EEN-305 Advanced Control Systems Lab Report

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Batch: ***P8(Electrical***)

Experiment No: 8

Experiment Title : **NONLINEAR SYSTEM ANALYSIS USING MATLAB**

Discussion

1. What are the commonly occurring non-linear system phenomenon?

Ans. Nonlinear phenomena are phenomena, which, in contrast to a linear system, cannot be explained by a mathematical relationship of proportionality (that is, a linear relationship between two variables). For example, the spread of an infectious disease is most often exponential, rather than linear, with time.

2. What are the different types non-linearities?

Ans. Common types of non-linearities are as follows:

a) Dead Zone b) Saturation c) Relay with Hysteresis d) Backlash e) Coulomb and Viscous friction.

3. Define Describing function.

Ans. The describing function method of a non-linear system is defined to be the complex ratio of amplitudes and phase angle between fundamental harmonic components of output to input sinusoid. We can also call sinusoidal describing function.

4. Write short note on phase portraits.

Ans. A phase portrait is a geometric representation of the trajectories of a dynamical system in the phase plane. Each set of initial conditions is represented by a different curve, or point. Phase portraits are an invaluable tool in studying dynamical systems. They consist of a plot of typical trajectories in the state space. This reveals information such as whether an attractor, a repellor or limit cycle is present for the chosen parameter value.

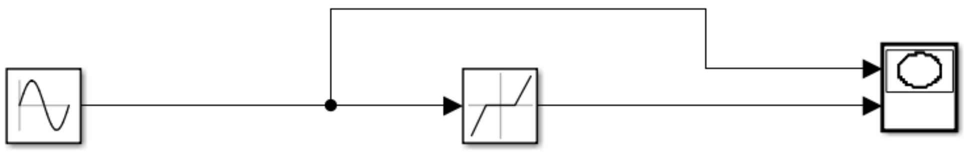
5. What do you mean by limit cycles?

Ans. A limit cycle is a closed trajectory in phase space having the property that at least one other trajectory spirals into it, either as time approaches to infinity or as time approaches to negative infinity. In other words, the limit cycle is an isolated trajectory (isolated in the sense that neighbouring trajectories are not closed); it spirals either toward or away from the limit cycle. If all neighbouring trajectories approach the limit cycle, we say the limit cycle is stable or attracting, that is, in the case where all the neighbouring trajectories approach the limit cycle as time approaches to infinity. Otherwise, the limit cycle is unstable, that is, instead all neighbouring trajectories approach it as time approaches to negative infinity, an unstable limit cycle.

