

Scilab Manual for
Control of Electric Drive
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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 characterisitic

```
1
2
3 //Experiment-1
4 // windows - 7 - 64-Bit
5 //Scilab - 5.4.1
6
7
8 //AIM:  Develop a program to plot Torque - slip
      characteristics.
9 clear all
10 clc
11 // Considering that the Stator of Induction Motor is
      Star Connected.
12 // user define parameter for Torque - slip
      Characteristic.
```

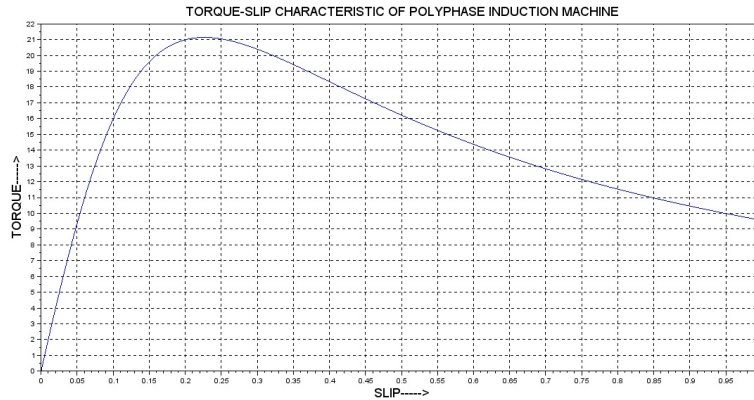


Figure 1.1: User define Torque Slip characterisitc

```

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

```

```

26 R1 = Rr./s;
27 R = (Rs + R1);
28 X = (Xs + Xr);
29 T = (3 * V1^2 .* R1)./(Wms*(R.^2 + X.^2));
30 plot(s,T)
31 //Smax = Rr/sqrt((Rs)^2+(Xs+Xr)^2)
32 title('TORQUE-SLIP CHARACTERISTIC OF POLYPHASE
        INDUCTION MACHINE','fontsize',4);
33 xlabel("SLIP——>","fontsize",4);
34 ylabel("TORQUE——>","fontsize",4);
35 //plot(Smax,max(T),'*')
36 xgrid

```

Experiment: 2

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

Scilab code Solution 2.01 Speed Torque

```
1 //Experiment-2
2 // windows - 7 - 64-Bit
3 //Scilab - 5.4.1
4
5
6 //.... Torque-speed charecteristic of a polyphase
   induction motor.....
7 clear
8 clc
9 //-----Enter Data
   _____
10
11 Po = input('Enter the value of Output Power : ') //
   Enter: 2.8
12 v = input('Enter the value of Voltage in volts : ')
```

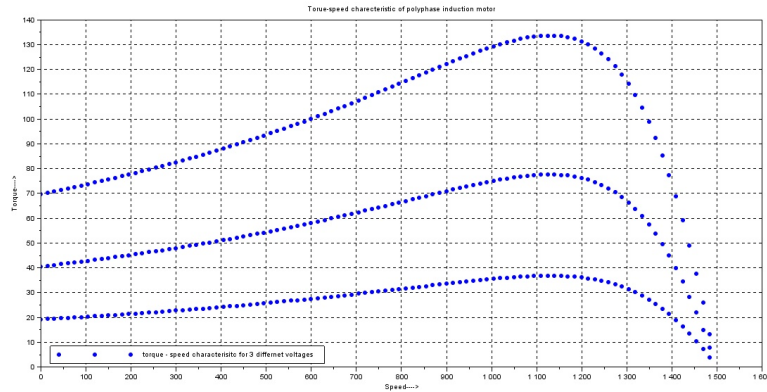


Figure 2.1: Speed Torque

```

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

```

```

25     Sm=(Rr/sqrt(Rs^2+(Xs+Xr)^2));
26     N=(1-s)*Ns;
27     a=(3/Ws);
28     b=((v^2)/((Rs+(Rr/s))^2+(Xs+Xr)^2));
29     c=(Rr/s);
30     T=a*b*c;
31     Tm=(3/(2*Ws))*(v^2/(Rs+sqrt(Rs^2+(Xs+Xr)^2)));
32     plot(N,T, '. ')
33
34 end
35 end
36
37 title ('Torue-speed charecteristic of polyphase
        induction motor')
38 xlabel('Speed——>');
39 ylabel('Torque——>');
40 xgrid;
41 legend('torque - speed characeterisite 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

