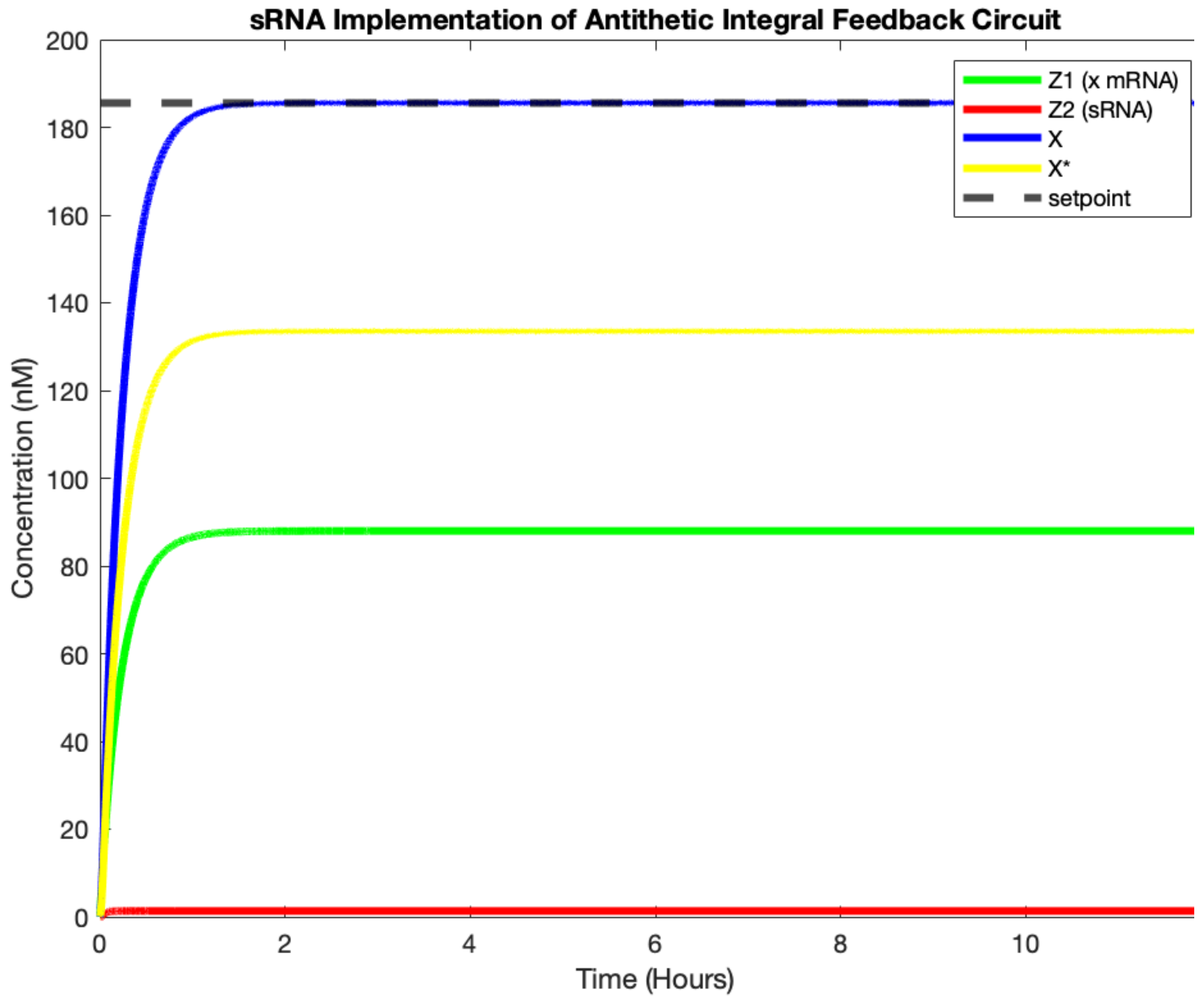
$$\frac{dC}{dt} = \theta Z_1 Z_2 - \delta_C C$$

