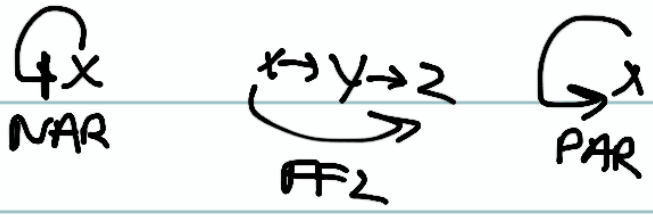
Overall: 

Topics:

→ Response/Rise Time

→ Robustness [Effect upon small noise/errors] / Steady State Accuracy

→ Filtering

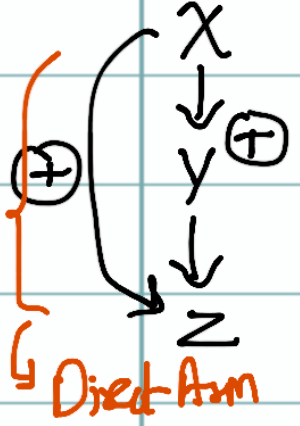
→ Sign-sensitive delay

→ Pulse Generation

∴

20th Oct, 2020

Feedforward Loop



⊣ → Refers to activation

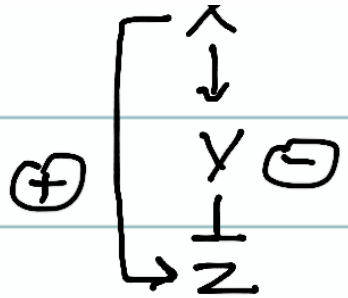
→ Activation

⊣ Inhibition

Total feed forward loops = 8 $[2^3]$ → No. of nodes, → No. of path

Coherent [C-FFL]

Incoherent



→ Same signs

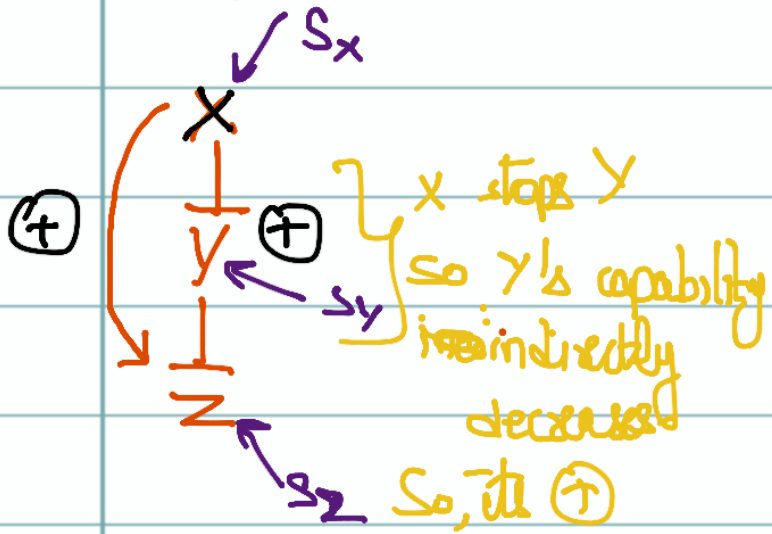
→ 4 combinations

(+,+), (−,−)

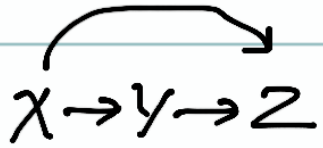
→ Different signs

→ 4 combinations

(+,−), (−,+)



Coherent Feedforward loops :



