Scilab Manual for
Control of Electric Drive
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[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Scilab Manual and Scilab codes written in it can be downloaded from the "Migrated Labs" section at the website http://scilab.in

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Experiment: 1

Develop a program, to plot Torque-Slip characteristics of poly phase induction motor.

Scilab code Solution 1.01 User define Torque Slip characterisitc

```


//Experiment-1
// windows - 7 - 64-Bit
//Scilab - 5.4.1


//AIM: Devlop a program to plot Torque - slip
    characteristics.
clear all
clc
// Considering that the Stator of Induction Motor is
    Star Connected.
// user define perameter for Torque - slip
    Characteristic.
```

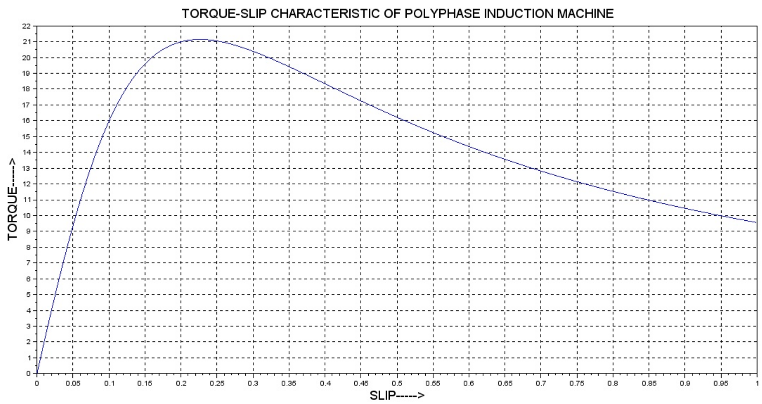

Figure 1.1: User define Torque Slip characterisitc

```
V = input('Enter the value of Voltage in volts : ')          // Example v= 400 Volt
f = input('Enter the value of frequency in Hertz : ')          // Example f=50 Hz
p = input('Enter the nos. of Poles : ')          // Example Pole = 4
N = input('Enter the Rated Speed in rpm : ')          // Example speed =  1500 rpm
Rs = input('Enter the value of Stator Resistance : ')          // Example Rs = 2 ohm
Rr = input('Enter the value of Rotor Resistance with referred to Stator : ')          // Example Rr= 5 ohm
Xs = input('Enter the value of Stator Reactance : ')          // Example Xs = 12
Xr = input('Enter the value of Rotor Reactance with referred to Stator : ')          // Example xr = 10
V1 = V/sqrt(3)
Ns = (120*f/p)
s = (Ns - N)/Ns
Wms = Ns*(2*%pi/60)
s = [0.0001:0.001:1];
```

```
R1 = Rr./s;
R = (Rs + R1);
X = (Xs + Xr);
T = (3 * V1^2 .* R1)./(Wms*(R.^2 + X.^2));
plot(s,T)
//Smax = Rr/sqrt((Rs)^2+(Xs+Xr)^2)
title('TORQUE-SLIP CHARACTERISTIC OF POLYPHASE
   INDUCTION MACHINE',"fontsize",4);
xlabel("SLIP------->","fontsize",4);
ylabel("TORQUE------->","fontsize",4);
//plot(Smax,max(T),'*')
xgrid
```

Experiment: 2

Develop a program, to plot Torque-Speed characteristics of poly phase induction motor.

Scilab code Solution 2.01 Speed Torque

```
//Experiment-2
// windows - 7 - 64-Bit
//Scilab - 5.4.1


//.... Torque-speed charecteristic of a polyphase induction motor......
clear
clc
//--------------------------------------Enter Data--------------------------------------

Po = input('Enter the value of Output Power : ') // Enter: 2.8
v = input('Enter the value of Voltage in volts : ')
```