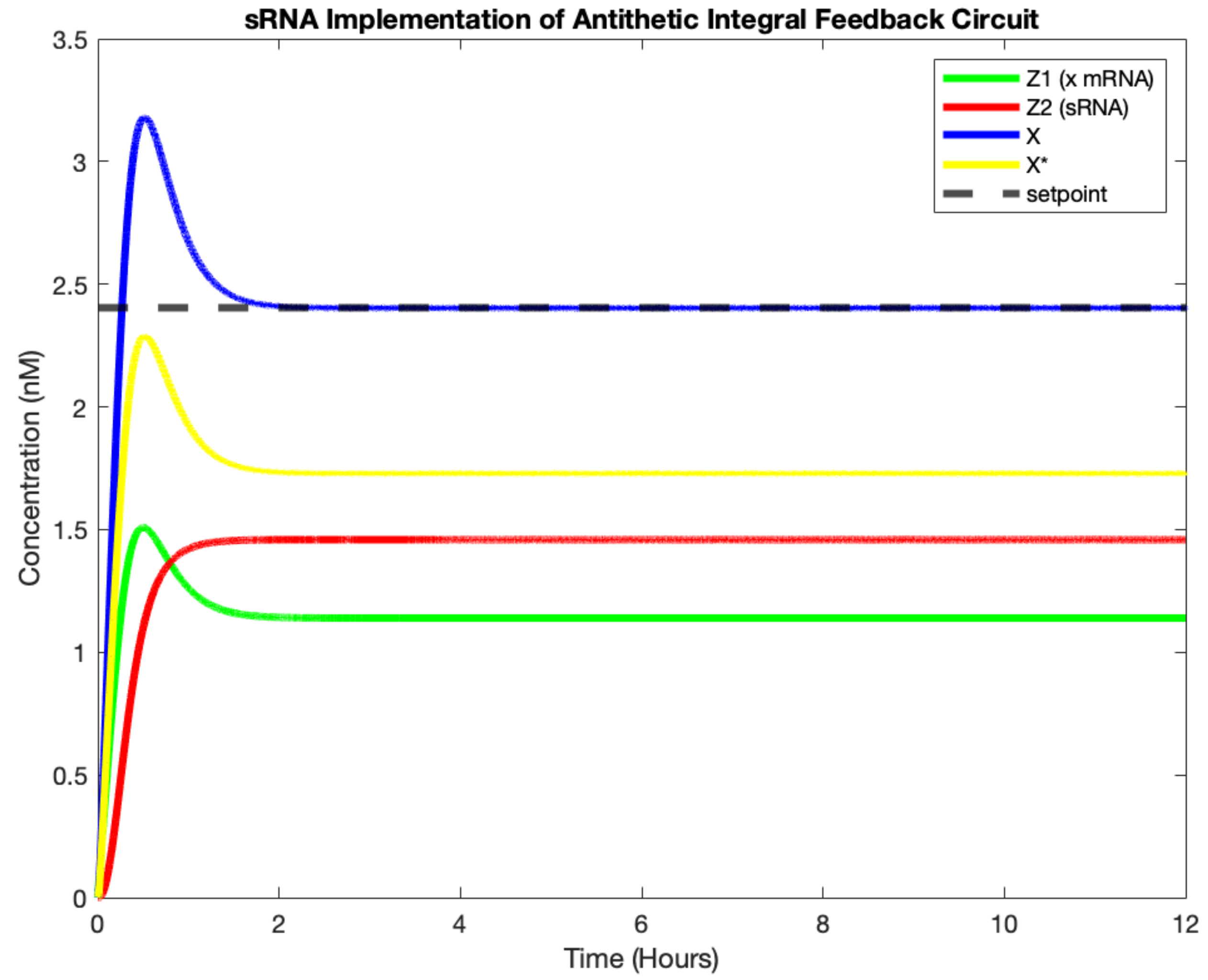
$$\frac{dX^*}{dt} = \alpha_1 X - \alpha_2 X^* - \delta_* X^*$$











Can tune this to make it work by increasing alpha 1 but always stops working at some point and leads to more X* than X in the system