```
1 //Experiment-3
2 // windows - 7 - 64-Bit
3 //Scilab - 5.4.1
4
5
6 //AIM: Develop a program to plot torque-speed
   characteristics of single phase half controlled
   rectifier fed separately excited DC motor
7 clear
8 clc
```

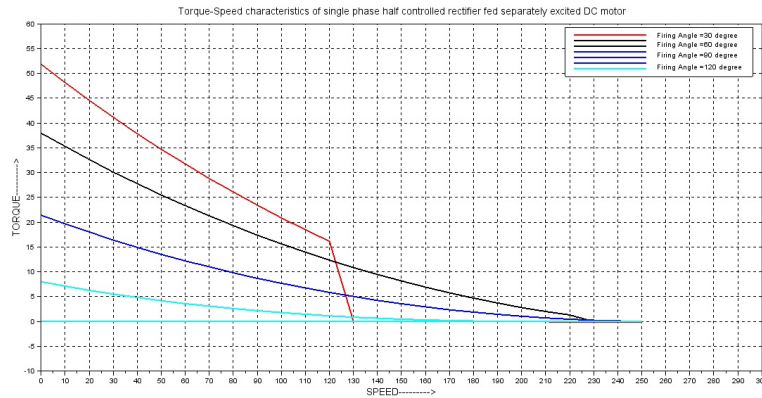


Figure 3.1: Halfwave rectifier control for different firing angle

```

9
10 Vs=230; // SUPPLY VOLTAGE IN VOLT
11 Va=220; // ARMATURE VOLTAGE IN VOLT
12 f=50; // FREQUENCY IN Hz
13 Wr=1500*%pi/30; // RATED SPEED IN r.p.s.
14 Ia=11.6; // ARMATURE CURRENT IN AMP
15 Ra=2; // ARMATURE RESISTANCE IN OHM
16 La=28.36e-3; // ARMAURE INDUCTANCE IN HENRY
17
18 Vm=Vs*sqrt(2); // MAXIMUM VOLTAGE IN VOLT
19 E=Va-Ia*Ra; // BACK EMF IN VOLT
20 Tr=E*Ia/Wr; // RATED TORQUE IN Nm
21
22 K=E/Wr;
23 Wmo=Vm/K; // NO LOAD SPEED IN r.p.s.
24 w=2*%pi*f;
25
26 Z=sqrt(Ra^2+(w*La)^2); // Calculation of impedance
27 fai=atan((w*La)/Ra);
28
29 j=1;
30 for alpha=30 //

```

```

For Firing angle = 30 degree
31     alphas=alpha*%pi/180;
32     i=1;
33     for Wm=0.01:10:Wmo
34         Wmi(j,i)=Wm;
35         a=%pi+alphar;
36         ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-
            sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg
            (fai))/Ra);
37         if ia<=0 then
38             for b=(alpha+0.1):0.1:360
39                 betar=b*%pi/180;
40                 ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                    Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((
                    alphar-betar)*cotg(fai)));
41                 if ia<=1e-4 then
42                     break;
43                 end
44             end
45             Tor1(j,i)=((Vm*K*(cos(alphar)-cos(betar)
                ))-(Wm*K^2*(betar-alphar)))/(pi*Ra);
46         else
47             Tor1(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm
                *K^2))/Ra;
48         end
49         i=i+1;
50     end
51     j=j+1;
52 end
53 plot(Wmi',Tor1', 'r', 'LineWidth',2)
54
55 for alpha=60 //
    For Firing angle = 60 degree
56     alphas=alpha*%pi/180;
57     i=1;
58     for Wm=0.01:10:Wmo
59         Wmi(j,i)=Wm;
60         a=%pi+alphar;

```