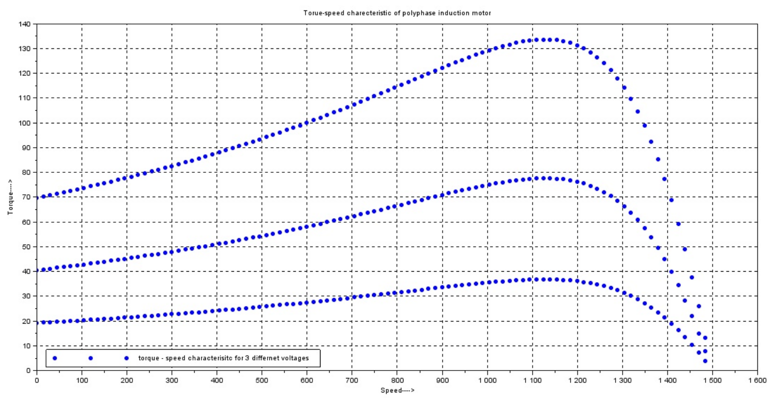

Figure 2.1: Speed Torque

```
    //Enter: 420
f =input('Enter the value of frequency in Hertz : ')
    //Enter: 50
p = input('Enter the nos. of Poles : ')//Enter: 4
n = input('Enter the Rated Speed in rpm : ')//Enter:
    1500
Rs =input('Enter the value of Stator Resistance : ')
    //Enter: 2.5
Rr = input('Enter the value of Rotor Resistance with
    referred to Stator : ')//Enter: 2.5
Xs =input('Enter the value of Stator Reactance : ')
    //Enter: 4.9
Xr =input('Enter the value of Rotor Reactance with
    referred to Stator : ')//Enter: 4.9
Xm = input('Enter the value of Magnetizing Reactance
    : ')//Enter: 80
Ns=((120*f)/p);                          //Synchronous
    speed,rpm
Ws=((2*%pi)/60)*Ns;                       //Angular
    synchoronous speed,rad/sec
for s=0.01:0.01:1;
  for  v=(v-200):100:v;
```

```
    Sm=(Rr/sqrt(Rs^2+(Xs+Xr)^2));
    N=(1-s)*Ns;
    a=(3/Ws);
    b=((v^2)/((Rs+(Rr/s))^2+(Xs+Xr)^2));
    c=(Rr/s);
    T=a*b*c;
    Tm=(3/(2*Ws))*(v^2/(Rs+sqrt(Rs^2+(Xs+Xr)^2)));
    plot(N,T,'.')

end
end

 title ('Torue-speed charecteristic of polyphase induction motor')
    xlabel('Speed———>');
    ylabel('Torque———>');
    xgrid;
    legend('torque - speed characterisitc for 3 differnet voltages',3)
```

Experiment: 3

Develop a program to plot torque-speed characteristics of single phase half controlled rectifier fed separately excited DC motor

Scilab code Solution 3.01 Halfwave rectifier control for different firing angle

```
//Experiment-3
// windows - 7 - 64-Bit
//Scilab - 5.4.1


//AIM: Develop a program to plot torque-speed
    characteristics of single phase half controlled
    rectifier fed separately excited DC motor
clear
clc
```