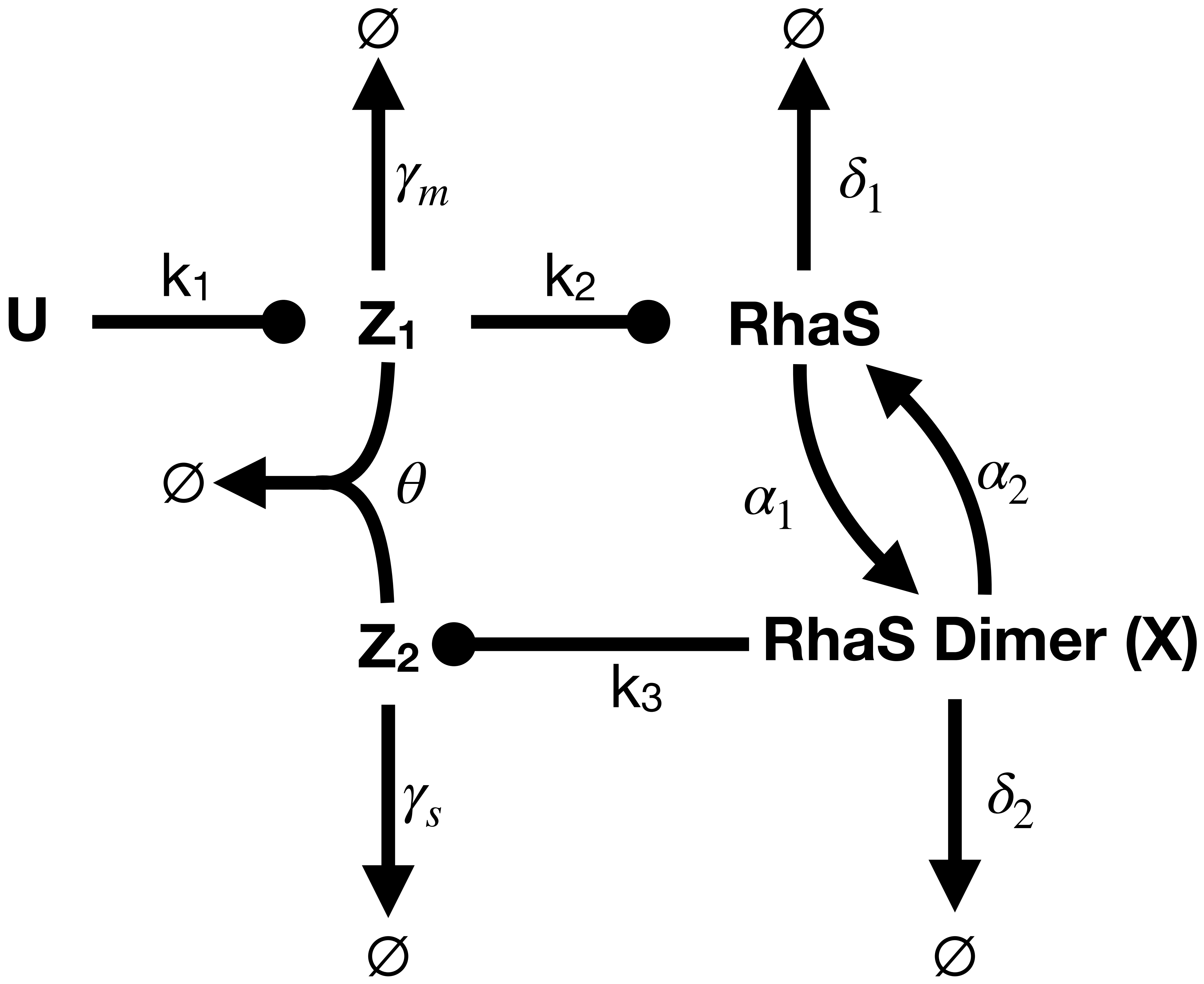
$\alpha_1 = 0.1\ \text{s}^{-1}; \alpha_2 = 0.1\ \text{s}^{-1}; \delta = 0.00039\ \text{s}^{-1}; \delta_* = 0.039\ \text{s}^{-1}$