$$\frac{dz}{dt} = k_{s_z}\,\theta(x > k_{xz})\,\theta(y > k_{yz}) - k_{d_z} z$$

AND Logic

K_{xz}, K_{yz} are activation thresholds

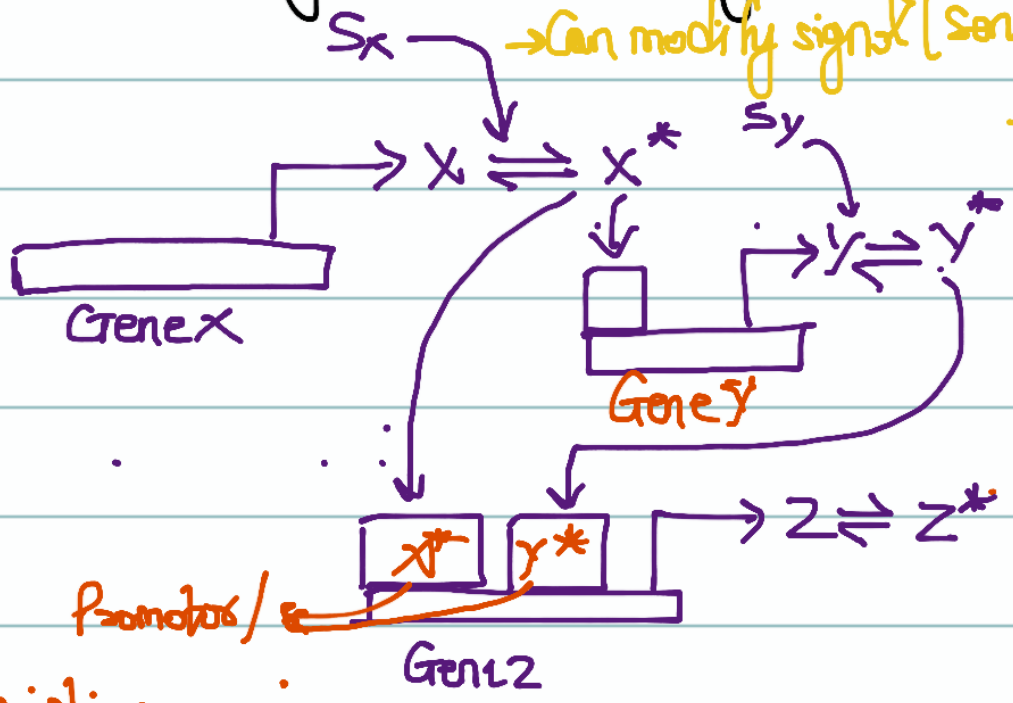
K_{sz} = Synthesis of Z

K_{dz} = Degradation of Z

S_x, S_x, S_z : Input signals

In C-FFL, they can recieve signals

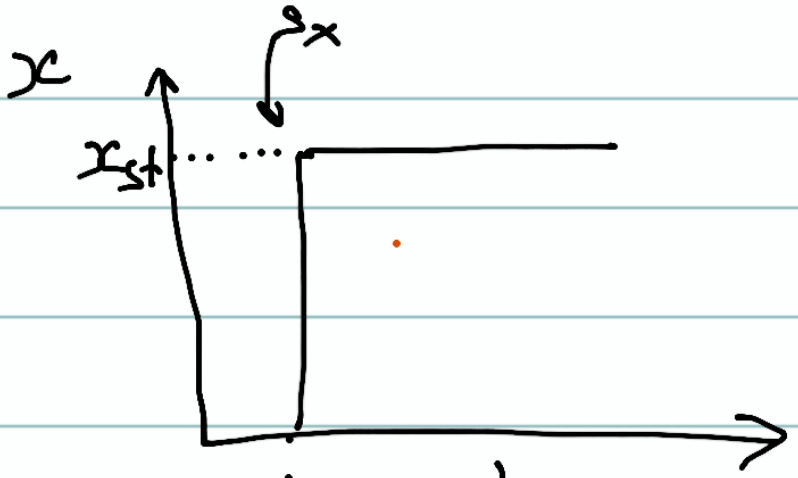
Mechanism



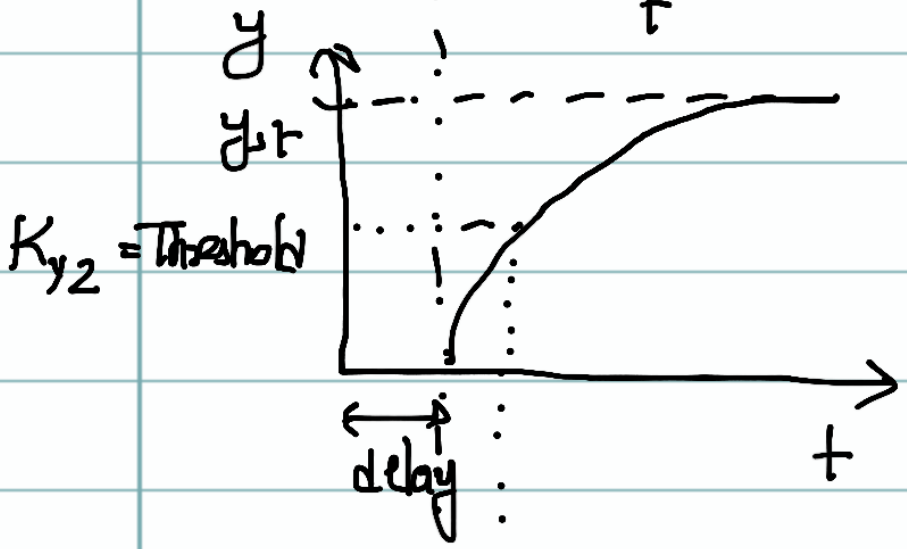
Transcription activators that bind to gene