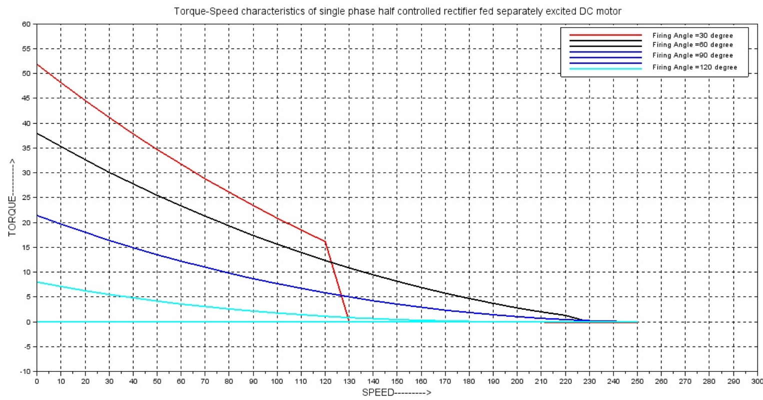

Figure 3.1: Halfwave rectifier control for different firing angle

```

Vs=230;                    // SUPPLY VOLTAGE IN VOLT
Va=220;                    //ARMATURE VOLTAGE IN VOLT
f=50;                      // FREQUENCY IN Hz
Wr=1500*%pi/30;             // RATED SPEED IN r.p.s.
Ia=11.6;                   // ARMATURE CURRENT IN AMP
Ra=2;                      // ARMATURE RESISTANCE IN OHM
La=28.36e-3;               // ARMAURE INDUCTANCE IN HENRY

Vm=Vs*sqrt(2);             //MAXIMUM VOLTAGE IN VOLT
E=Va-Ia*Ra;                // BACK EMF IN VOLT
Tr=E*Ia/Wr;               // RATED TORQUE IN Nm

K=E/Wr;
Wmo=Vm/K;                  // NO LOAD SPEED IN r.p.s.
w=2*%pi*f;

Z=sqrt(Ra^2+(w*La)^2); // Calculation of impedance
fai=atan((w*La)/Ra);

j=1;
for alpha=30                                          //
```

```
   For  Firing angle = 30 degree
    alphar=alpha*%pi/180;
    i=1;
    for Wm=0.01:10:Wmo
        Wmi(j,i)=Wm;
        a=%pi+alphar;
        ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg(fai))/Ra);
        if ia<=0 then
        for b=(alpha+0.1):0.1:360
            betar=b*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
            if ia<=1e-4 then
              break;
            end
        end
            Tor1(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
        else
            Tor1(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K^2))/Ra;
        end
        i=i+1;
    end
    j=j+1;
end
plot(Wmi',Tor1','r','LineWidth',2)

for alpha=60                                              //For  Firing angle = 60 degree
    alphar=alpha*%pi/180;
    i=1;
    for Wm=0.01:10:Wmo
        Wmi(j,i)=Wm;
        a=%pi+alphar;
```

```
        ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg(fai))/Ra);
        if ia<=0 then
        for b=(alpha+0.1):0.1:360
            betar=b*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
            if ia<=1e-4 then
                break;
            end
        end
            Tor2(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
        else
            Tor2(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K^2))/Ra;
        end
        i=i+1;
    end
    j=j+1;
end
plot(Wmi',Tor2','k','LineWidth',2)
for alpha=90                                        //For Firing angle = 90 degree
    alphar=alpha*%pi/180;
    i=1;
    for Wm=0.01:10:Wmo
        Wmi(j,i)=Wm;
        a=%pi+alphar;
        ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg(fai))/Ra);
        if ia<=0 then
        for b=(alpha+0.1):0.1:360
            betar=b*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
```

```
Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                if ia<=1e-4 then
                    break;
                end
            end
                Tor3(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
            else
                Tor3(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K^2))/Ra;
            end
            i=i+1;
        end
        j=j+1;
end
plot(Wmi',Tor3','b','LineWidth',2)

for alpha=120                                              // For Firing angle = 120 degree
        alphar=alpha*%pi/180;
        i=1;
        for Wm=0.01:10:Wmo
            Wmi(j,i)=Wm;
            a=%pi+alphar;
            ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg(fai))/Ra);
            if ia<=0 then
            for b=(alpha+0.1):0.1:360
                betar=b*%pi/180;
                ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                if ia<=1e-4 then
                    break;
                end
            end
```

```
                Tor4(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
            else
              Tor4(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K^2))/Ra;
            end
            i=i+1;
        end
        j=j+1;
end

plot(Wmi',Tor4','c','LineWidth',2)

title(' Torque--Speed characteristics of single phase half controlled rectifier fed separately excited DC motor','fontsize',3)
xlabel("SPEED----------->",'fontsize',3)
ylabel("TORQUE----------->",'fontsize',3)
xgrid
legend('Firing Angle =30 degree','Firing Angle =60 degree','','Firing Angle =90 degree','','','Firing Angle =120 degree')
```

Experiment: 4

Develop a program to plot torque-speed characteristics of single phase fully controlled rectifier fed separately excited DCmotor

Scilab code Solution 4.01 Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor

```
//Experiment-4
// windows - 7 - 64-Bit
//Scilab - 5.4.1


//AIM: Develop a program to plot torque-speed
   characteristics of single phase full controlled
   rectifier fed separately excited DC motor
clear
clc
```