sRNA RhaS PI Controller

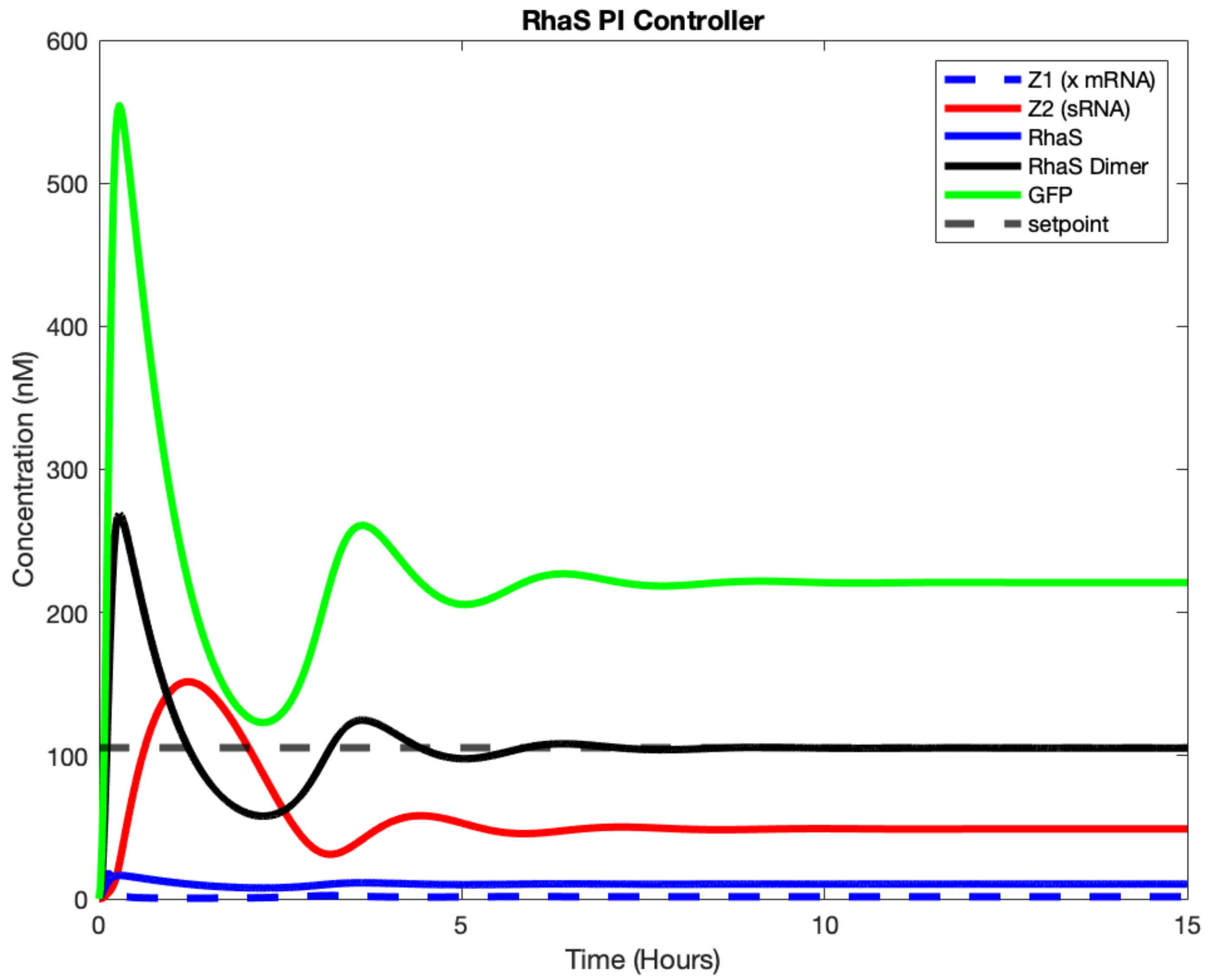
$$\frac{dZ_1}{dt} = \frac{k_1 U}{K_U + U} - \gamma_m Z_1 - \theta Z_1 Z_2 \qquad \frac{dZ_2}{dt} = \frac{k_3 X}{K_X + X} - \gamma_s Z_2 - \theta Z_1 Z_2$$

$$\frac{d\text{RhaS}}{dt} = k_2 Z_1 - \delta_1 \text{RhaS} - 2\alpha_1 \text{RhaS}^2 + 2\alpha_2 X$$

