Scilab Manual for Control of Electric Drive by Prof Priyen S. Patel Electrical Engineering Swarnim Startup And Inovation University[1]

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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

```
1
2
3 //Experiment-1
4 // windows - 7 - 64-Bit
5 //Scilab - 5.4.1
6
7
8 //AIM: Devlop 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.
```

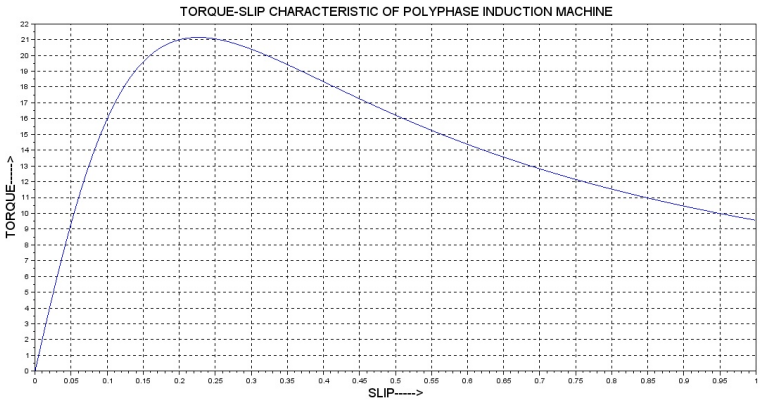


Figure 1.1: User define Torque Slip characterisitc

```
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 : ')
```

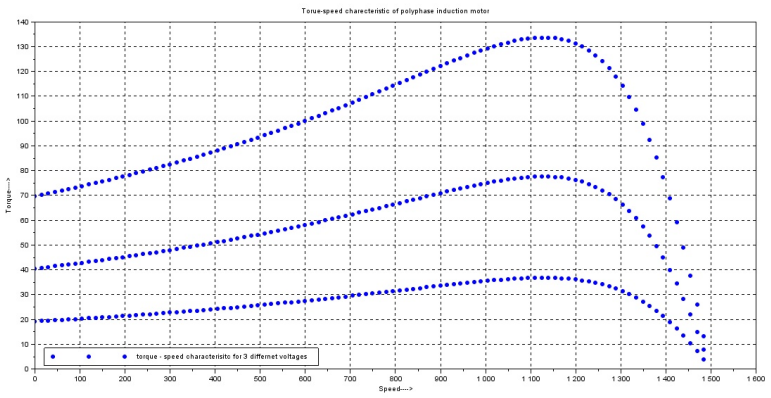


Figure 2.1: Speed Torque

```
    //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
    synchoronous 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 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

```
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
```

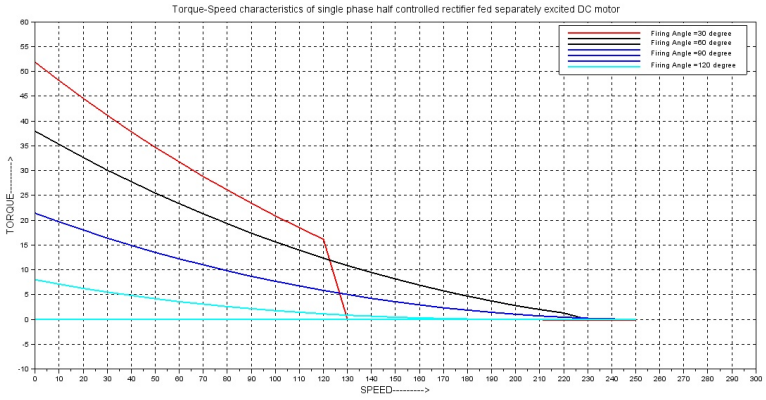


Figure 3.1: Halfwave rectifier control for different firing angle

