

Scilab Manual for
Control of Electric Drive
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Contents

List of Scilab Solutions	3
1 Develop a program, to plot Torque-Slip characteristics of poly phase induction motor.	5
2 Develop a program, to plot Torque-Speed characteristics of poly phase induction motor.	8
3 Develop a program to plot torque-speed characteristics of single phase half controlled rectifier fed separately excited DC motor	11
4 Develop a program to plot torque-speed characteristics of single phase fully controlled rectifier fed separately excited DCmotor	17
5 Develop a program, to plot Torque-Slip characteristics of poly phase induction motor using VVVF control.	23
6 To Study and Simulation of the single phase half controlled AC to DC Converter and effect of firing angle on load voltage	26
7 To Study and Simulation of the single phase fully controlled AC to DC Converter and effect of firing angle on load voltage	28

List of Experiments

Solution 1.01	User define Torque Slip characterisitic	5
Solution 2.01	Speed Torque	8
Solution 3.01	Halfwave rectifier control for different firing angle	11
Solution 4.01	Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC mo- tor	17
Solution 5.01	VVVF Control	23

List of Figures

1.1	User define Torque Slip characterisite	6
2.1	Speed Torque	9
3.1	Halfwave rectifier control for different firing angle	12
4.1	Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor	18
5.1	VVVF Control	24
6.1	Halfwave uncontrolled Rectifier	27
6.2	Halfwave Controlled Rectifier	27
7.1	Fullwave Uncontrolled Rectifier	29
7.2	Fullwave Uncontrolled Rectifier	29
7.3	Fullwave Controlled Rectifier For 45 alpha	30
7.4	Fullwave Controlled Rectifier For 90 alpha	31

Experiment: 1

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

Scilab code Solution 1.01 User define Torque Slip characterisite

```
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 perameter for Torque - slip
      Characteristic.
```

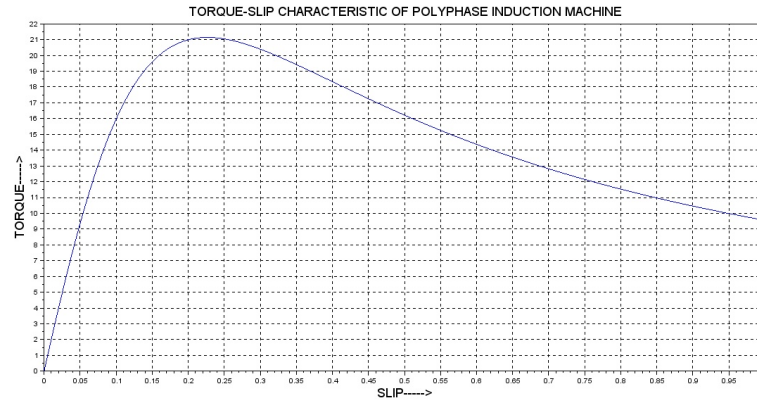


Figure 1.1: User define Torque Slip characterisitc

```

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 : ')
```

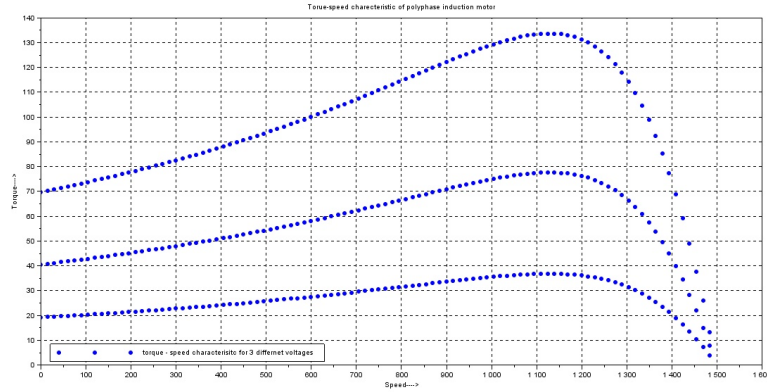


Figure 2.1: Speed Torque

```

//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 characterisite 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
```