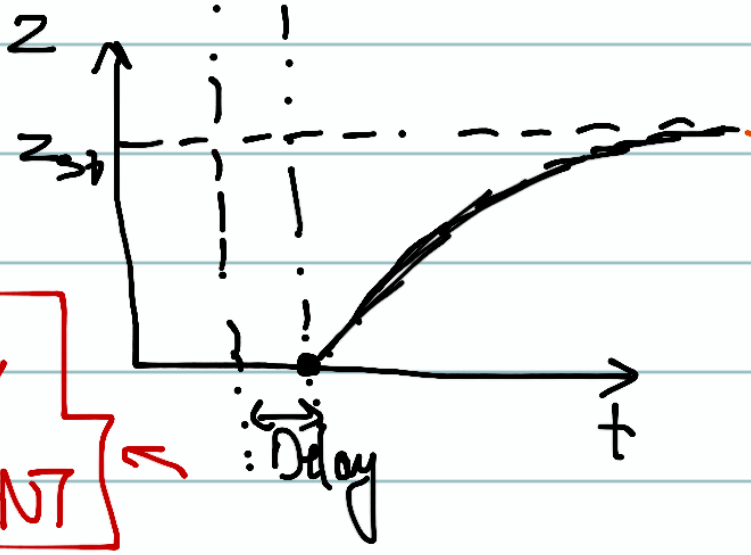
x, y gets modified and help in synthesis of Z

$\frac{dz}{dt} = -Kx$ → Not possible, there's always some state



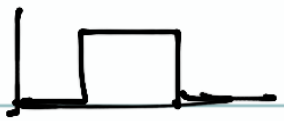
Assume X changes in step wise matter



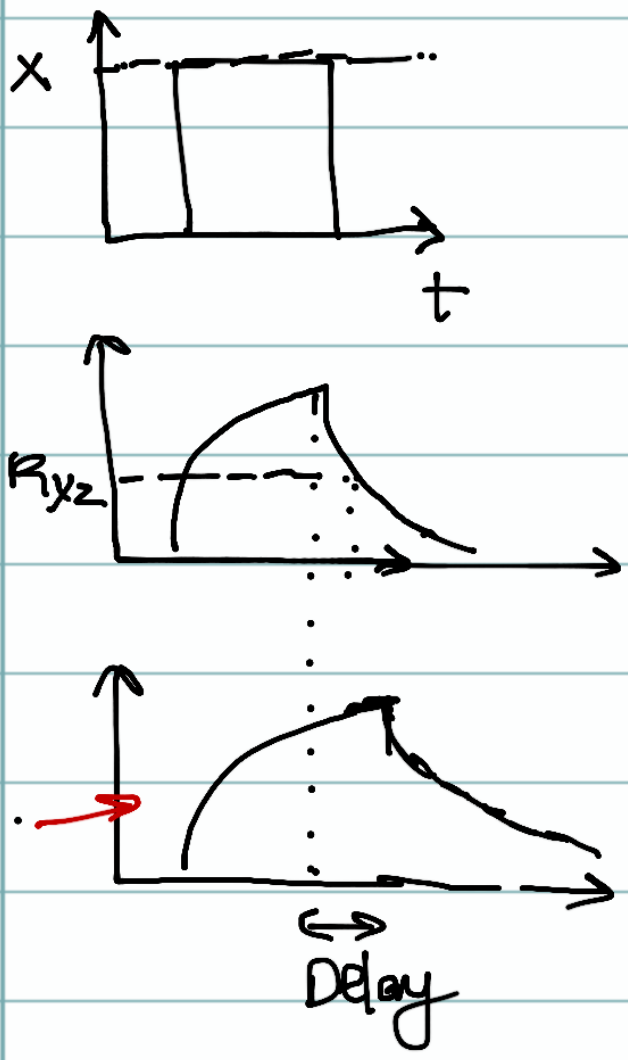


Ability to create delay

DELAY ELEMENT

If X is shut off after a point,  then Y, Z will immediately begin to fall without delay.