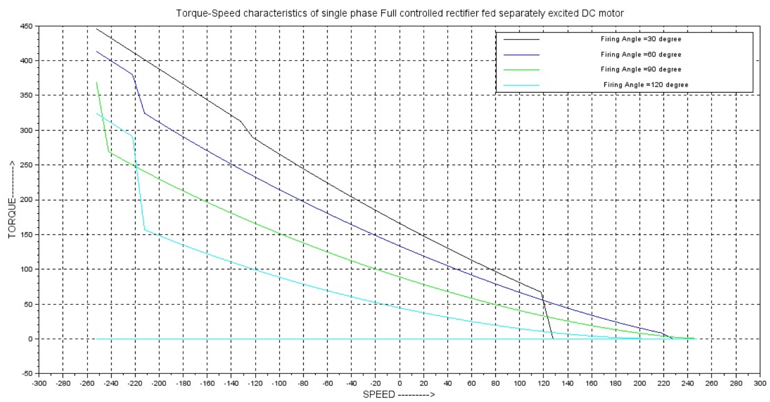

Figure 4.1: Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor

```
Vs=230;                                   // SUPPLY VOLTAGE IN VOLT
Vm=Vs*sqrt(2);            //MAXIMUM VOLTAGE IN VOLT
f=50 ;                     // FREQUENCY IN Hz
w=2*%pi*f

Wr=1500*%pi/30;            // RATED SPEED IN r.p.s.
Ia=11.6;                       // ARMATURE CURRENT IN AMP
Ra=1.5;                      // ARMATURE RESISTANCE IN OHM
La=0.6e-6;                 // ARMAURE INDUCTANCE IN HENRY

Va=220;                   //ARMATURE VOLTAGE IN VOLT
E = Va-(Ia*Ra);                // BACK EMF IN VOLT
K = E/Wr
Wmo=Vm/K;                 // NO LOAD SPEED IN r.p.s.
Z=sqrt(Ra^2+(w*La)^2);  // Calculation of impedance
fai=atan((w*La)/Ra)
Tr=E*Ia/Wr;              // RATED TORQUE IN Nm
j=1;

for  alpha=30                                 // For  Firing
```

```
    angle = 30 degree
alphar=alpha*%pi/180;
i=1;
    for Wm = - Wmo:10:Wmo;
    Wmi(j,i)=Wm;
    eta=%pi+alphar;
    ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-eta)*cotg(fai)));
        if ia<=0   then                                          // if current is discontinuous
            for beta=(alpha+0.1):0.1:360
            betar=beta*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                if ia<=0.00001 then
                break;
                end
            end
        Tor1(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
        else
        Tor1(j,i)=((Vm*K*(1+cos(alphar))/%pi)-(Wm*K^2))/Ra;
        end
        i=i+1;
    end
j=j+1;
end
plot(Wmi',Tor1','k','LineWidth',2)

for  alpha=60                          // For  Firing angle = 60 degree
alphar=alpha*%pi/180;
i=1;
    for Wm = - Wmo:10:Wmo;
```

```
    Wmi(j,i)=Wm;
    eta=%pi+alphar;
    ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-eta)*cotg(fai)));
        if ia<=0   then                                  // if current is discontinuous
            for beta=(alpha+0.1):0.1:360
            betar=beta*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                if ia<=0.00001 then
                break;
                end
            end
        Tor2(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
        else
        Tor2(j,i)=((Vm*K*(1+cos(alphar))/%pi)-(Wm*K^2))/Ra;
        end
        i=i+1;
    end
j=j+1;
end
plot(Wmi',Tor2','b','LineWidth',2)

for  alpha=90                            // For  Firing angle = 90 degree
alphar=alpha*%pi/180;
i=1;
    for Wm = - Wmo:10:Wmo;
    Wmi(j,i)=Wm;
    eta=%pi+alphar;
    ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-eta)*cotg(
```

```
        fai)));
        if ia<=0   then                                    // if current is discontinuous
            for beta=(alpha+0.1):0.1:360
            betar=beta*%pi/180;
            ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                if ia<=0.00001 then
                break;
                end
            end
        Tor3(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
        else
        Tor3(j,i)=((Vm*K*(1+cos(alphar))/%pi)-(Wm*K^2))/Ra;
        end
        i=i+1;
    end
j=j+1;
end
plot(Wmi',Tor3','g','LineWidth',2)

for  alpha=120                           // For  Firing angle = 120 degree
alphar=alpha*%pi/180;
i=1;
    for Wm = - Wmo:10:Wmo;
    Wmi(j,i)=Wm;
    eta=%pi+alphar;
    ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-eta)*cotg(fai)));
        if ia<=0   then                                    // if current is discontinuous
```

```
                for beta=(alpha+0.1):0.1:360
                betar=beta*%pi/180;
                ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((alphar-betar)*cotg(fai)));
                    if ia<=0.00001 then
                    break;
                    end
                end
            Tor4(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
            else
            Tor4(j,i)=((Vm*K*(1+cos(alphar))/%pi)-(Wm*K^2))/Ra;
            end
            i=i+1;
        end
j=j+1;
end
plot(Wmi',Tor4','c','LineWidth',2)
//legend('Firing Angle =30 degree','','Firing Angle =60 degree','','Firing Angle =90 degree','','Firing Angle =120 degree')
xgrid
title(' Torque-Speed characteristics of single phase Full controlled rectifier fed separately excited DC motor','fontsize',3)
xlabel("SPEED ------------->",'fontsize',3)
ylabel("TORQUE------------->",'fontsize',3)
//legends(["pqr";"xyz"],[[5;2],[3;4]], with_box=%f, opt="?")
legends(["Firing Angle =30 degree";"Firing Angle =60 degree";"Firing Angle =90 degree";"Firing Angle =120 degree"],[1 2 3 4], opt=1, font_size=1)
```