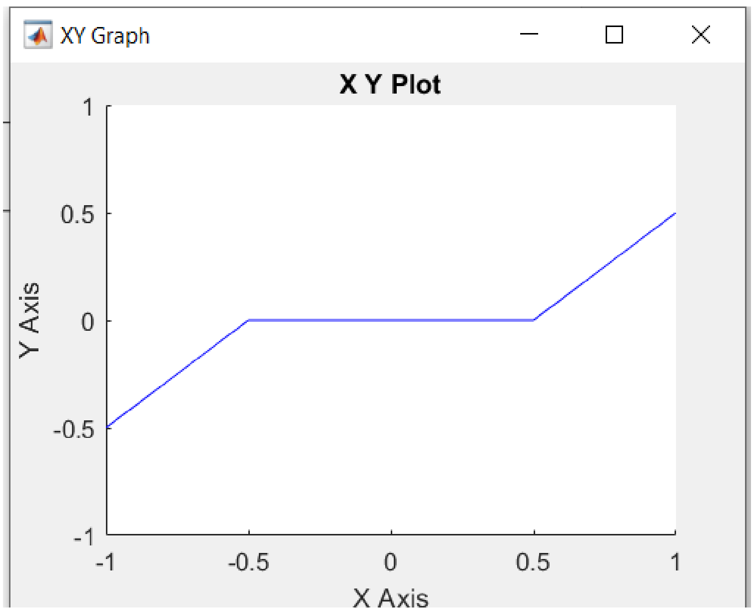
OBJECTIVE 1

Using SIMULINK models verify the transfer characteristics of

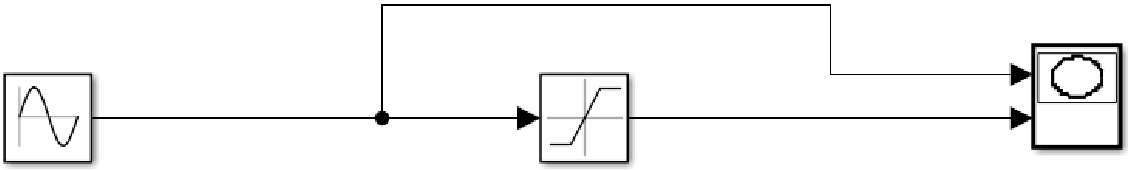
a) Dead Zone



Transfer characteristics:



b) Saturation



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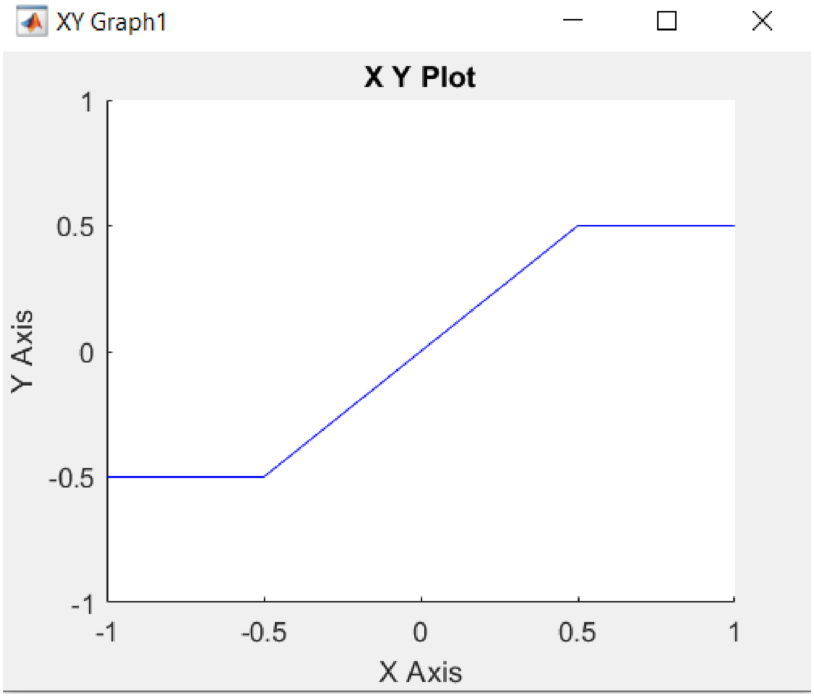
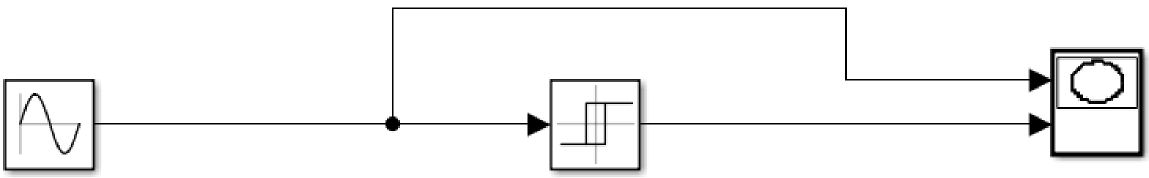
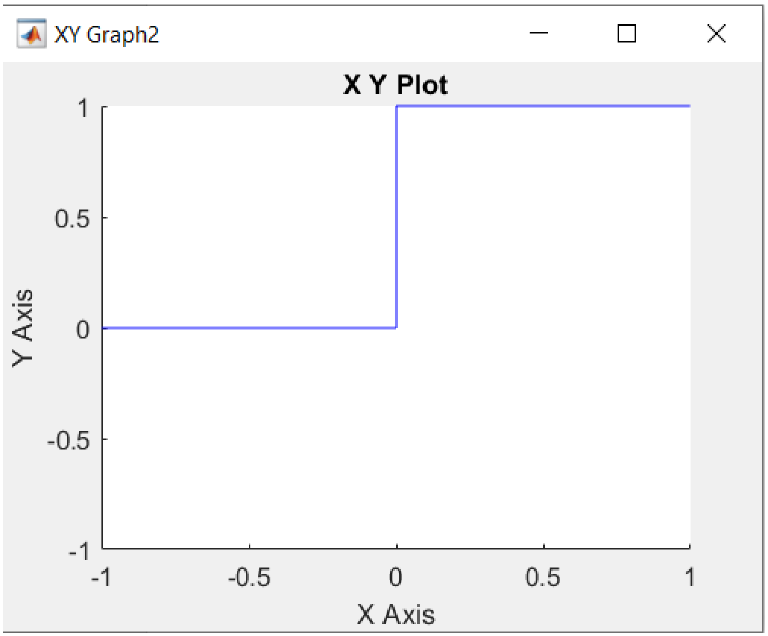