OR Logic :



→ Delay is in inactivation

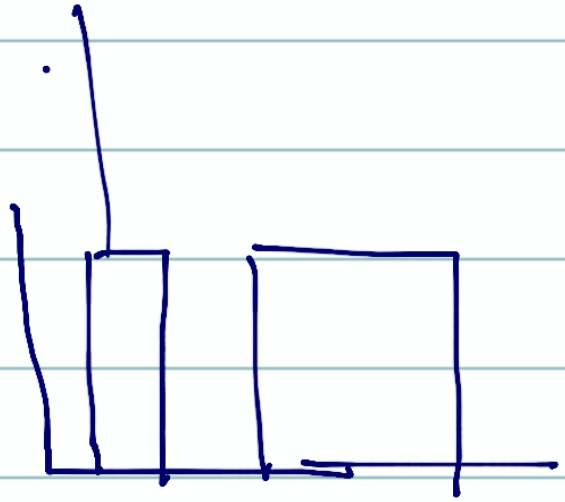
→ Doesn't decrease for sometime

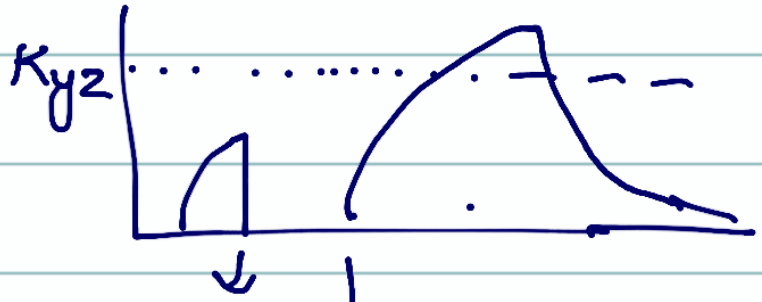
CALLED SIGN SENSITIVE DELAY ELEMENT (BASED ON AND/OR

Example: Elevator

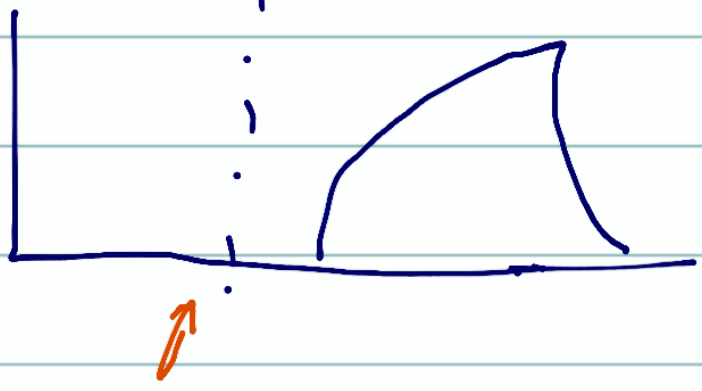
↳ Keeps hand open immediately. [Quick]

↳ If remove hand, then slowly [Slow]