Experiment: 5

Develop a program, to plot Torque-Slip characteristics of poly phase induction motor using VVVF control.

Scilab code Solution 5.01 VVVF Control

```
//Experiment-5
// windows - 7 - 64-Bit
//Scilab - 5.4.1


//AIM: Devlop a program to plot Torque - speed characteristics (VVVF Mode included).
clear
clc
Po = input('Enter the value of Output Power : ') //Enter: 3.7
V = input('Enter the value of Voltage in volts : ') //Enter: 415
```

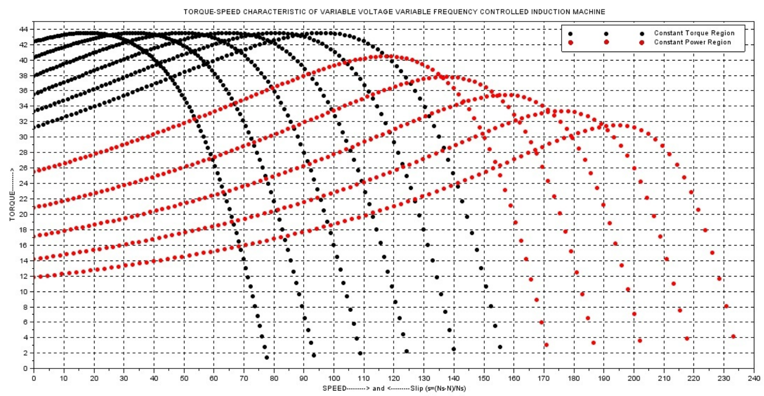

Figure 5.1: VVVF Control

```
fb =input('Enter the value of frequency in Hertz : ')//Enter: 50
P = input('Enter the nos. of Poles : ')//Enter: 4
N = input('Enter the Rated Speed in rpm : ')//Enter: 1420
Rs =input('Enter the value of Stator Resistance : ')//Enter: 2.5
Rr = input('Enter the value of Rotor Resistance with referred to Stator : ')//Enter: 3.9
Xs =input('Enter the value of Stator Reactance : ')//Enter: 4.9
Xr =input('Enter the value of Rotor Reactance with referred to Stator : ')//Enter: 4.9
Xm = input('Enter the value of Magnetizing Reactance : ')//Enter: 30
Ns=120*fb/P                //Synchronous Speed of Motor
Wms=(2*%pi*Ns)/120   //Angular Velocity of Motor rad/sec
S=(Ns-N)/Ns                //Slip
V1 = V/sqrt(3)
for f=25:5:75          // frequency range from 25 to 75 Hz ( Can vary based on drive)
```

```
    Wms=4*%pi*f/P;
    if(f<=fb) then
        for s=1:-0.01:0.01
            Ws=4*%pi*f/P;
            Wm=(1-s)*Ws;
            k=f/fb;
            T1=(3/Ws)*(V1^2*(Rr/s))/((Rs+(Rr/(k*s)))^2+(Xs+Xr)^2);
            plot(Wm,T1,'k.')
    end
    else
        for s=1:-0.01:0.01
            Ws=4*%pi*f/P;
            Wm=(1-s)*Ws;
            k=f/fb;
            T2=(3/Ws)*(V1^2*(Rr/s))/(((Rs+(Rr/(k*s)))^2+(k*Xs+k*Xr)^2));
            plot(Wm,T2,'r.')
        end
    end
end
title('TORQUE-SPEED CHARACTERISTIC OF VARIABLE VOLTAGE VARIABLE FREQUENCY CONTROLLED INDUCTION MACHINE')
xlabel("SPEED-------------> and <-------------Slip (s=(Ns-N)/Ns)")
ylabel("TORQUE------------->")
xgrid
legend("Constant Torque Region", "Constant Power Region")
```