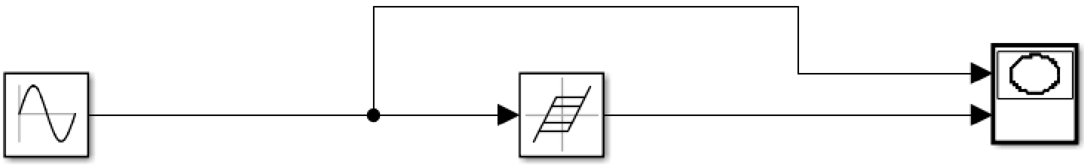
c) Relay with Hysteresis



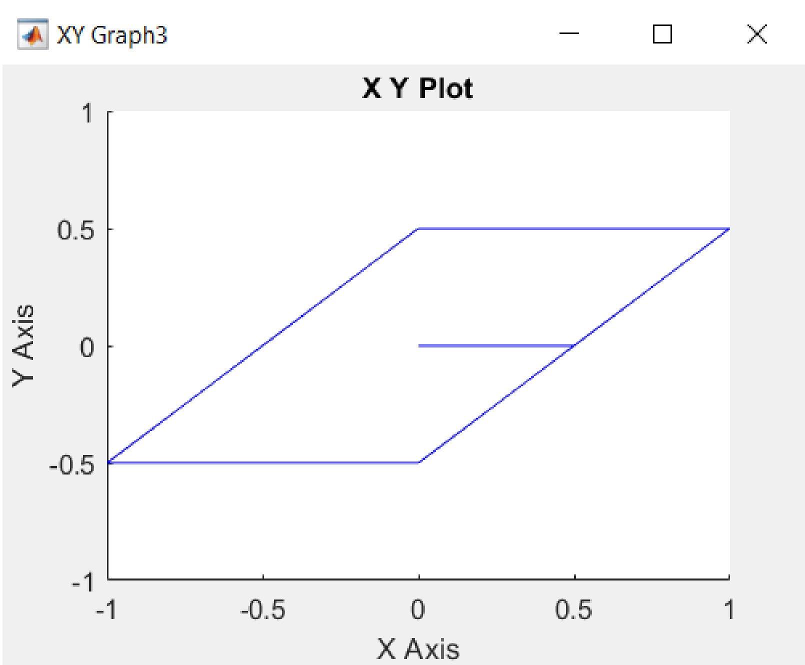
Transfer characteristics:



d) Backlash



Transfer characteristics:



OBJECTIVE 2

For the nonlinear system shown in the fig.1 determine the amplitude and frequency of the limit cycle using Simulink model.

