EE49001: Control and Electronic System Design

Assignment-5

Submitted By:

21EE30004: Anirvan Krishna | 21EE30001: Aditya Kumar

SECTION - I

Networked Control Systems (NCSs):-

1. Consider an NCS whose plant is a discrete-time linear system

$$x(t+1) = \underbrace{\begin{pmatrix} -2 & -13 & 9 \\ -5 & -10 & 9 \\ -10 & -11 & 12 \end{pmatrix}}_{A} x(t) + \underbrace{\begin{pmatrix} 1 \\ 4 \\ 7 \end{pmatrix}}_{B} u(t), \;\; x(0) = \begin{pmatrix} 2 \\ 5 \\ 8 \end{pmatrix}, \;\; t \in \mathbb{N}_0, \tag{1}$$

and the controller is state-feedback

$$u(t) = \underbrace{\begin{pmatrix} 2.2225 & -10.44 & 5.5944 \end{pmatrix}}_{K} x(t), \;\; t \in \mathbb{N}_0. \tag{2}$$

Plot the state trajectory of system using equations (1)-(2) until t = 15 units of time, i.e. $x(t)_{t=0}^{15}$.

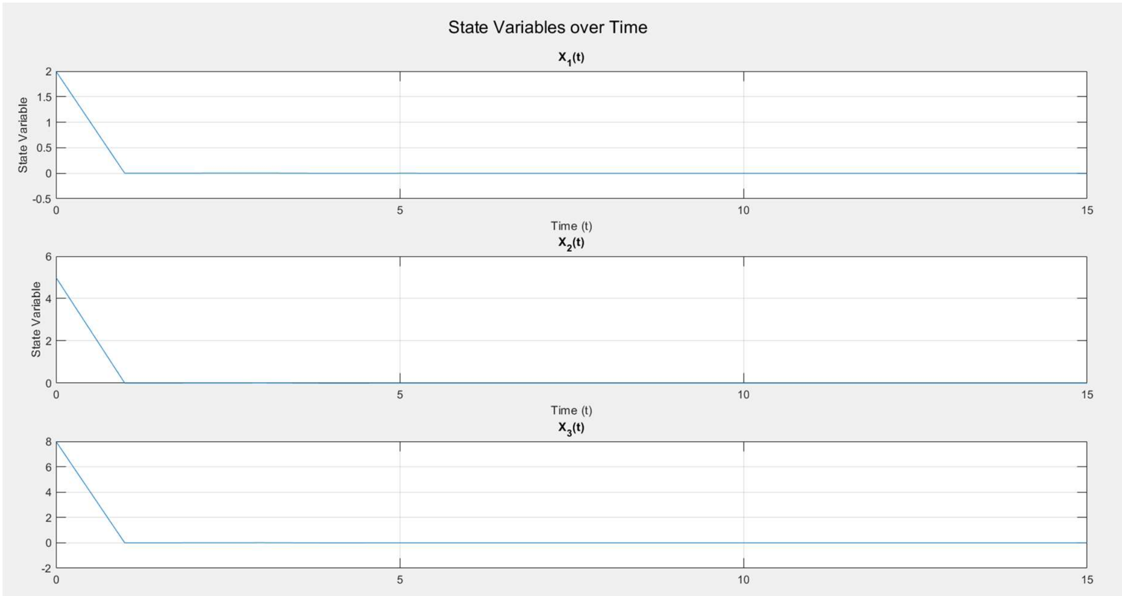

Fig: Plot of Trajectories over time t = 0 to 15

Data Losses Trajectory

Communication channels from the controller to the plant are prone to data losses. As a result, control input u may be lost in the network intermittently. Let $\kappa : N_0 \rightarrow \{0, 1\}$ denote the data loss signal, defined as follows: if $\kappa(t) = 0$, then the control input $u(t)$ is lost in the network at time t and if $\kappa(t) = 1$, then the control input $u(t)$ is received by the plant at time t, $t \in N_0$.

```
k = [0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 0];
```