Experiment: 6

To Study and Simulation of the single phase half controlled AC to DC Converter and effect of firing angle on load voltage

This code can be downloaded from the website wwww.scilab.in

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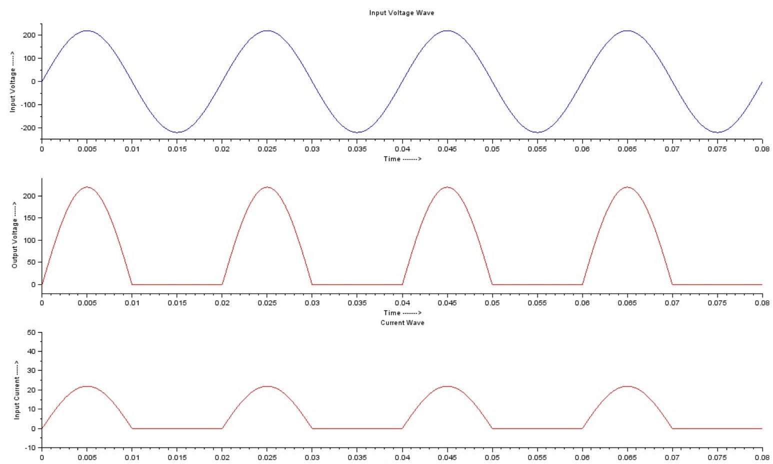

Figure 6.1: Halfwave unontrolled Rectifier

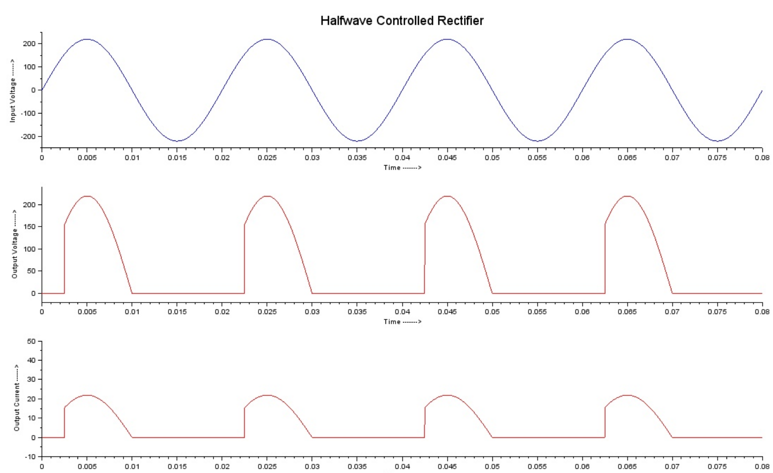

Figure 6.2: Halfwave Controlled Rectifier

Experiment: 7

To Study and Simulation of the single phase fully controlled AC to DC Converter and effect of firing angle on load voltage

This code can be downloaded from the website wwww.scilab.in This code can be downloaded from the website wwww.scilab.in