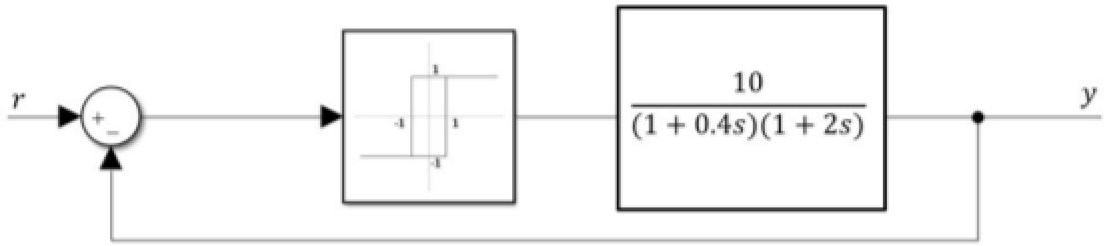
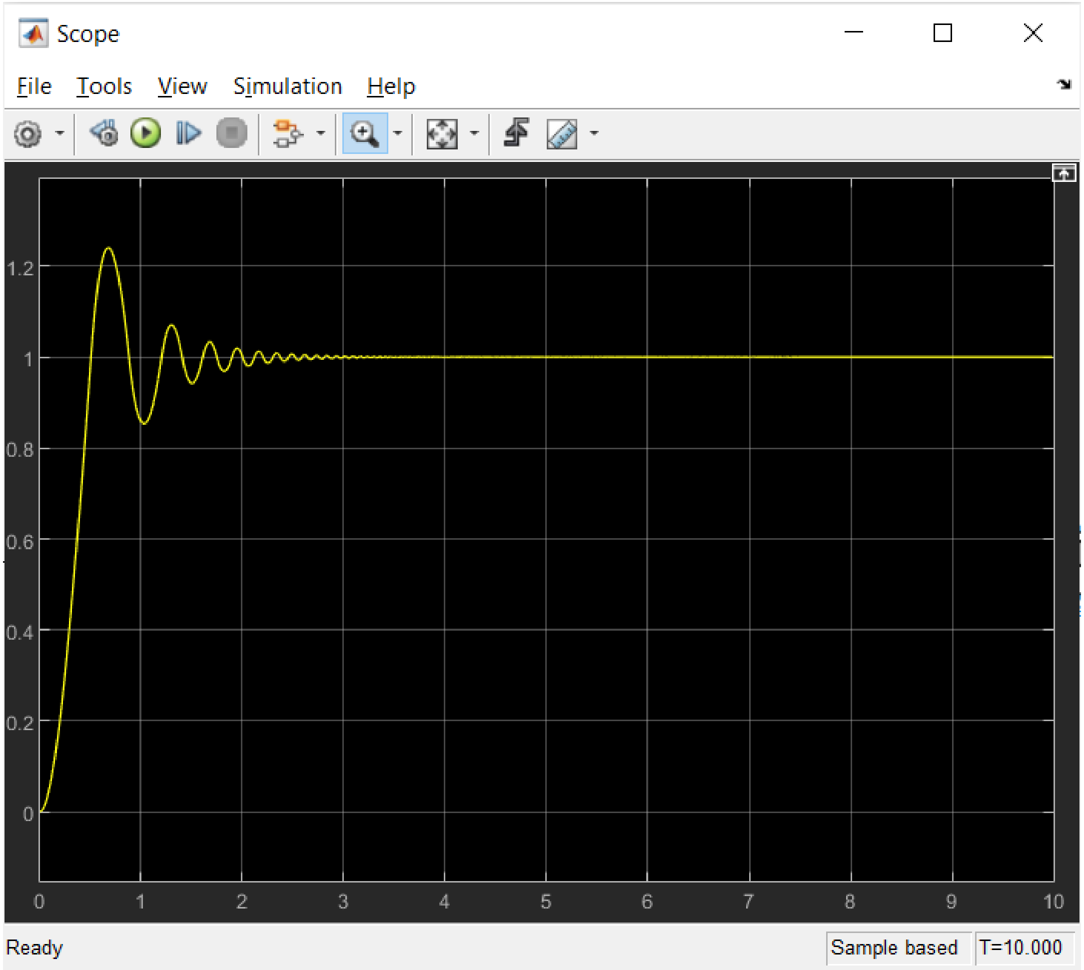


