



Faculty of Engineering
Electrical Engineering Department
Electrical machines ENEE 2408

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Assignment on Induction Motors

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Use the parameters of the Y-induction motor of problem 6-15 (5th edition) :

$V_T = 460$, $f_e = 60\text{Hz}$, $p = 4$, rated power 25 hp , $R_1 = 0.15 \Omega$, $R_2 = 0.154 \Omega$, $X_m = 20 \Omega$,
 $X_1 = 0.852 \Omega$, $X_2 = 1.066 \Omega$, $P_{F\&W} = 400 \text{ W}$, $P_{\text{misc. (stray)}} = 150 \text{ W}$, $P_{\text{core}} = 400 \text{ W}$.

to write a Matlab code to plot the torque speed curve for s in the range $\{-1.0001, 2.0001\}$.

Avoid running the simulation for $s=0.0$; use instead any very small value for example $s=0.0005!$

a) Show the torque plot versus speed and also the torque versus s at rated voltage, **Also show the converted output power versus slip.**

b) repeat a) for VLL reduced to 75% of VLL rated, 50%, 25% then to 10% of rated voltage (show plots on the same figure)

c) repeat a) for R_2 increased to have every time one of the following values: 0.1, 0.2, 0.6, 1.2, 2.8, 4.5, 8 and 15 OHMs (show plots on the same figure).