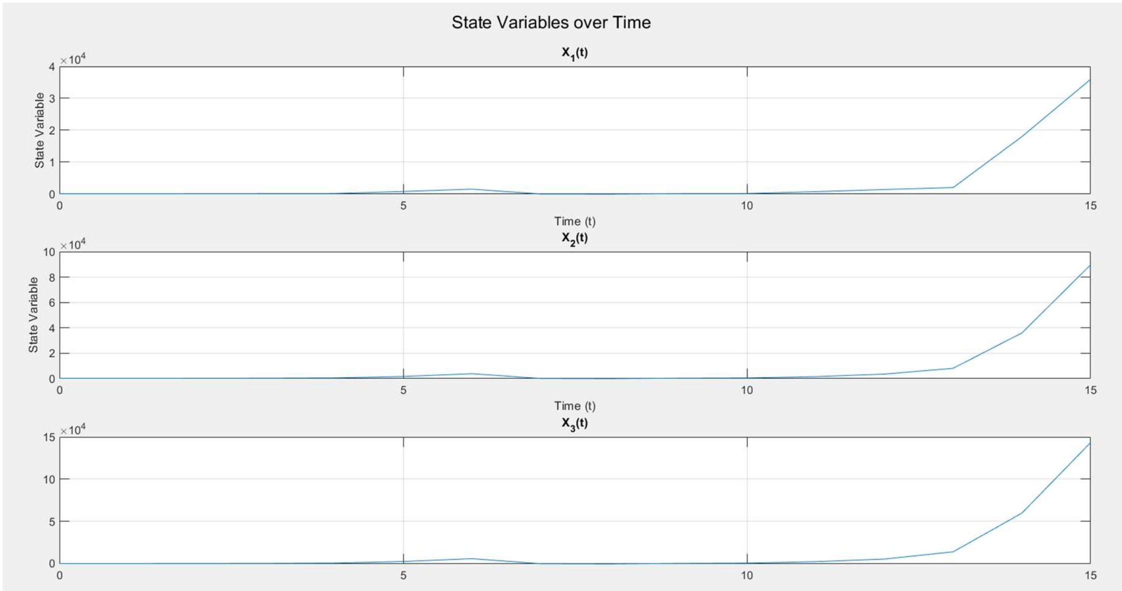

Fig:- Plot of Trajectories with Losses

(C). Observation :- Without Communication losses the system settles down to it's equilibrium point which is [0, 0, 0] that is it has settled down. But with communication losses the system diverges and goes to instability.

(D) Probability :-

With Changing values of P, generate the K = [], such that the state trajectory can be made with data losses dependent on probability.