fig.1

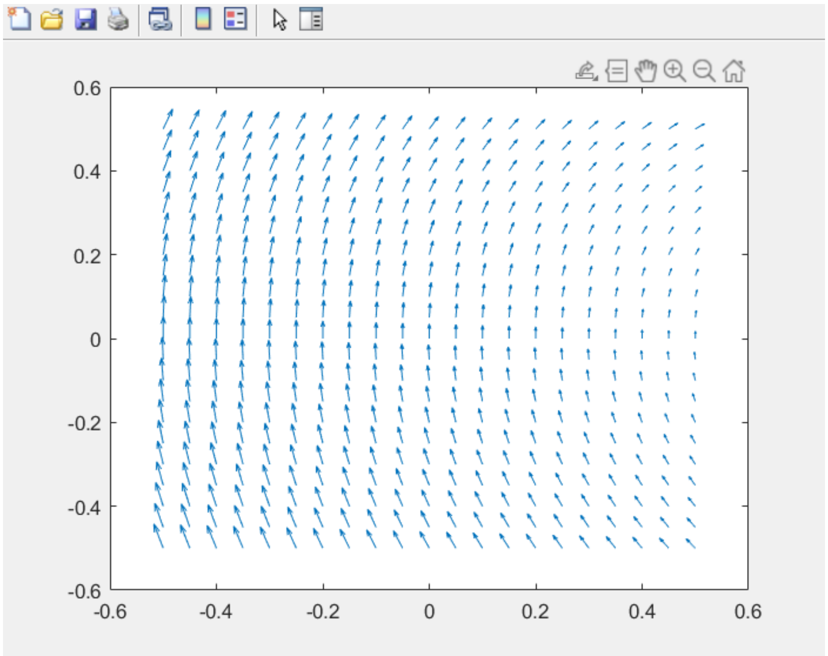


OBJECTIVE 3

Using MATLAB commands draw the vector fields for the given systems

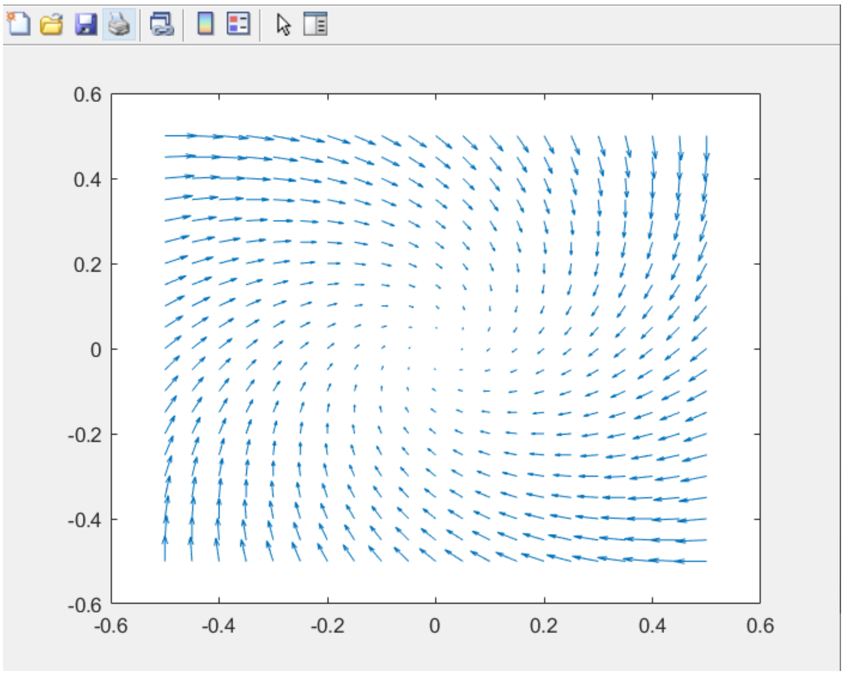
a) $\dot{x}_1 = x_2,\ \dot{x}_2 = -x_1 - 0.3x_2 + 1$

```
clc
clear all
[x,y] = meshgrid(-0.5:0.05:0.5,-0.5:0.05:0.5);
xd = y;
yd = -x - 0.3*y + 1;
quiver(x,y,xd,yd)
```



b) $\dot{x}_1 = -x_1 - 2x_2x_1^2 + x_2,\ \dot{x}_2 = -x_1 - x_2$

```
clc
clear all
[x,y] = meshgrid(-0.5:0.05:0.5,-0.5:0.05:0.5);
xd = -x - 2*y*x*x + y;
yd = -x - y
quiver(x,y,xd,yd)
```