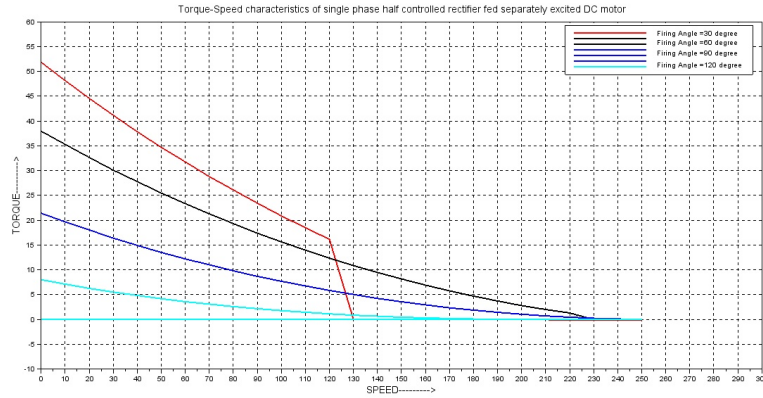


Figure 3.1: Halfwave rectifier control for different firing angle

```

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+alphas;
36         ia=(Vm*exp(-(alphas)*cotg(fai))*(sin(fai)-
            sin(alphas-fai))/Z)-(E*exp(-(alphas)*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(alphas-fai)/Z))*exp((
                    alphas-betar)*cotg(fai)));
41                 if ia<=1e-4 then
42                     break;
43                 end
44             end
45             Tor1(j,i)=((Vm*K*(cos(alphas)-cos(betar)
                ))-(Wm*K^2*(betar-alphas)))/(%pi*Ra);
46         else
47             Tor1(j,i)=((Vm*K*(1+cos(alphas))/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+alphas;

```

```

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
    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
```

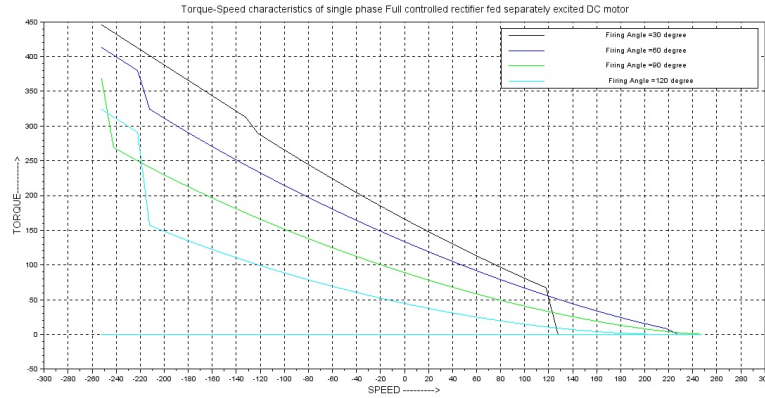


Figure 4.1: Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor

```

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+alphas;
34          ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
              *sin(alphas-fai)/Z))*exp((alphas-eta)*cotg(
              fai)));
35          if ia<=0      then
                                                                    // if
                                                                    current is discontinuous
36              for betas=(alpha+0.1):0.1:360
37                  betar=betas*%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
```