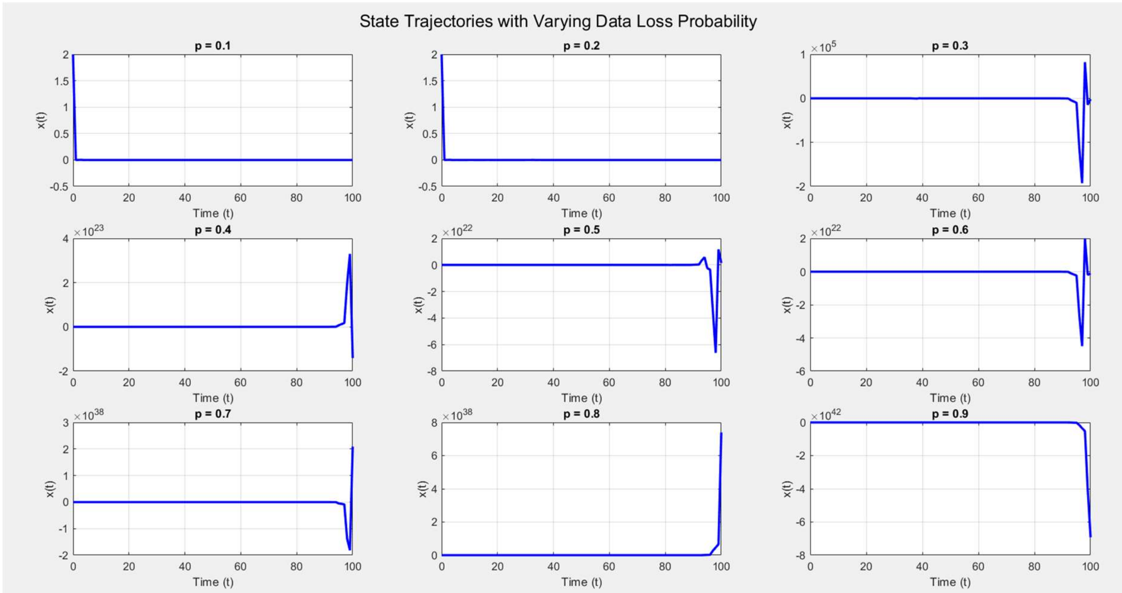

Fig : - State Trajectory with Varying Probability

(D)Range of P :-

FOR,

$$X(15) = \begin{matrix} 0 \\ 0 \\ 0 \end{matrix}$$

range of probability = 0.1 to 0.3 .

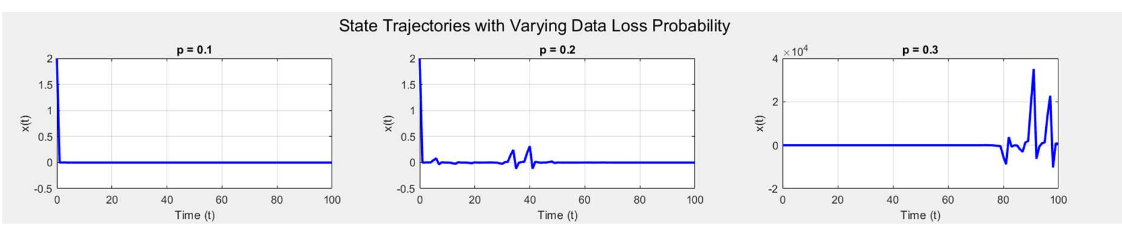

Fig:- Trajectories for X(15) = [0,0,0]

Section - II

$$x(t+1) = A_{\sigma(t)}x(t),\ x(0) = \begin{pmatrix} -1 \\ 1 \end{pmatrix},\ t \in \mathbb{N}_0, \tag{4}$$

where $A_1 = \begin{pmatrix} 0.47 & 0.12 \\ -3.90 & 0.19 \end{pmatrix}$, $A_2 = \begin{pmatrix} -0.03 & 0.78 \\ 0.60 & 0.47 \end{pmatrix}$ and $\sigma : \mathbb{N}_0 \to \{1, 2\}$.

(a) Let

$$\begin{array}{cccc} \sigma(0) = 1, & \sigma(1) = 1, & \sigma(2) = 2, & \sigma(3) = 2, \\ \sigma(4) = 2, & \sigma(5) = 2, & \sigma(6) = 1, & \sigma(7) = 1, \\ \sigma(8) = 2, & \sigma(9) = 2, & \sigma(10) = 2, & \sigma(11) = 2, \\ \sigma(12) = 1, & \sigma(13) = 1, & \sigma(14) = 2, & \ldots\ldots\ldots \end{array}$$

Write a MATLAB script to plot the trajectory of the switched system (4) up to $t = 15$ units of time, i.e., $(x(t))_{t=0}^{15}$.

(b) Repeat (a) with

$$\begin{array}{cccc} \sigma(0) = 1, & \sigma(1) = 1, & \sigma(2) = 1, & \sigma(3) = 2, \end{array}$$

$$\begin{array}{cccc} \sigma(4) = 2, & \sigma(5) = 1, & \sigma(6) = 1, & \sigma(7) = 1, \\ \sigma(8) = 2, & \sigma(9) = 2, & \sigma(10) = 1, & \sigma(11) = 1, \\ \sigma(12) = 1, & \sigma(13) = 2, & \sigma(14) = 2, & \ldots\ldots\ldots \end{array}$$