OBJECTIVE 4

Using MATLAB commands draw the phase portrait for the given system

$$\dot{x}_1 = x_1 + 3x_2,\ \dot{x}_2 = -5x_1 + 2x_2$$

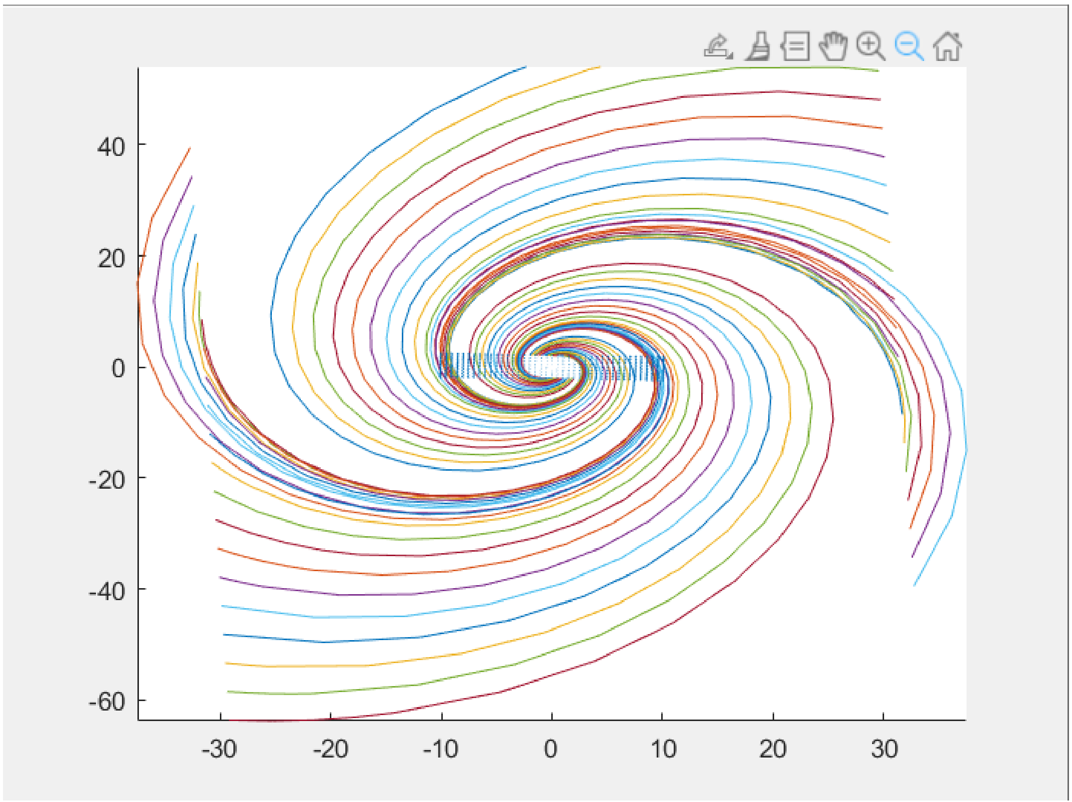
Also determine the type of the phase portrait.

```
clc
clear all
close all
hold on
 for theta=[-10:10]/5
      x0=[theta 2];
      [t,x]=ode45(@dxdt2, [0 2], x0)
      plot(x(:,1), x(:,2))
      x0=[theta -2]
      [t,x]=ode45(@dxdt2,[0 2], x0);
       plot(x(:,1), x(:,2))
 end
 axis([-10 10 -2 2])
 hold on;
 [x,y] = meshgrid(-10:0.5:10,-2:0.5:2);
 xd = x+3*y
 yd = -5*x +2*y
 quiver(x,y,xd,yd)
```

Code for function dxdt2 used above

```
function d=dxdt2(t,x)
d=[x(1)+3*x(2); -5*x(1)+2*x(2)];
end
```

Phase portrait



Code for eigen values

```
1 -     [D,V] = eig([1 3; -5 2])
```

Command Window

```
>> Untitled4

D =

   0.0791 - 0.6072i   0.0791 + 0.6072i
   0.7906 + 0.0000i   0.7906 + 0.0000i


V =

   1.5000 + 3.8406i   0.0000 + 0.0000i
   0.0000 + 0.0000i   1.5000 - 3.8406i
```

Since eigen values are complex with positive real part therefore it is unstable focus/spiral.