If threshold is not reached, then y will immediately drop

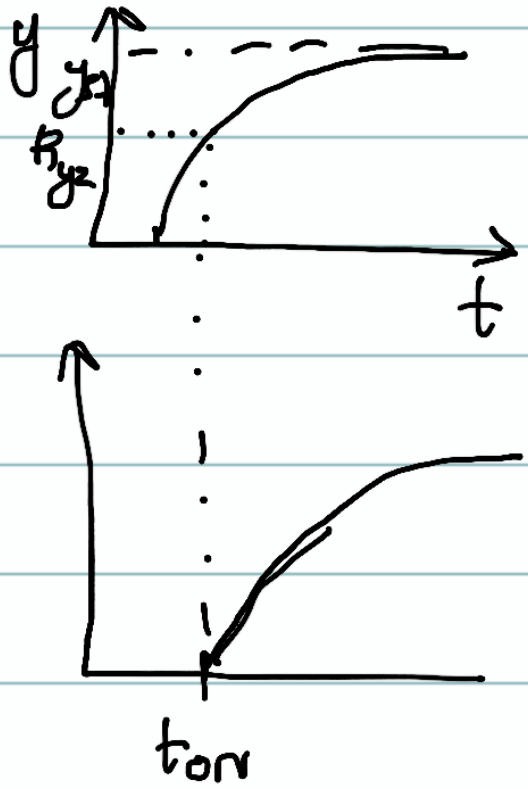


Coincidence detector

IMP

Acts as a filter so it avoid all signals less than threshold and the system is sustained

Calculate t_{ON},



$$\frac{dy}{dt} = k_{sy}X - k_{dy}Y$$

$$\frac{dy}{dt} = k_{sy} - k_{dy}Y$$

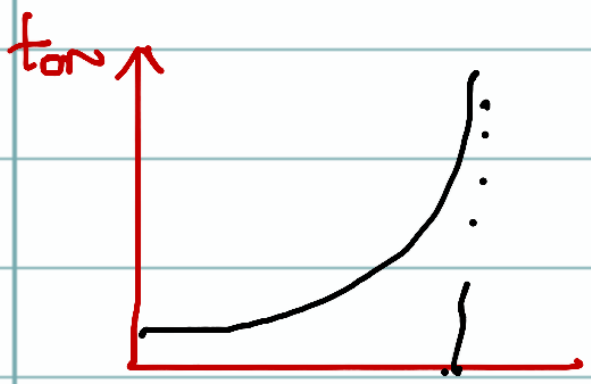
$$y = y_{st}\left(1 - e^{-k_{dy}t}\right)$$

$$k_{y2} = y_{st}\left(1 - e^{-k_{dy}t}\right)$$

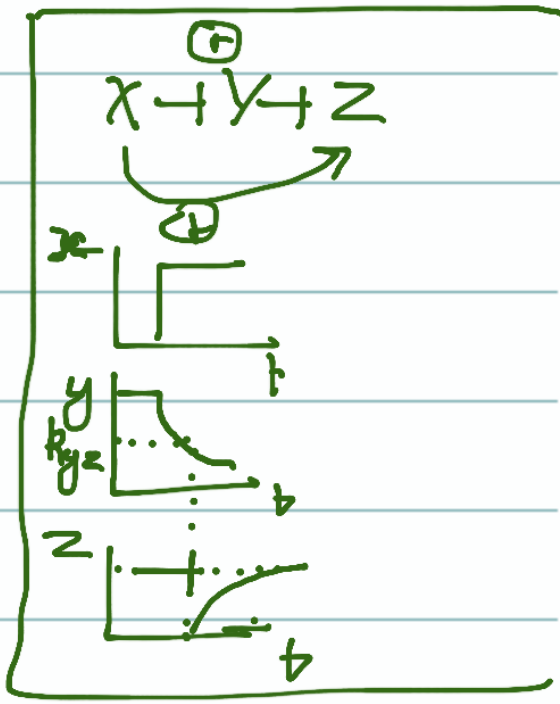
$$e^{-k_{dy}t} = 1 - \frac{k_{y2}}{y_{st}}$$

$$+k_{dy}t = \ln\left(\frac{y_{st}}{y_{st} - k_{dy}}\right)$$

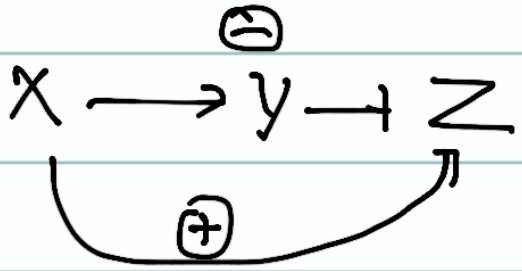
$$t_{ON} = \frac{1}{k_{DY}} \ln\left[\frac{y_{st}}{y_{st} - k_{y2}}\right]$$