```
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      alphar=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      alphar=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(-(alphar)*cotg(fai))*(sin(fai)-
                sin(alphar-fai))/Z)-(E*exp(-(alphar)*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(alphar-fai)/Z))*exp((
                    alphar-betar)*cotg(fai)));
66              if ia<=1e-4 then
67                  break;
68              end
69          end
70              Tor2(j,i)=((Vm*K*(cos(alphar)-cos(betar)
                    ))-(Wm*K^2*(betar-alphar)))/(%pi*Ra);
71          else
72              Tor2(j,i)=((Vm*K*(1+cos(alphar))/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      alphar=alpha*%pi/180;
81      i=1;
82      for Wm=0.01:10:Wmo
83          Wmi(j,i)=Wm;
84          a=%pi+alphar;
85          ia=(Vm*exp(-(alphar)*cotg(fai))*(sin(fai)-
                sin(alphar-fai))/Z)-(E*exp(-(alphar)*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
```

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

```
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
```

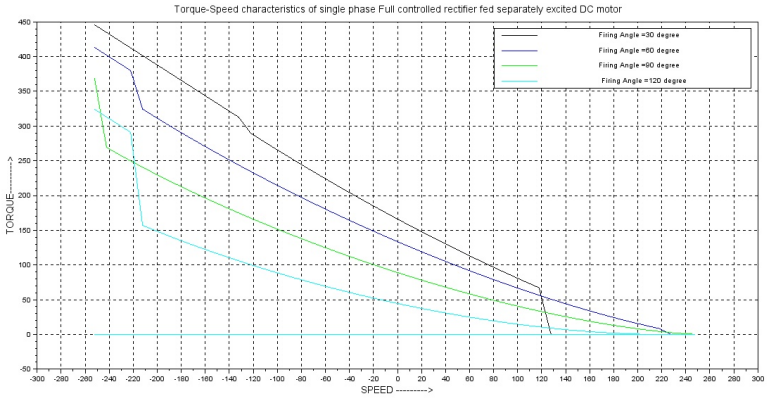


Figure 4.1: Torque Speed characteristics of single phase full controlled rectifier fed separately excited DC motor

```
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;
```

```
57      Wmi(j,i)=Wm;
58      eta=%pi+alphar;
59      ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
           *sin(alphar-fai)/Z))*exp((alphar-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(alphar-fai)/Z))*exp((
                   alphar-betar)*cotg(fai)));
64                  if ia<=0.00001 then
65                  break;
66                  end
67              end
68          Tor2(j,i)=((Vm*K*(cos(alphar)-cos(betar)))-(
               Wm*K^2*(betar-alphar)))/(%pi*Ra);
69          else
70          Tor2(j,i)=((Vm*K*(1+cos(alphar))/%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  alphar=alpha*%pi/180;
80  i=1;
81      for Wm = - Wmo:10:Wmo;
82      Wmi(j,i)=Wm;
83      eta=%pi+alphar;
84      ia=(Vm*sin(eta-fai)/Z)-(K*Wm/Ra)+(((K*Wm/Ra)-(Vm
           *sin(alphar-fai)/Z))*exp((alphar-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: Devlop 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
```

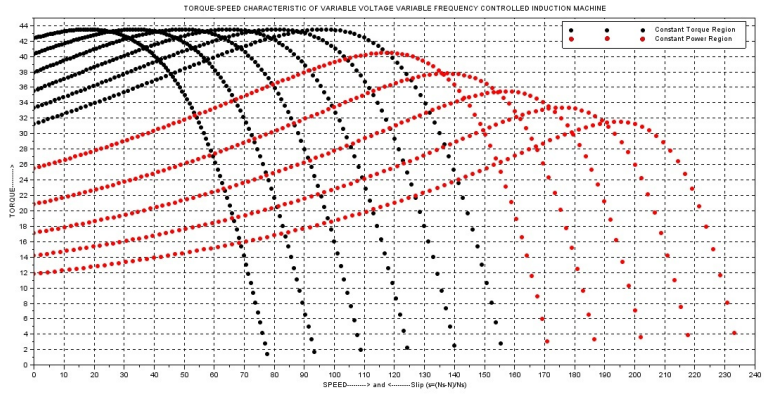


Figure 5.1: VVVF Control