```

61     ia=(Vm*exp(-(alphan)*cotg(fai))*(sin(fai)-
        sin(alphan-fai))/Z)-(E*exp(-(alphan)*cotg
        (fai))/Ra);
62     if ia<=0 then
63     for b=(alpha+0.1):0.1:360
64         betar=b*%pi/180;
65         ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
            Wm/Ra)-(Vm*sin(alphan-fai)/Z))*exp((
            alphan-betar)*cotg(fai)));
66         if ia<=1e-4 then
67             break;
68         end
69     end
70     Tor2(j,i)=((Vm*K*(cos(alphan)-cos(betar)
        ))-(Wm*K^2*(betar-alphan)))/(%pi*Ra);
71     else
72     Tor2(j,i)=((Vm*K*(1+cos(alphan))/pi)-(Wm
        *K^2))/Ra;
73     end
74     i=i+1;
75     end
76     j=j+1;
77 end
78 plot(Wmi',Tor2','k','LineWidth',2)
79 for alpha=90 //
    For Firing angle = 90 degree
80     alphan=alpha*%pi/180;
81     i=1;
82     for Wm=0.01:10:Wmo
83         Wmi(j,i)=Wm;
84         a=%pi+alphan;
85         ia=(Vm*exp(-(alphan)*cotg(fai))*(sin(fai)-
            sin(alphan-fai))/Z)-(E*exp(-(alphan)*cotg
            (fai))/Ra);
86         if ia<=0 then
87         for b=(alpha+0.1):0.1:360
88             betar=b*%pi/180;
89             ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*

```

```

        Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((
        alphar-betar)*cotg(fai)));
90     if ia<=1e-4 then
91         break;
92     end
93     end
94     Tor3(j,i)=((Vm*K*(cos(alphar)-cos(betar)
        ))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
95     else
96     Tor3(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm
        *K^2))/Ra;
97     end
98     i=i+1;
99     end
100    j=j+1;
101    end
102    plot(Wmi','Tor3','b','LineWidth',2)
103
104    for alpha=120 //
        For Firing angle = 120 degree
105        alphar=alpha*%pi/180;
106        i=1;
107        for Wm=0.01:10:Wmo
108            Wmi(j,i)=Wm;
109            a=%pi+alphar;
110            ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-
                sin(alphar-fai))/Z)-(E*exp(-(alphar)*cotg
                (fai))/Ra);
111            if ia<=0 then
112                for b=(alpha+0.1):0.1:360
113                    betar=b*%pi/180;
114                    ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                        Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((
                        alphar-betar)*cotg(fai)));
115                    if ia<=1e-4 then
116                        break;
117                    end
118                end
        end

```



```

119         Tor4(j,i)=((Vm*K*(cos(alphar)-cos(betar)
120             ))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
121     else
122         Tor4(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K
123             ^2))/Ra;
124     end
125     i=i+1;
126 end
127 j=j+1;
128 end
129 plot(Wmi',Tor4','c','LineWidth',2)
130 title(' Torque-Speed characteristics of single phase
131     half controlled rectifier fed separately excited
132     DC motor ','fontsize',3)
133 xlabel("SPEED————>","fontsize',3)
134 ylabel("TORQUE————>","fontsize',3)
135 xgrid
136 legend('Firing Angle =30 degree','Firing Angle =60
137     degree','','Firing Angle =90 degree','','','Firing
138     Angle =120 degree')

```

Experiment: 4

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

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

```
1 //Experiment-4
2 // windows - 7 - 64-Bit
3 //Scilab - 5.4.1
4
5
6 //AIM: Develop a program to plot torque-speed
      characteristics of single phase full controlled
      rectifier fed separately excited DC motor
7 clear
8 clc
```

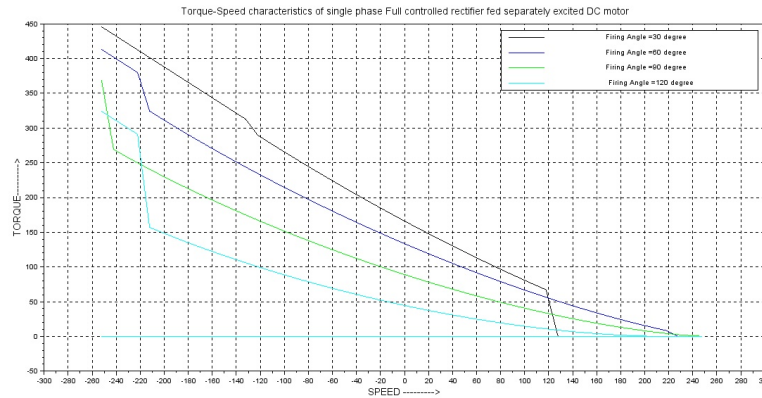


Figure 4.1: Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor