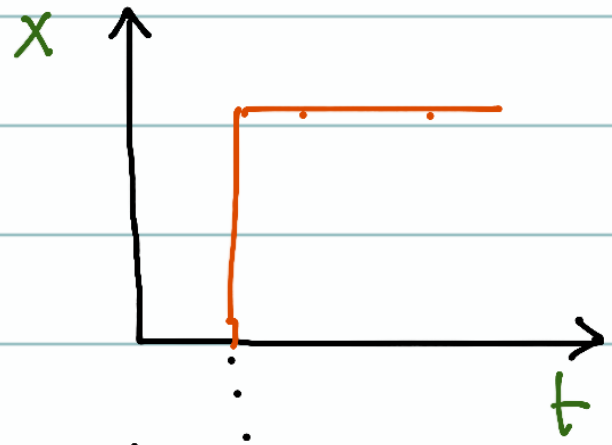


$\left(\frac{K_{yz}}{y_{st}}\right)$



Incoherent-FFL:

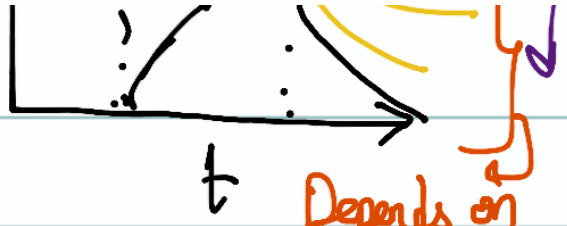




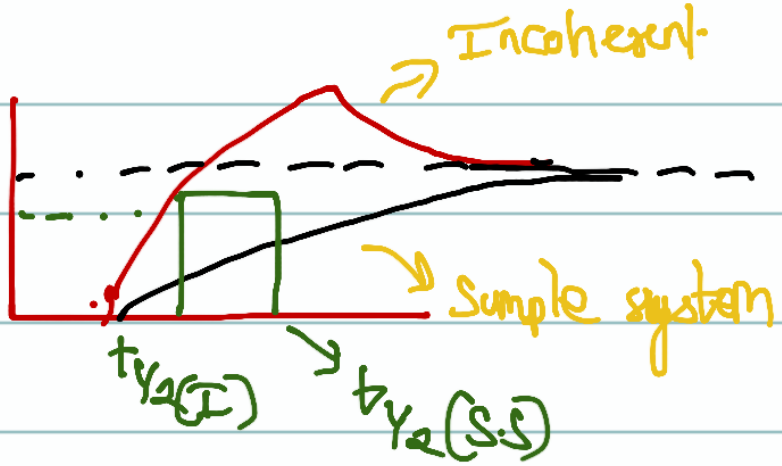
→ Increasing F, more repression so, lower steady state.

→ Increasing F will adjust steady state.