```
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)
```

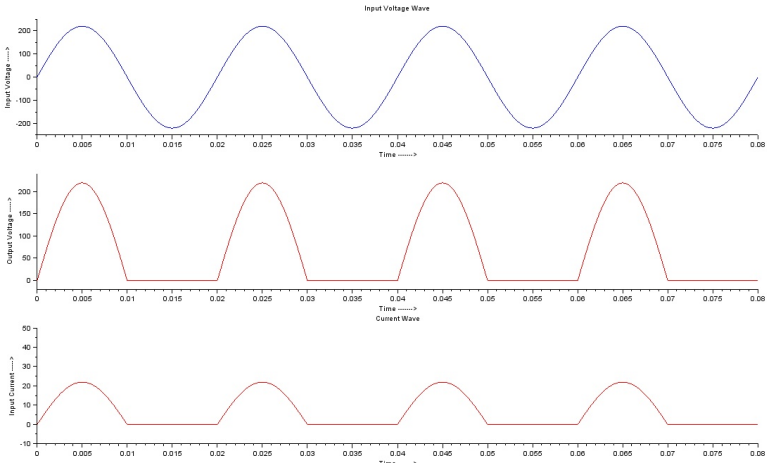
```
24      Wms=4*%pi*f/P;
25      if(f<=fb) then
26          for s=1:-0.01:0.01
27              Ws=4*%pi*f/P;
28              Wm=(1-s)*Ws;
29              k=f/fb;
30              T1=(3/Ws)*(V1^2*(Rr/s))/((Rs+(Rr/(k*s)))
                    ^2+(Xs+Xr)^2);
31              plot(Wm,T1,'k.')
32      end
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 wwww.scilab.in

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


Input Voltage Wave
Input Voltage ----->
Time ------->
Output Voltage ----->
Time ------->
Current Wave
Input Current ----->
Time ------->
Output Current ----->
Time ------->
Output Current ----->
Time ------->
Halfwave Controlled Rectifier
Input Voltage ----->
Time ------->
Output Voltage ----->
Time ------->
Output Current ----->
Time ------->
Output Current ----->
Time ------->
Output Current

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

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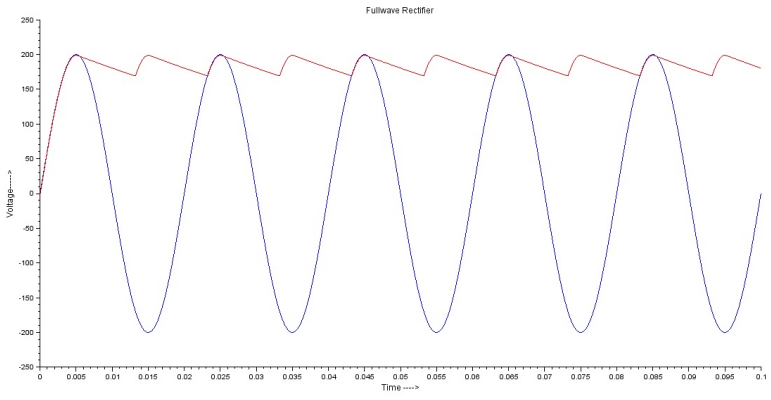