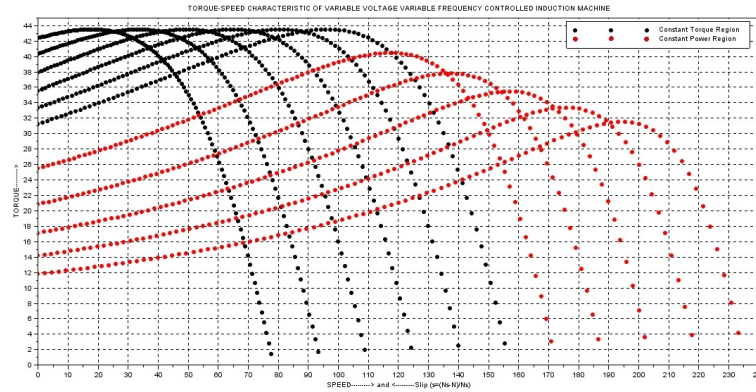



Figure 5.1: VVVF Control

```

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

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

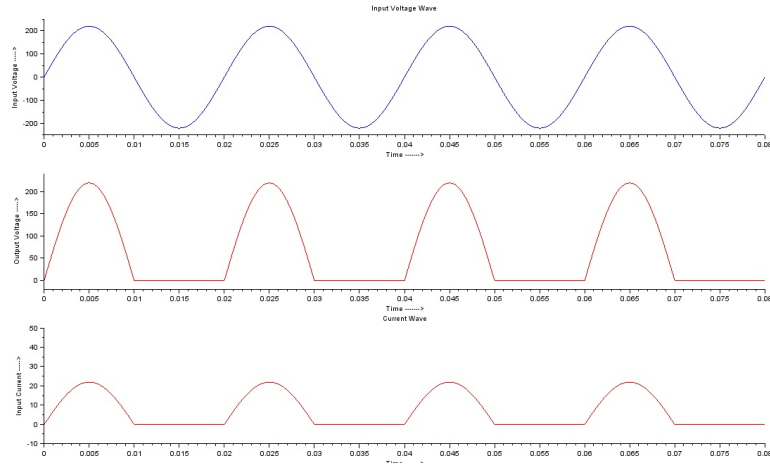


Figure 6.1: Halfwave uncontrolled Rectifier

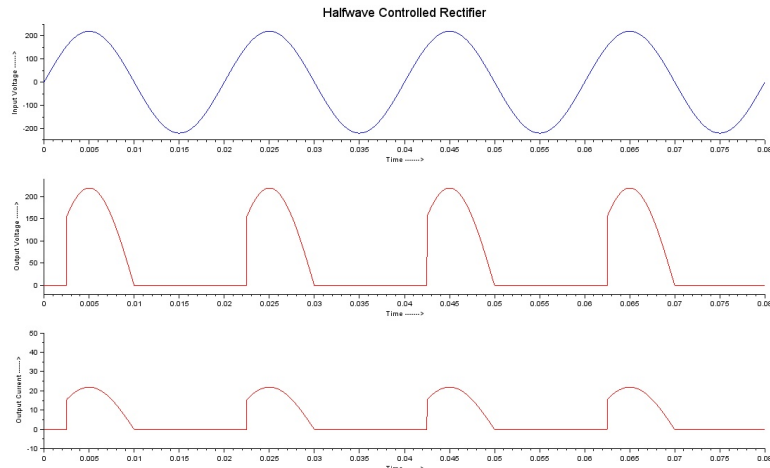


Figure 6.2: Halfwave Controlled Rectifier

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