```

9 Vs=230; // SUPPLY VOLTAGE
  IN VOLT
10 Vm=Vs*sqrt(2); //MAXIMUM VOLTAGE IN VOLT
11 f=50; // FREQUENCY IN Hz
12 w=2*pi*f
13
14 Wr=1500*pi/30; // RATED SPEED IN r.p.s.
15 Ia=11.6; // ARMATURE CURRENT IN AMP
16 Ra=1.5; // ARMATURE RESISTANCE IN OHM
17 La=0.6e-6; // ARMAURE INDUCTANCE IN HENRY
18
19 Va=220; //ARMATURE VOLTAGE IN VOLT
20 E = Va-(Ia*Ra); // BACK EMF IN VOLT
21 K = E/Wr
22 Wmo=Vm/K; // NO LOAD SPEED IN r.p.s.
23 Z=sqrt(Ra^2+(w*La)^2); // Calculation of impedance
24 fai=atan((w*La)/Ra)
25 Tr=E*Ia/Wr; // RATED TORQUE IN Nm
26 j=1;
27
28 for alpha=30 // For Firing

```

```

    angle = 30 degree
29 alphas=alpha*%pi/180;
30 i=1;
31     for Wm = - Wmo:10:Wmo;
32         Wmi(j,i)=Wm;
33         eta=%pi+alphar;
34         ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
            *sin(alphas-fai)/Z))*exp((alphar-eta)*cotg(
            fai)));
35         if ia<=0     then
                                                    // if
            current is discontinuous
36             for beta=(alpha+0.1):0.1:360
37                 betar=beta*%pi/180;
38                 ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                    Wm/Ra)-(Vm*sin(alphas-fai)/Z))*exp((
                    alphas-betar)*cotg(fai)));
39                 if ia<=0.00001 then
40                     break;
41                 end
42             end
43             Tor1(j,i)=((Vm*K*(cos(alphas)-cos(betar)))-(
                Wm*K^2*(betar-alphas)))/(%pi*Ra);
44         else
45             Tor1(j,i)=((Vm*K*(1+cos(alphas))/%pi)-(Wm*K
                ^2))/Ra;
46         end
47         i=i+1;
48     end
49 j=j+1;
50 end
51 plot(Wmi','Tor1','k','LineWidth',2)
52
53 for alpha=60 // For Firing
    angle = 60 degree
54 alphas=alpha*%pi/180;
55 i=1;
56     for Wm = - Wmo:10:Wmo;

```

```

57     Wmi(j,i)=Wm;
58     eta=%pi+alphan;
59     ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
        *sin(alphan-fai)/Z))*exp((alphan-eta)*cotg(
        fai)));
60         if ia<=0     then                                     // if
                                                    current is discontinuous
61             for beta=(alpha+0.1):0.1:360
62                 betar=beta*%pi/180;
63                 ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                    Wm/Ra)-(Vm*sin(alphan-fai)/Z))*exp((
                    alphan-betar)*cotg(fai)));
64                     if ia<=0.00001 then
65                         break;
66                     end
67                 end
68                 Tor2(j,i)=((Vm*K*(cos(alphan)-cos(betar)))-(
                    Wm*K^2*(betar-alphan)))/(%pi*Ra);
69             else
70                 Tor2(j,i)=((Vm*K*(1+cos(alphan))/%pi)-(Wm*K
                    ^2))/Ra;
71             end
72             i=i+1;
73         end
74     j=j+1;
75 end
76 plot(Wmi',Tor2', 'b', 'LineWidth',2)
77
78 for alpha=90                                     // For Firing
    angle = 90 degree
79 alphan=alpha*%pi/180;
80 i=1;
81     for Wm = - Wmo:10:Wmo;
82         Wmi(j,i)=Wm;
83         eta=%pi+alphan;
84         ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
            *sin(alphan-fai)/Z))*exp((alphan-eta)*cotg(

```