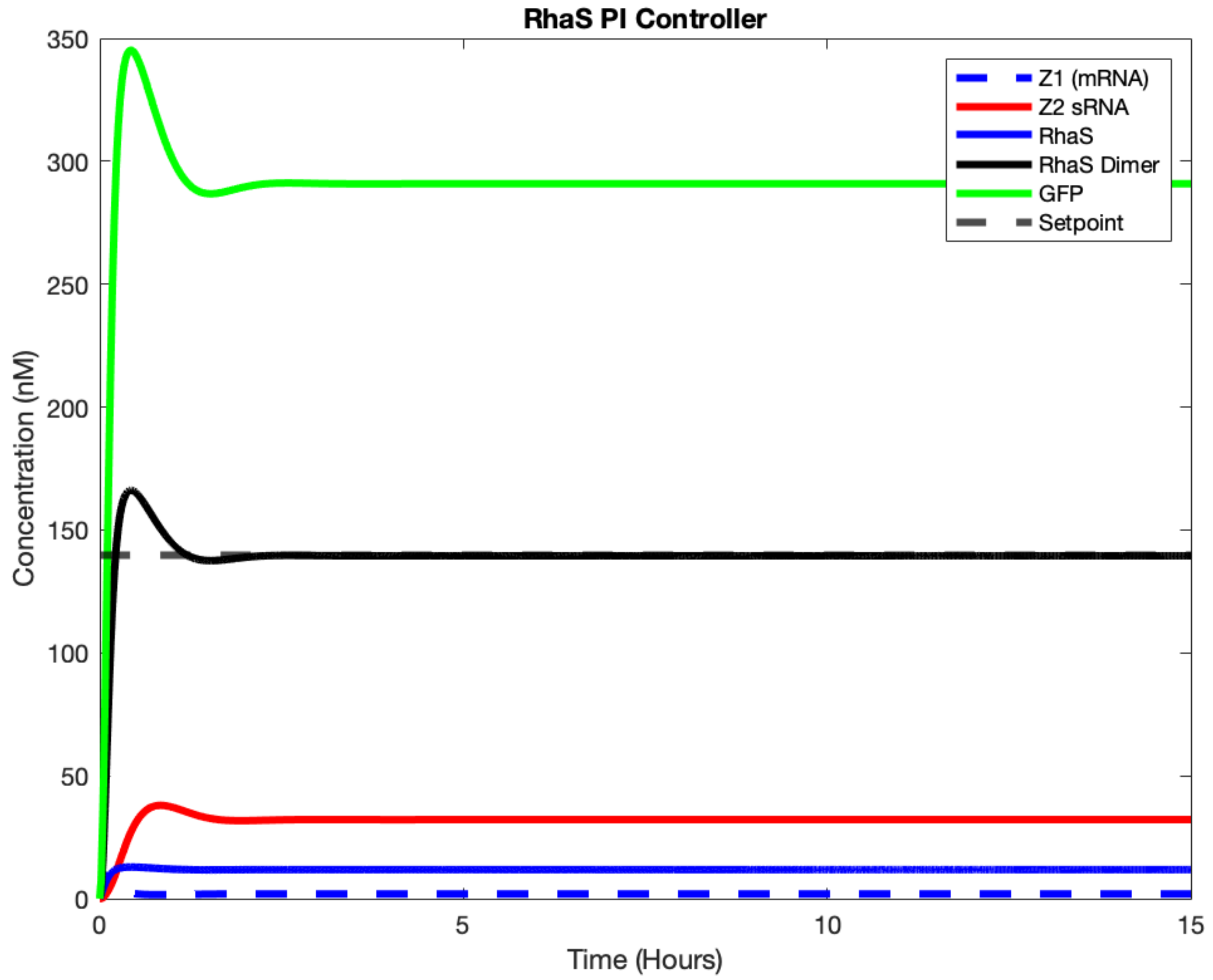
$$\frac{dX}{dt} = \alpha_1 \text{RhaS}^2 - \alpha_2 X - \delta_2 X$$