A)

```
close all; clc ; clear all ;
VT= 460 ;
fe= 60 ;
p=4 ;
ratedpower =25 ;
R1=0.15 ;
R2=0.154 ;
Xm=20 ;
X1=0.852 ;
X2=1.066 ;
Pwandf= 400 ;
Pstray =150 ;
Pcore = 400 ;
nsync= (120*fe)/p ;
wsync=2*3.14*nsync/60;
Xth=X1 ;
Rth=R1*(Xm/(Xm+X1))^2 ;
Vphase=VT/power(3, .5);
Vth=(Xm/(Xm+X1))*Vphase;

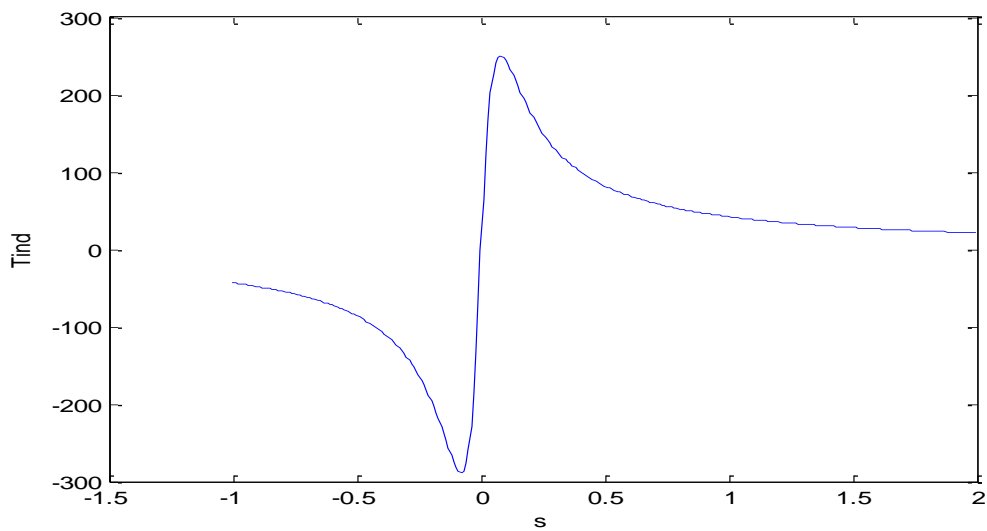
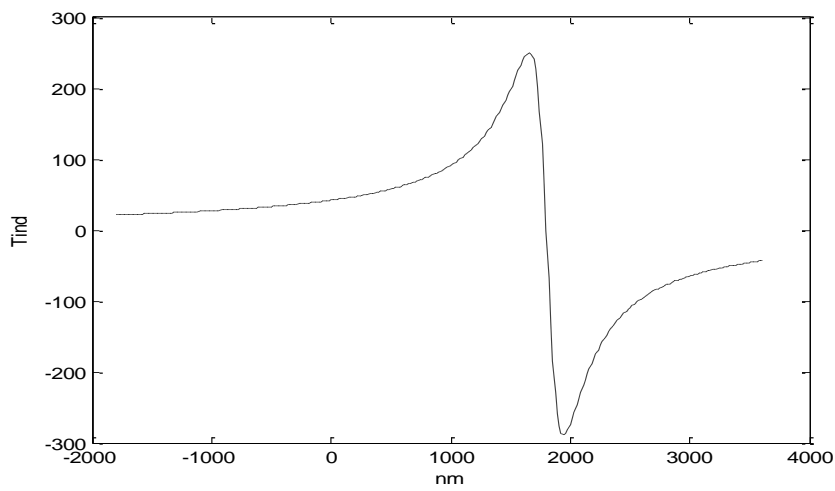
s=-1.0001:.01:2.0001;
nm=(1-s)*nsync ;
wm=(1-s)*wsync ;

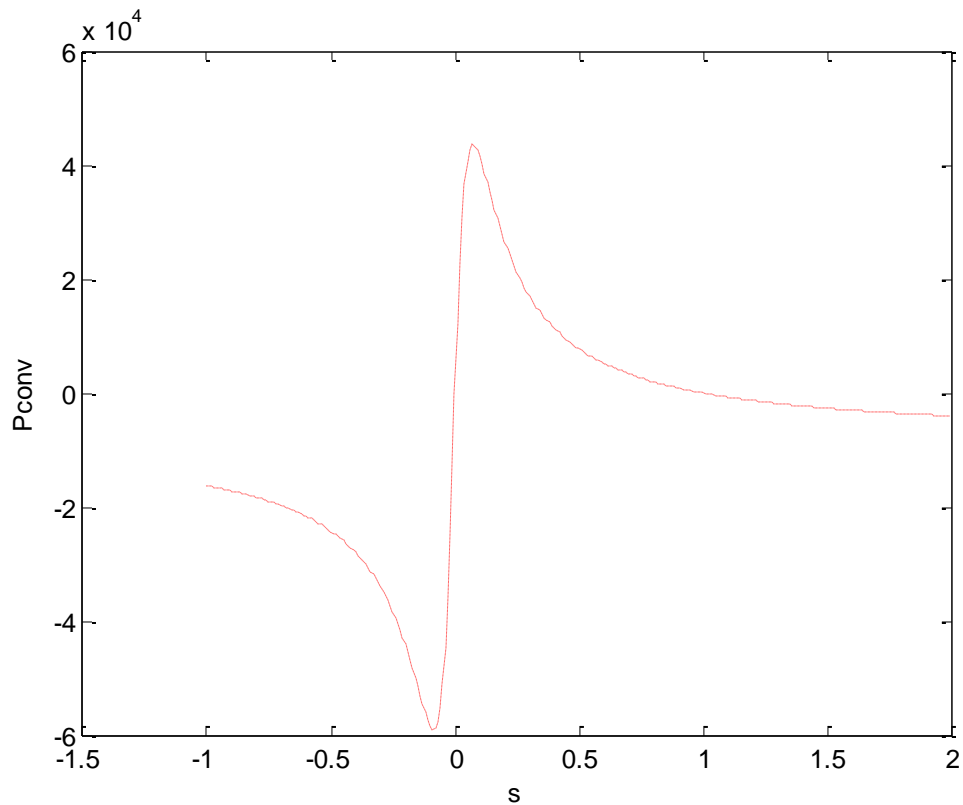
for i = 1:length(s)
Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));
Pconv(i)=Tind(i)*wm(i) ;
end
```

```
figure
plot (nm,Tind,'--k');
xlabel('nm');
ylabel('Tind');
```

```
figure
plot (s,Tind,'-b');
xlabel('s');
ylabel('Tind');
```

```
figure
plot (s,Pconv,':r');
xlabel('s');
ylabel('Pconv');
```