```

fai)));
85     if ia<=0     then
                                                    // if
        current is discontinuous
86         for beta=(alpha+0.1):0.1:360
87             betar=beta*%pi/180;
88             ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((
                alphar-betar)*cotg(fai)));
89                 if ia<=0.00001 then
90                     break;
91                 end
92             end
93             Tor3(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(
                Wm*K^2*(betar-alphar)))/(pi*Ra);
94         else
95             Tor3(j,i)=((Vm*K*(1+cos(alphar))/pi)-(Wm*K
                ^2))/Ra;
96         end
97         i=i+1;
98     end
99     j=j+1;
100 end
101 plot(Wmi',Tor3', 'g', 'LineWidth',2)
102
103 for alpha=120
                                                    // For Firing
        angle = 120 degree
104     alphar=alpha*%pi/180;
105     i=1;
106         for Wm = - Wmo:10:Wmo;
107             Wmi(j,i)=Wm;
108             eta=%pi+alphar;
109             ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
                *sin(alphar-fai)/Z))*exp((alphar-eta)*cotg(
                fai)));
110             if ia<=0     then
                                                    // if
                current is discontinuous

```

```

111         for beta=(alpha+0.1):0.1:360
112             betar=beta*%pi/180;
113             ia=(Vm*sin(betar-fai)/Z)-(K*Wm/Ra)+(((K*
                Wm/Ra)-(Vm*sin(alphar-fai)/Z))*exp((
                alphar-betar)*cotg(fai)));
114                 if ia<=0.00001 then
115                     break;
116                 end
117             end
118             Tor4(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-
                (Wm*K^2*(betar-alphar)))/(%pi*Ra);
119         else
120             Tor4(j,i)=((Vm*K*(1+cos(alphar))/%pi)-(Wm*K
                ^2))/Ra;
121         end
122         i=i+1;
123     end
124     j=j+1;
125 end
126 plot(Wmi',Tor4','c','LineWidth',2)
127 //legend('Firing Angle =30 degree','','Firing Angle
        =60 degree','','Firing Angle =90 degree','','
        Firing Angle =120 degree')
128 xgrid
129 title(' Torque-Speed characteristics of single phase
        Full controlled rectifier fed separately excited
        DC motor ','fontsize',3)
130 xlabel("SPEED ----->","fontsize',3)
131 ylabel("TORQUE ----->","fontsize',3)
132 //legends([" pqr ";" xyz "],[[5;2],[3;4]], with_box=%f,
        opt="??")
133 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

```
1 //Experiment-5
2 // windows - 7 - 64-Bit
3 //Scilab - 5.4.1
4
5
6 //AIM:  Develop a program to plot Torque - speed
      characteristics (VVVF Mode included).
7 clear
8 clc
9 Po = input('Enter the value of Output Power : ') //
      Enter: 3.7
10 V = input('Enter the value of Voltage in volts : ')
      //Enter: 415
```

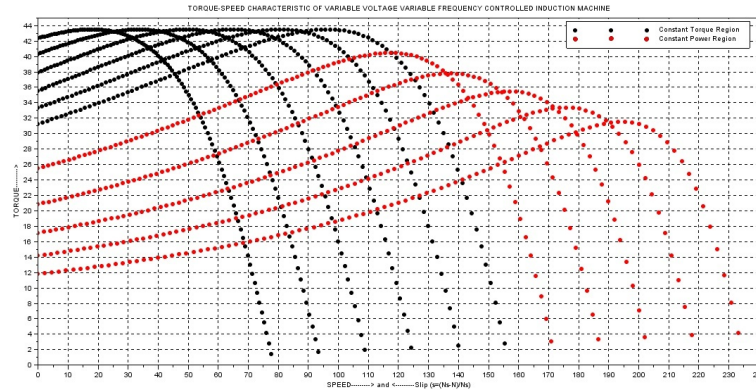



Figure 5.1: VVVF Control

```

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