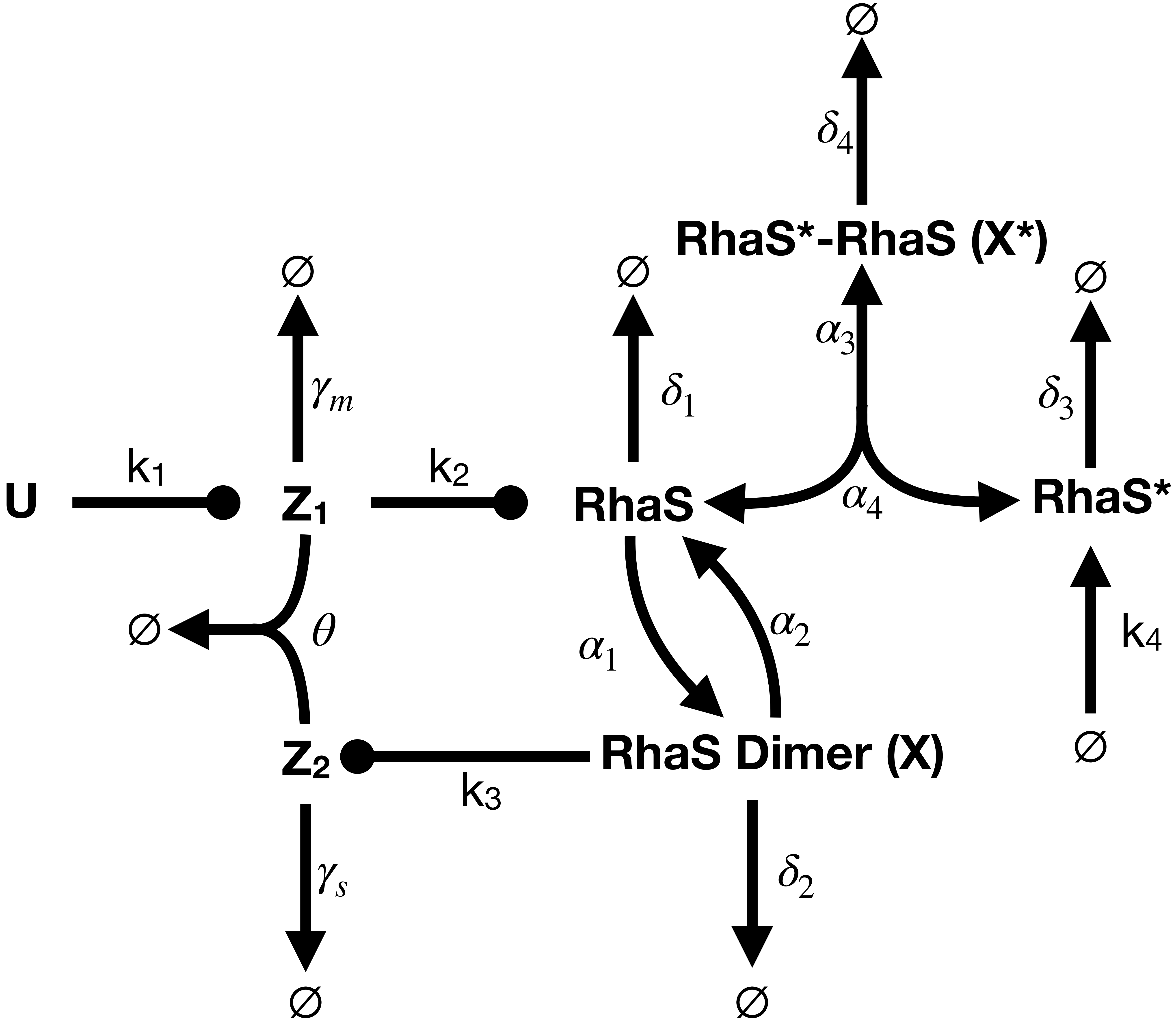
No Dilution/ degradation of Z1 and Z2



Dilution/degradation of Z1 and Z2



sRNA RhaS PID Controller



$$\frac{dZ_1}{dt} = \frac{k_1 U}{K_U + U} - \gamma_m Z_1 - \theta Z_1 Z_2$$

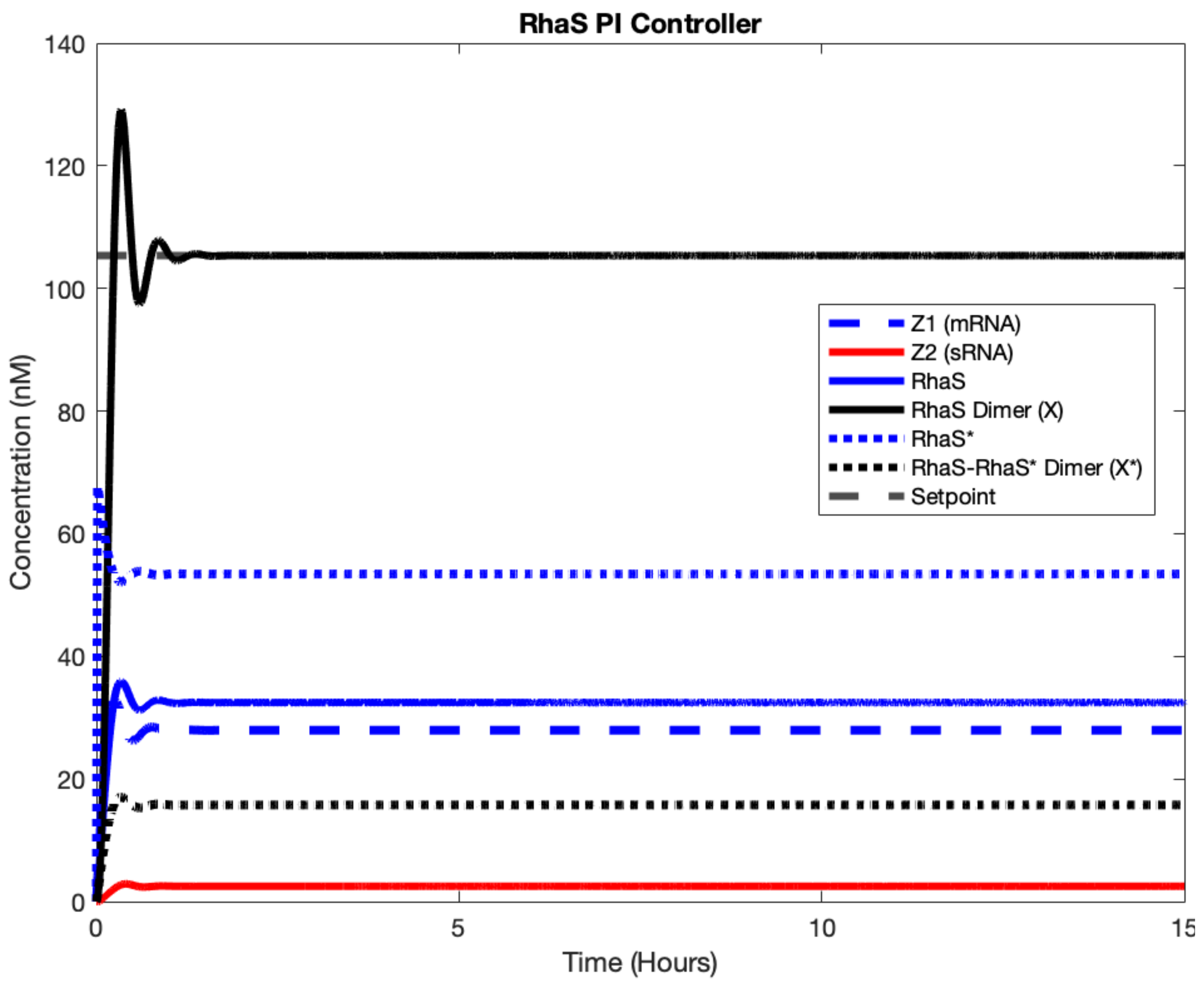
$$\frac{dZ_2}{dt} = \frac{k_3 X}{K_X + X} - \gamma_s Z_2 - \theta Z_1 Z_2$$