b)

```
close all; clc ; clear all ;
```

```
fe= 60 ;
p=4 ;
ratedpower =25 ;
R1=0.15 ;
R2=0.154 ;
Xm=20 ;
X1=0.852 ;
X2=1.066 ;
Pwandf= 400 ;
Pstray =150 ;
Pcore = 400 ;
nsync= (120*fe)/p ;
wsync=2*3.14*nsync/60;
Xth=X1 ;
Rth=R1*(Xm/(Xm+X1))^2 ;
% 75% of VT Tind vs nm
VT= 460*0.75 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
```

```

Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
    nm=(1-s)*nsync ;
plot (nm,Tind,'-k');
xlabel('nm');
ylabel('Tind');
hold on
% 50% of VT Tind vs nm
VT= 460*0.50 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind,'-b');
hold on
% 25% of VT Tind vs nm
VT= 460*0.25 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind,'-g');
hold on
% 10% of VT Tind vs nm
VT= 460*0.10 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind,'-r');

figure
% 75% of VT Tind vs s
VT= 460*0.75 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
plot (s,Tind,'-k');
xlabel('s');

```

```

ylabel('Tind');
hold on
% 50% of VT Tind vs s
VT= 460*0.50 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
plot (s,Tind,'-b');
hold on
% 25% of VT Tind vs s
VT= 460*0.25 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
    plot (s,Tind,'-g');
hold on
% 10% of VT Tind vs s
VT= 460*0.10 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));

    end
plot (s,Tind,'-r');

figure
% 75% of VT Pconv vs s
VT= 460*0.75 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

plot (s,Pconv,'-k');
xlabel('s');
ylabel('Pconv');
hold on
% 50% of VT Pconv vs s
VT= 460*0.50 ;
Vphase=VT/power(3,.5);
s=-1.0001:.01:2.0001;