```

```

24     Wms=4*%pi*f/P;
25     if(f<=fb) then
26         for s=1:-0.01:0.01
27             Ws=4*%pi*f/P;
28             Wm=(1-s)*Ws;
29             k=f/fb;
30             T1=(3/Ws)*(V1^2*(Rr/s))/((Rs+(Rr/(k*s)))
                ^2+(Xs+Xr)^2);
31             plot(Wm,T1,'k.')
32         end
33     else
34         for s=1:-0.01:0.01
35             Ws=4*%pi*f/P;
36             Wm=(1-s)*Ws;
37             k=f/fb;
38             T2=(3/Ws)*(V1^2*(Rr/s))/(((Rs+(Rr/(k*s))
                )^2+(k*Xs+k*Xr)^2));
39             plot(Wm,T2,'r.')
40         end
41     end
42 end
43 title('TORQUE-SPEED CHARACTERISTIC OF VARIABLE
        VOLTAGE VARIABLE FREQUENCY CONTROLLED INDUCTION
        MACHINE')
44 xlabel("SPEED—————> and <—————Slip (s=(Ns-N)
        /Ns)")
45 ylabel("TORQUE—————>")
46 xgrid
47 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 www.scilab.in

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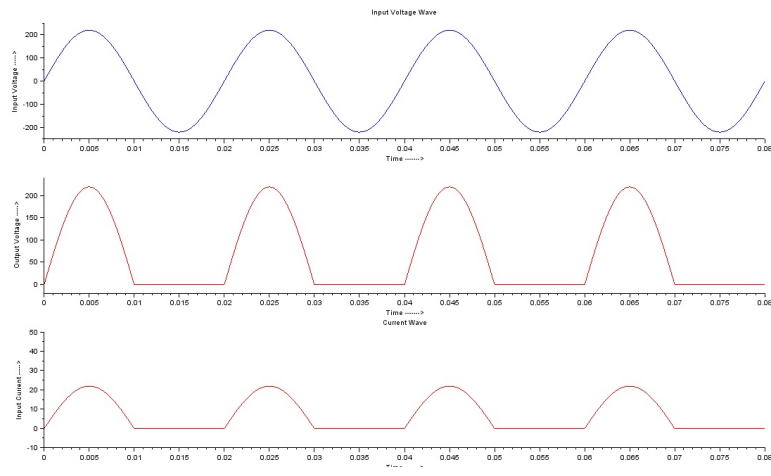


Figure 6.1: Halfwave uncontrolled Rectifier

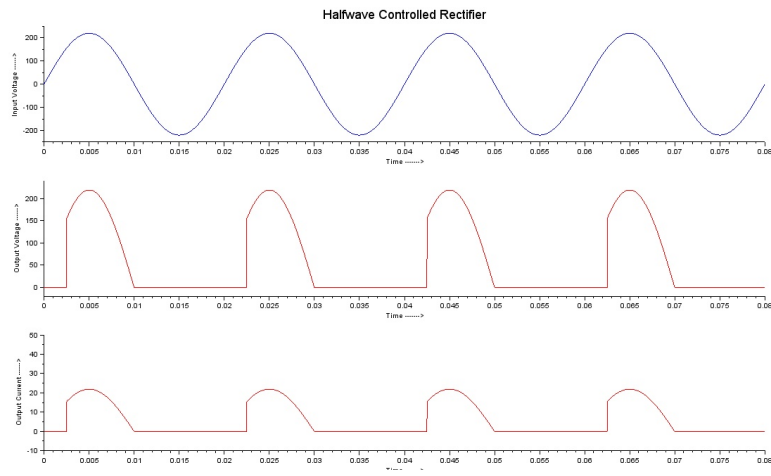


Figure 6.2: Halfwave Controlled Rectifier

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 www.scilab.in This code

can be downloaded from the website www.scilab.in

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

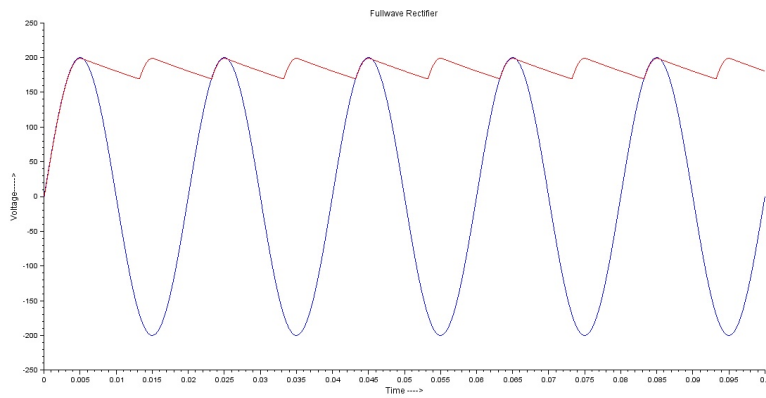


Figure 7.1: Fullwave Uncontrolled Rectifier

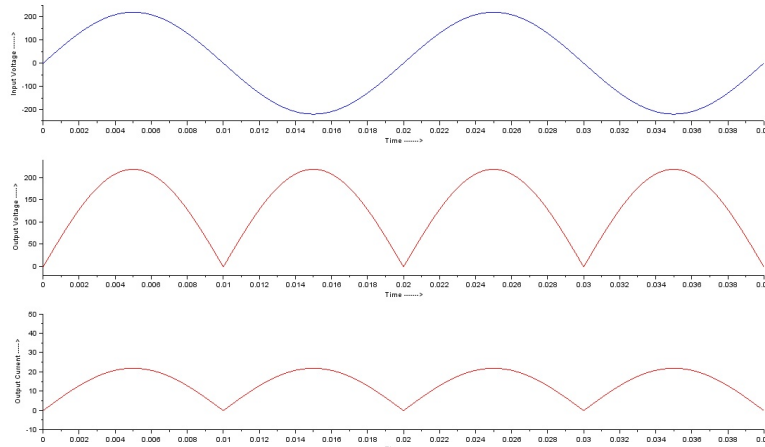


Figure 7.2: Fullwave Uncontrolled Rectifier

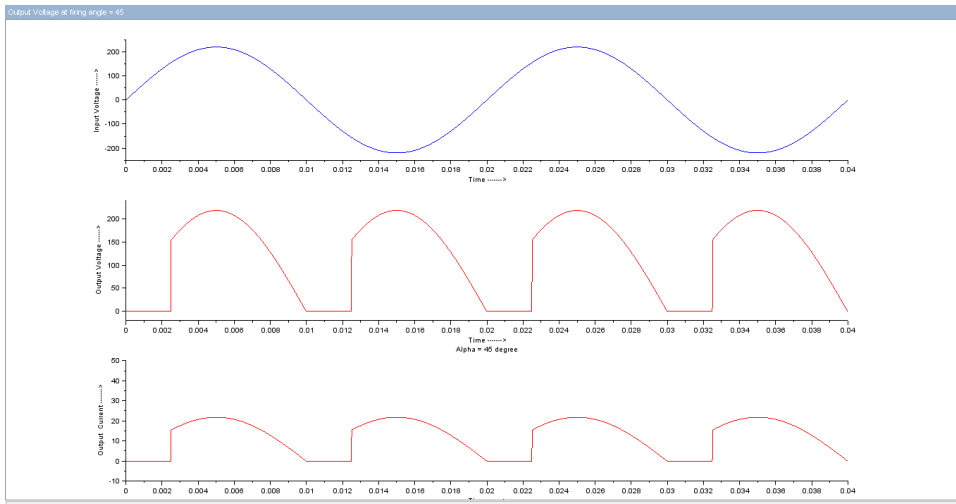


Figure 7.3: Fullwave Controlled Rectifier For 45 alpha

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

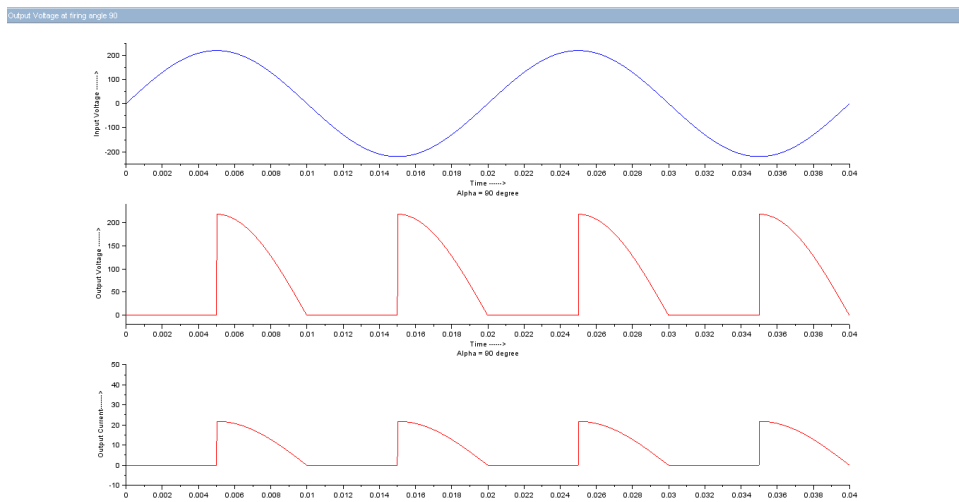


Figure 7.4: Fullwave Controlled Rectifier For 90 alpha