$$\frac{d\text{RhaS}}{dt} = k_2 Z_1 - \delta_1 \text{RhaS} - 2\alpha_1 \text{RhaS}^2 + 2\alpha_2 X - \alpha_3 \text{RhaS RhaS}^* + \alpha_4 X^*$$

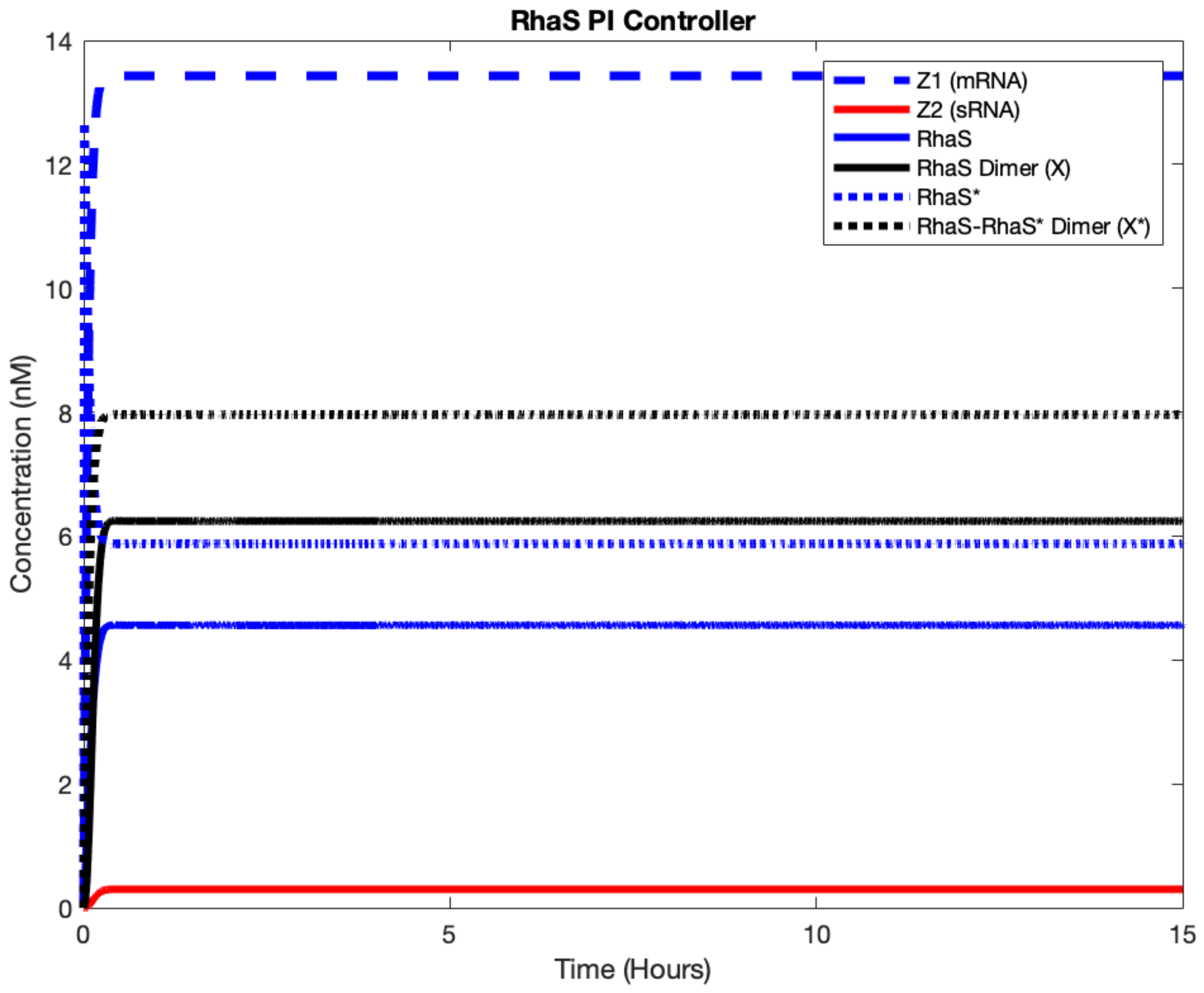
$$\frac{d\text{RhaS}^*}{dt} = k_4 - \delta_3 \text{RhaS}^* - \alpha_3 \text{RhaS RhaS}^* + \alpha_4 X^*$$