This code can be downloaded from the website wwww.scilab.in

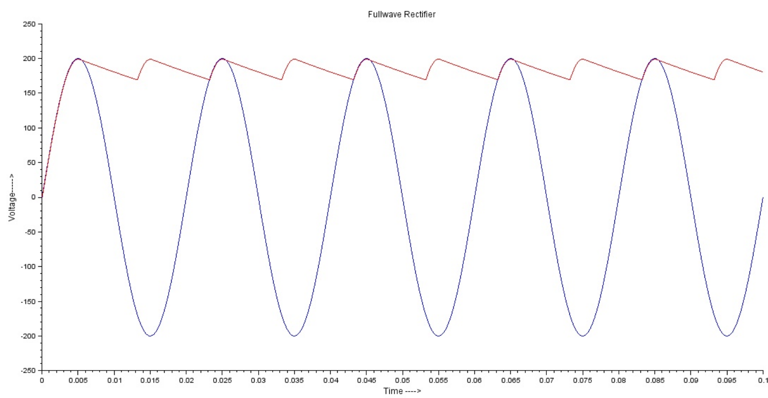

Figure 7.1: Fullwave Uncontrolled Rectifier

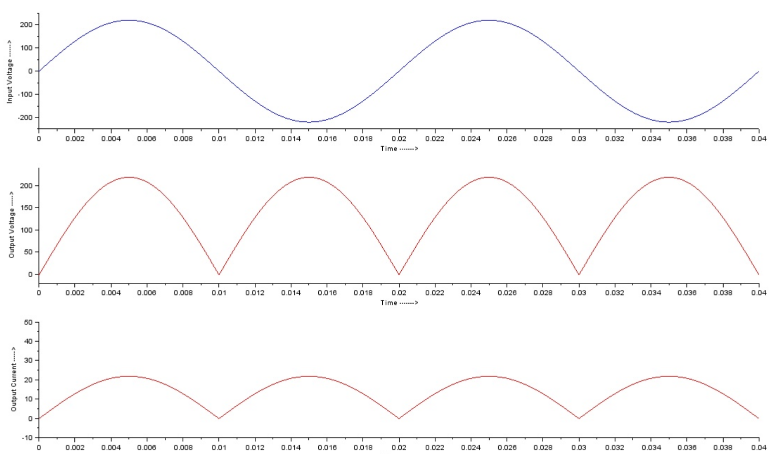

Figure 7.2: Fullwave Uncontrolled Rectifier

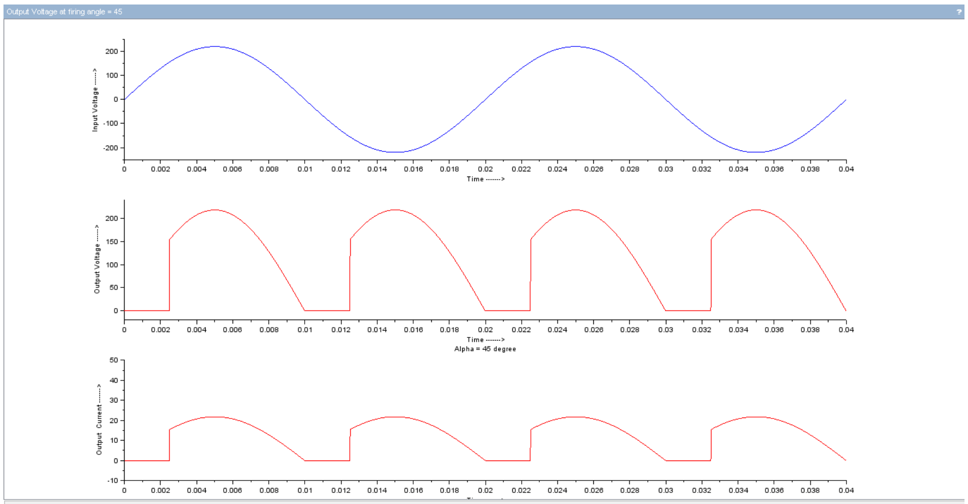

Figure 7.3: Fullwave Controlled Rectifier For 45 alpha

This code can be downloaded from the website wwww.scilab.in

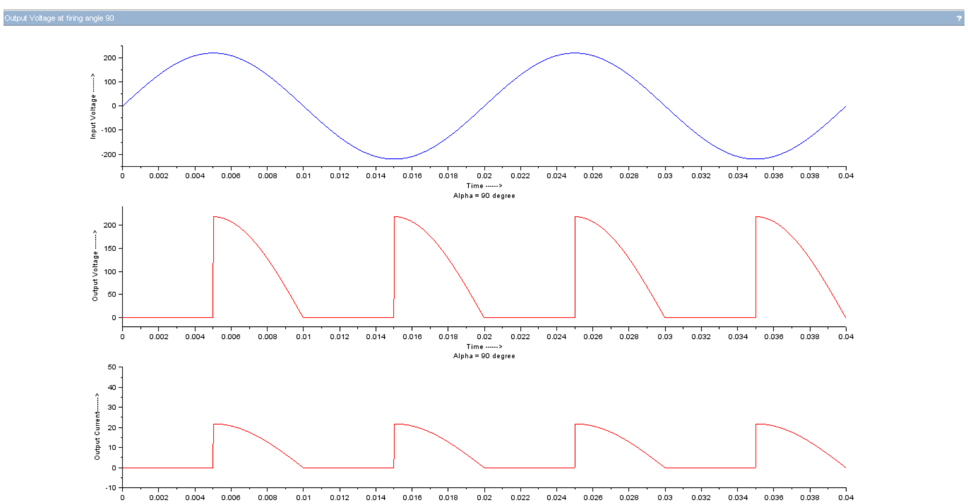

Figure 7.4: Fullwave Controlled Rectifier For 90 alpha