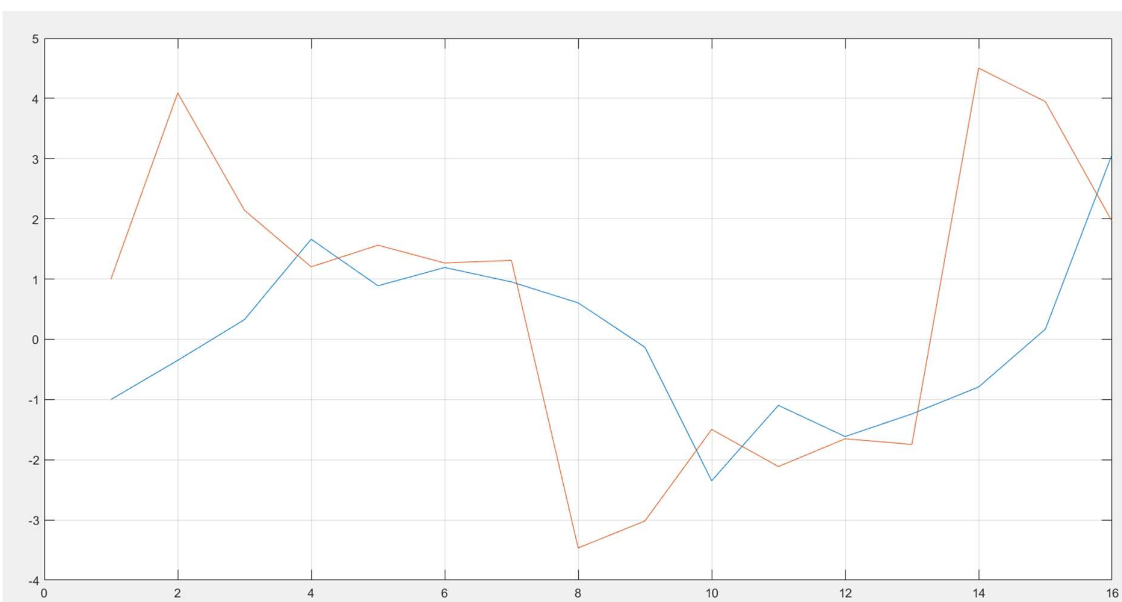

Fig:- Trajectory For First set of Sigma

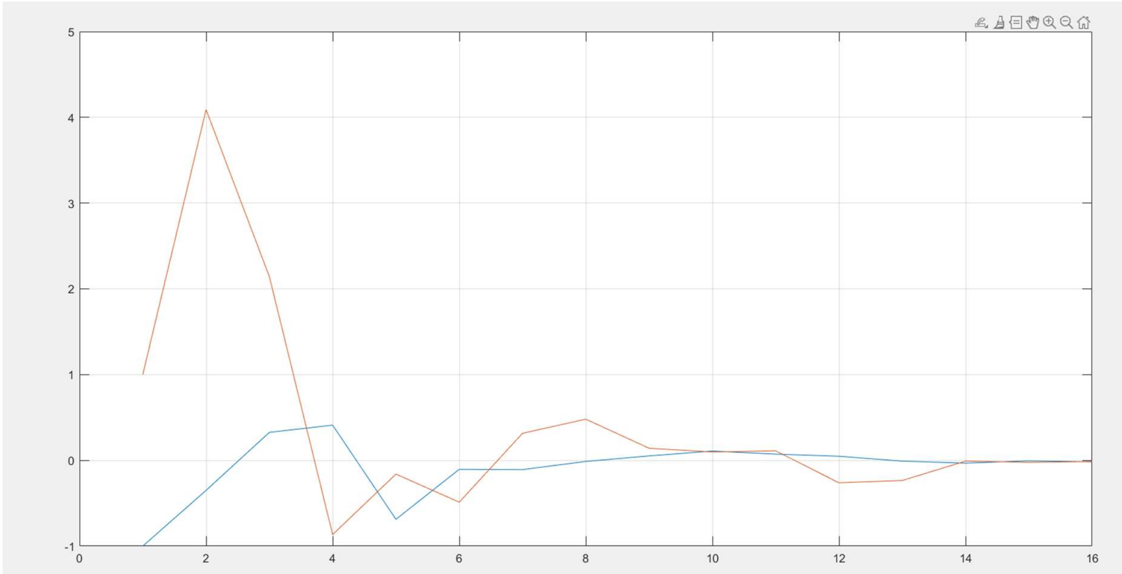

Fig:- Trajectory For Second Set of Sigma

(C). Based on experiments (a) and (b) comment on the following: “Switching between stable subsystems arbitrarily leads to a stable switched system” :-

The First set of sigma give unstable while the second is a stable one. A1 and A2 are stable as eigenvalues lies within unit circle. But if the system is switched then stability is decided by the switching. Stability depends on states and switching signal $\sigma(t)$.