$$\frac{dX}{dt} = \alpha_1 \text{RhaS}^2 - \alpha_2 X - \delta_2 X$$

$$\frac{dX^*}{dt} = \alpha_3 \text{RhaS RhaS}^* - \alpha_4 X^* - \delta_4 X^*$$

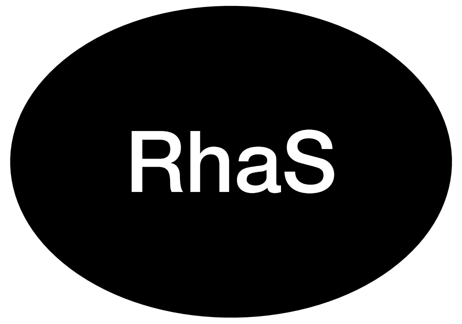


Gammas = 0
Closest I got



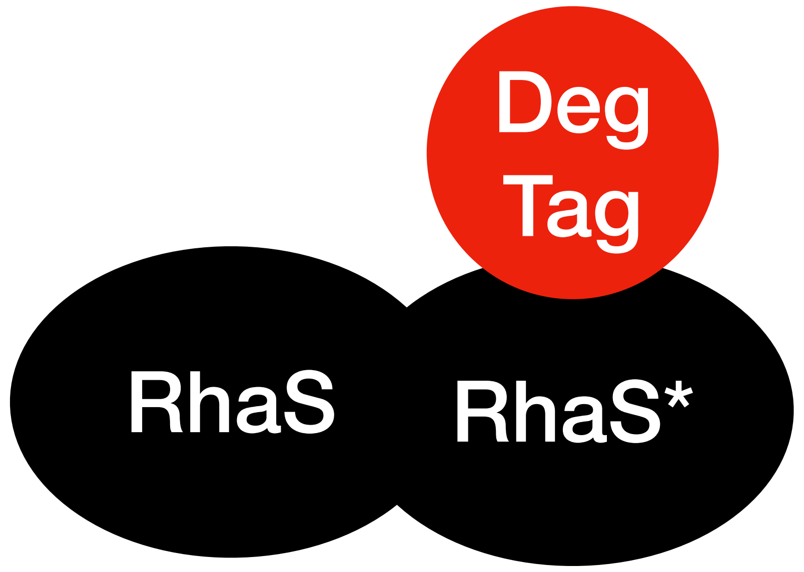
Gammas non 0

Still a bit confused as to how degradation of the mixed dimer would work



Degraded at dilution rate

Degraded at dilution rate
+ deg tag rate



Degraded at dilution rate
+ deg tag rate ?

At half deg tag rate because you’re degrading more protein?

Are both parts degraded or is RhaS released?

Change this so some RhaS is released on degradation of the dimer

A Possible solution to the GFP problem is to have a TF being controlled by Z2 that produces the Z1 mRNA
And then have the buffering act upon that transcription factor rather than the output