```

```

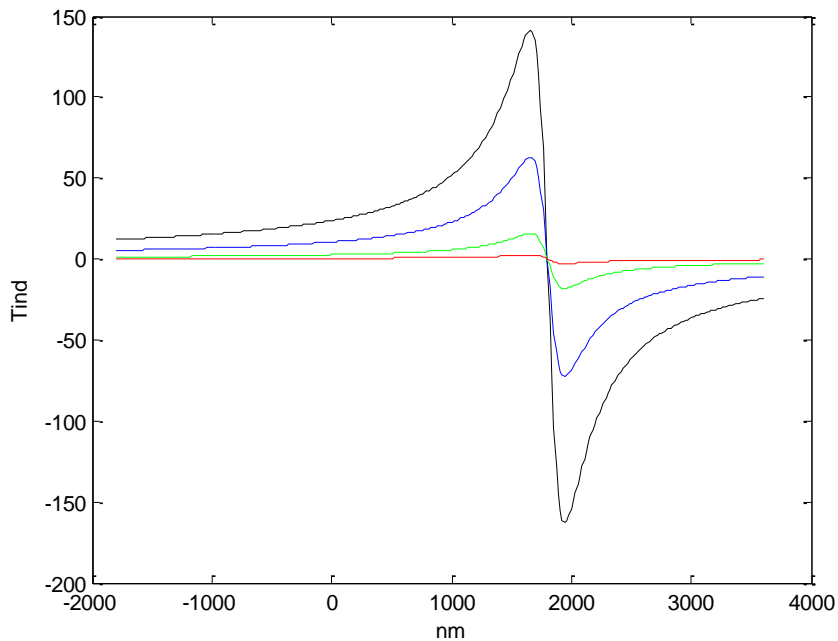
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

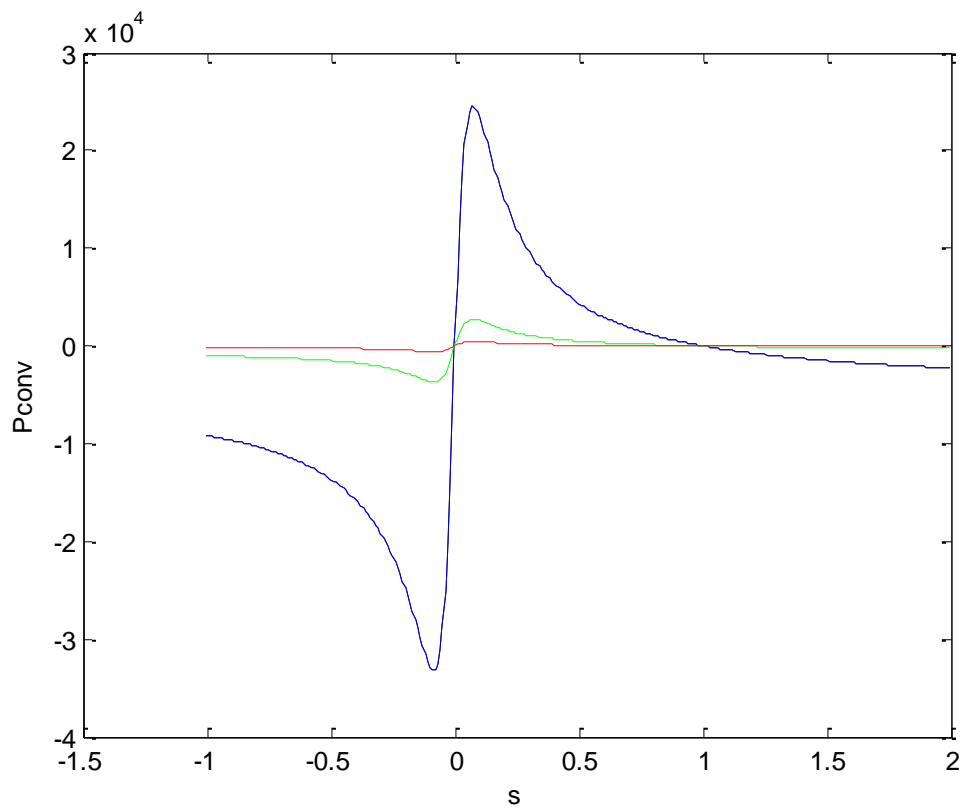
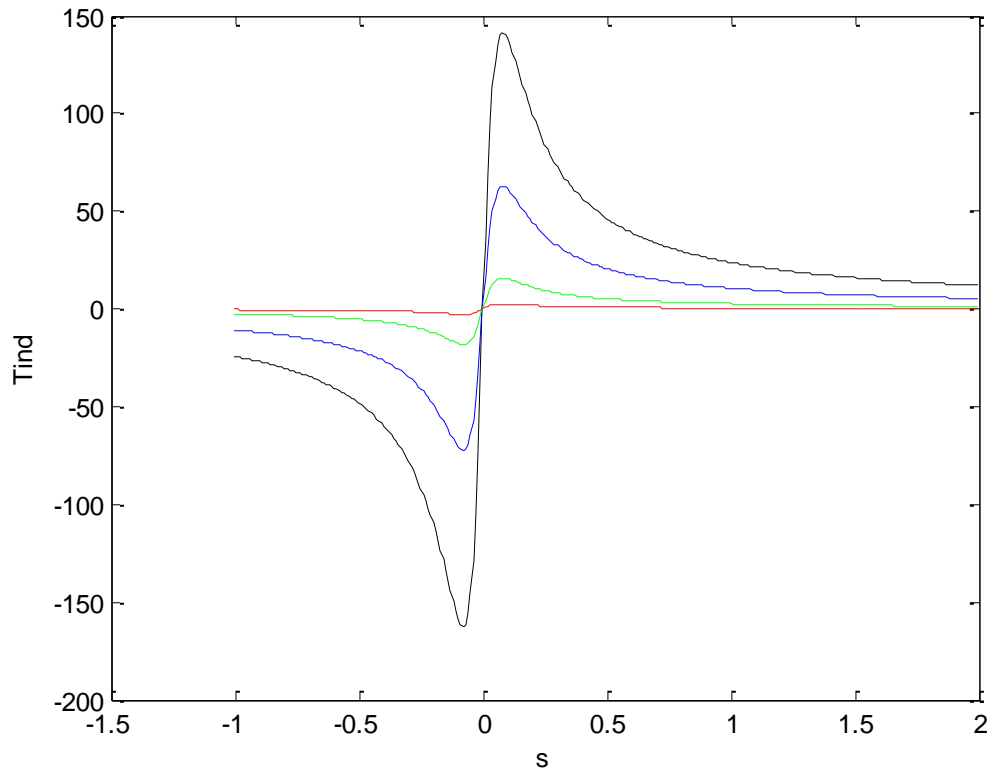
plot (s,Pconv,'-b');
hold on
% 25% of VT Pconv vs s
VT= 460*0.25 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

plot (s,Pconv,'-g');
hold on
% 10% of VT Pconv vs s
VT= 460*0.10 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;

    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i)).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end
end
plot (s,Pconv,'-r');