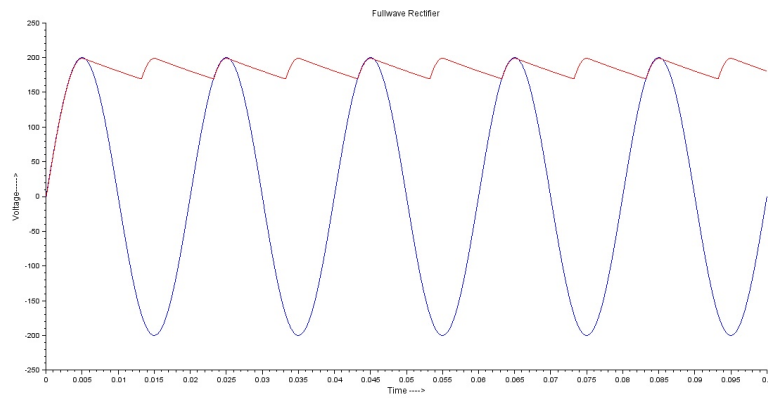


Figure 7.1: Fullwave Uncontrolled Rectifier

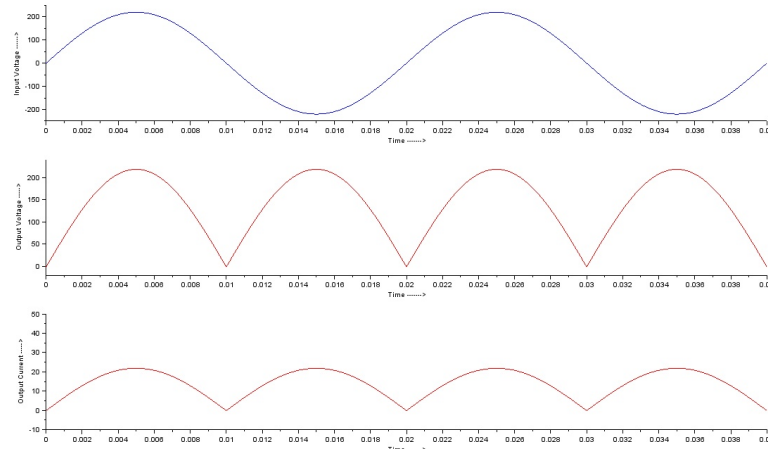


Figure 7.2: Fullwave Uncontrolled Rectifier

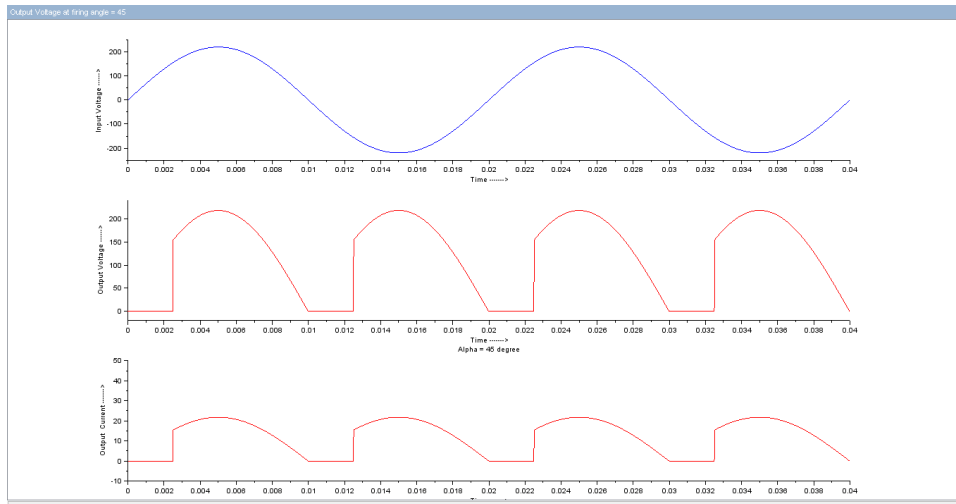


Figure 7.3: Fullwave Controlled Rectifier For 45 alpha

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

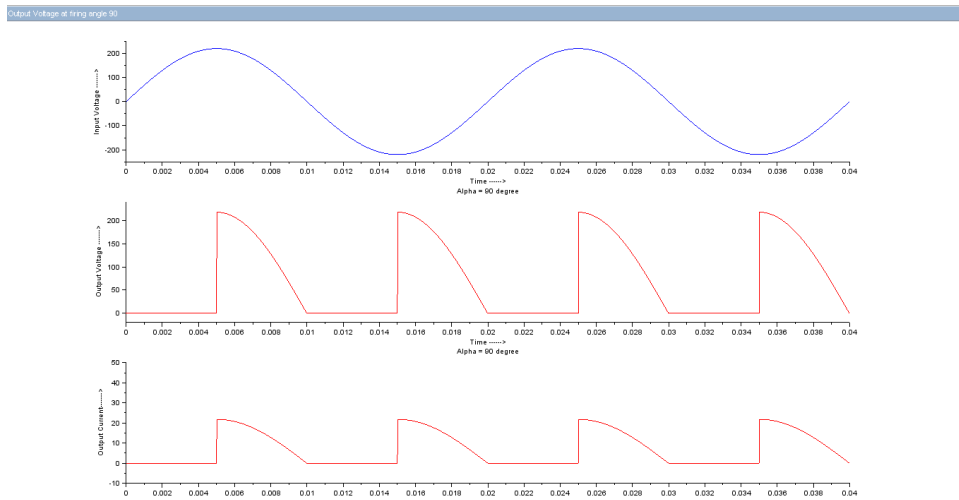


Figure 7.4: Fullwave Controlled Rectifier For 90 alpha