Figure 7.1: Fullwave Uncontrolled Rectifier

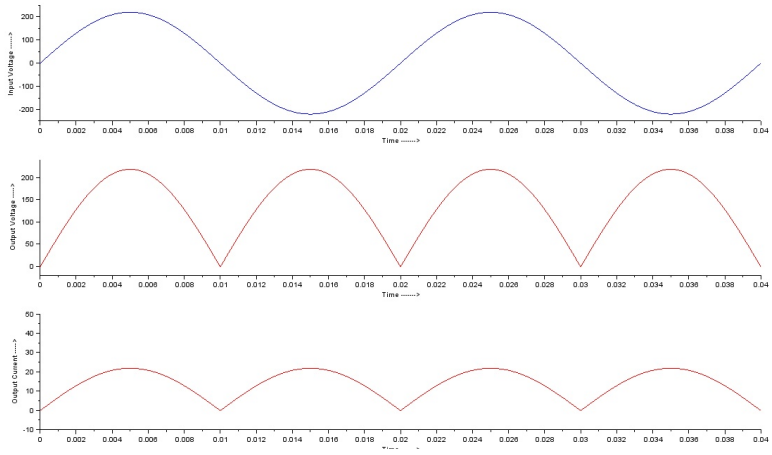


Figure 7.2: Fullwave Uncontrolled Rectifier

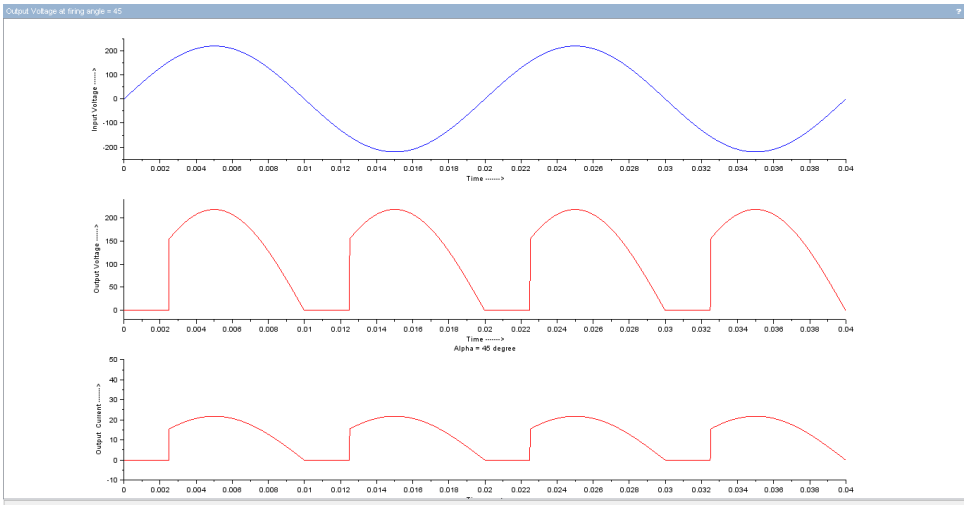


Figure 7.3: Fullwave Controlled Rectifier For 45 alpha

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

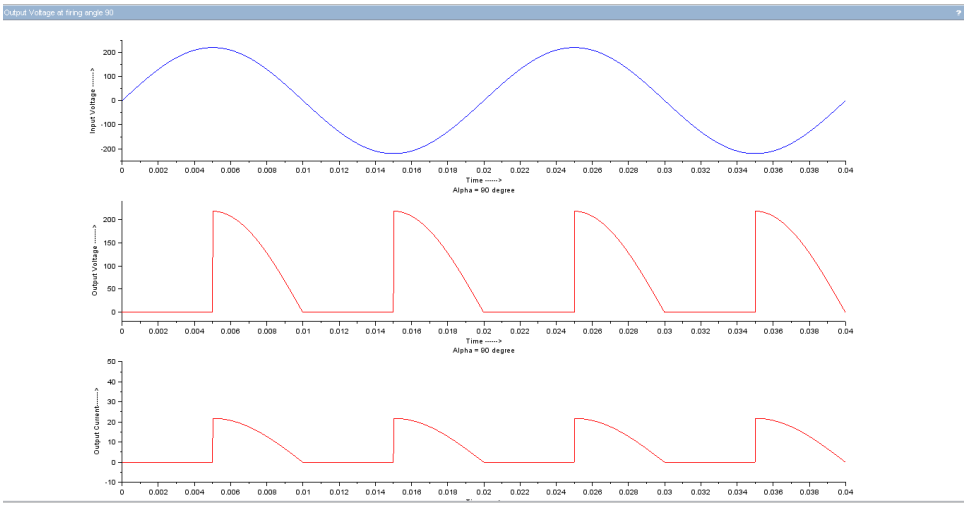


Figure 7.4: Fullwave Controlled Rectifier For 90 alpha