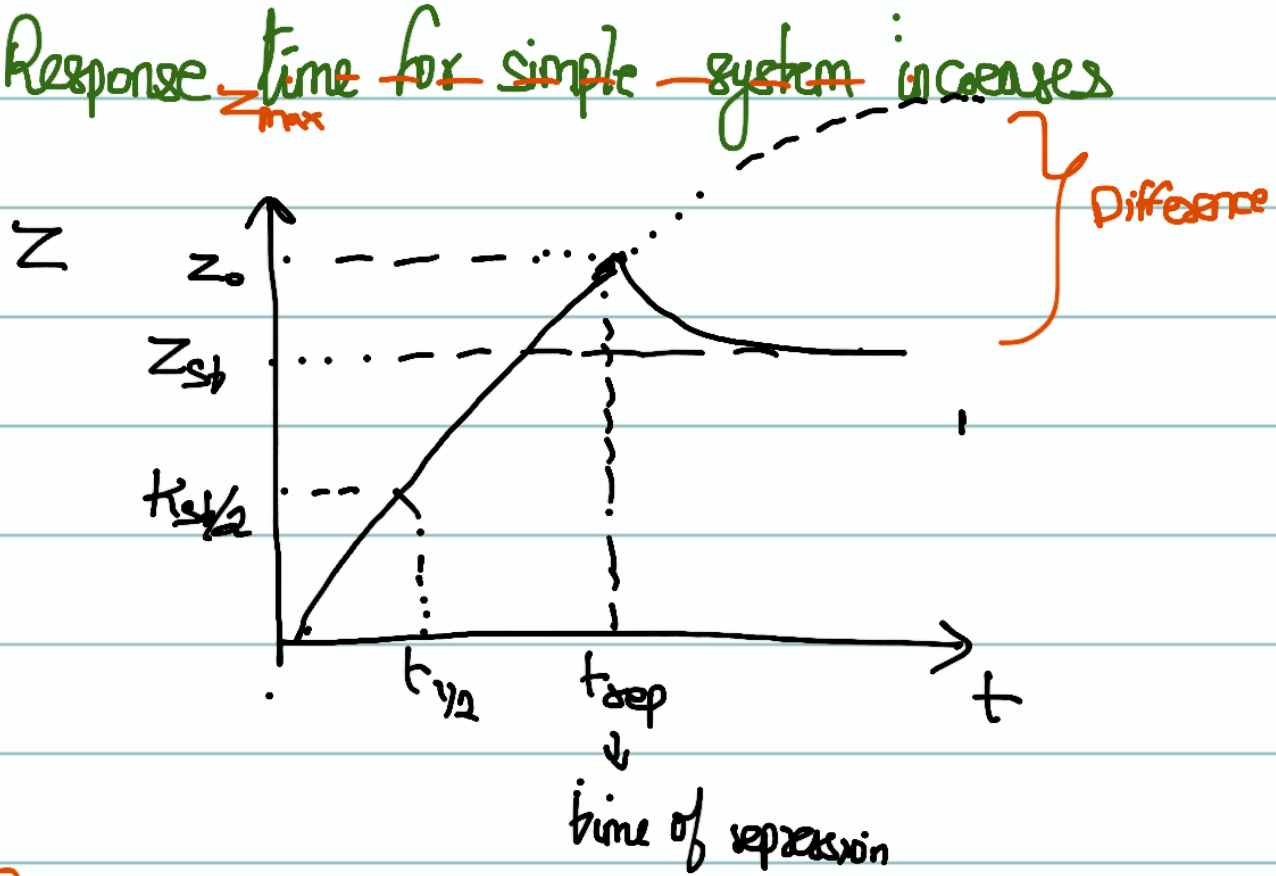
Pulse Generator



Depends on strength of inhibition



Response time for simple system increases



[:07:]

Ability to increase quickly and shut down fast too

$$Z_{Max} = \frac{K_{S2}}{K_{D2}} \quad , \quad Z_{sb} = \frac{(K_{S2})'}{K_{d2}} \rightarrow \text{Repressed rate}$$

$$Z = Z_M\left[1 - e^{-K_{D2}t}\right]$$

$$Z_0 = Z_M\left[1 - e^{-K_{D2}\,t_{rep}}\right]$$

To find t_{rep},

$$K_{y2} = y_{sb}\left[1 - e^{-K_{Dy}\,t_{rep}}\right]$$

$$t_{rep} = \frac{1}{K_{Dy}} \ln\left[\frac{y_{sb}}{y_{sb} - K_{y2}}\right]$$

↓

Same as t_{on}

To calculate response time t_{y2},

$$\frac{Z_{sb}}{2} = Z_M\left[1 - e^{-K_{d2}\,t_{y2}}\right]$$

$$\left[\frac{K_{S2}'}{2K_{S2}}\right] = \left[\frac{(K_{S2})}{K_{D2}}\right]\left[1 - e^{-K_{D2}\,t_{y2}}\right]$$

$$\frac{K_{S2}'}{2(K_{S2})} = 1 - e^{-K_{D2}\,t_{1/2}}$$

$$t_{Y_2} = \frac{1}{K_{D2}} \ln\left[\frac{2(K_{S2})}{2(K_{S2}) - K_{S2}'}\right] = \frac{1}{K_{D_2}} \ln\left[\frac{1}{1 - \frac{K_{S2}'}{2(K_{S2})}}\right]$$

If we take $F = \frac{Z_M}{Z_{SV}} = \frac{K_{S2}}{K_{S2}'}$

$$t_{Y_2} = \frac{1}{K_{D2}} \ln\left[\frac{2F}{2F-1}\right]$$

If $F = 1$, $K_{S2} = K_{S2}'$

$$\boxed{t_{Y_2} = \frac{\ln 2}{K_{D2}}}$$ → Same as standard case don't in previous

→ No inhibition [$K_S \rightarrow X \; K_d \rightarrow$]

→ No combat