```





C)

```
close all; clc ; clear all ;
VT= 460 ;
fe= 60 ;
p=4 ;
ratedpower =25 ;
R1=0.15 ;
Xm=20 ;
X1=0.852 ;
X2=1.066 ;
Pwandf= 400 ;
Pstray =150 ;
Pcore = 400 ;
nsync= (120*fe)/p ;
wsync=2*3.14*nsync/60;
Xth=X1 ;
Rth=R1*(Xm/(Xm+X1))^2 ;
Vphase=VT/power(3,.5);
Vth=(Xm/(Xm+X1))*Vphase;
s=-1.0001:.01:2.0001;
%Tind vs nm at R2=0.1
R2= 0.1;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
end
nm=(1-s)*nsync ;
plot (nm,Tind,'-k');
xlabel('nm');
ylabel('Tind');
hold on
%Tind vs nm at R2=0.2
R2= 0.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
end
nm=(1-s)*nsync ;
plot (nm,Tind,'-b');hold on
%Tind vs nm at R2=0.6
R2= 0.6;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
end
nm=(1-s)*nsync ;
plot (nm,Tind,'-g');
hold on
%Tind vs nm at R2=1.2
R2= 1.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
```



```

    end
nm=(1-s)*nsync ;
plot (nm,Tind, '-r');
hold on
%Tind vs nm at R2=2.8
R2=2.8;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind, '-y');
hold on
%Tind vs nm at R2=4.5
R2=4.5;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind, '-m');
hold on
%Tind vs nm at R2=8
R2=8;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind, '-c');
hold on
%Tind vs nm at R2=15
R2=15;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

    end
nm=(1-s)*nsync ;
plot (nm,Tind, ':k');

figure
%Tind vs s at R2=0.1
R2= 0.1;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

    end
plot (s,Tind, '-k');
xlabel('s');

```

```

ylabel('Tind');
hold on
%Tind vs s at R2=0.2
R2= 0.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-b');
hold on
%Tind vs s at R2=0.6
R2= 0.6;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-g');
hold on
%Tind vs s at R2=1.2
R2= 1.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-r');
hold on
%Tind vs s at R2=2.8
R2=2.8;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-y');
hold on
%Tind vs s at R2=4.5
R2=4.5;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-m');
hold on
%Tind vs s at R2=8
R2=8;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));

end
plot (s,Tind,'-c');
hold on

```

```

%Tind vs s at R2=15
R2=15;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
end
plot (s,Tind,':k');

figure
%Pconv vs s at R2=0.1
R2= 0.1;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
    wm=(1-s)*wsync ;
    Pconv(i)=Tind(i)*wm(i) ;
end

plot (s,Pconv,'-k');
xlabel('s');
ylabel('Pconv');
hold on
%Pconv vs s at R2=0.2
R2= 0.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
    wm=(1-s)*wsync ;
    Pconv(i)=Tind(i)*wm(i) ;
end

plot (s,Pconv,'-b');
hold on
%Pconv vs s at R2=0.6
R2= 0.6;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
    wm=(1-s)*wsync ;
    Pconv(i)=Tind(i)*wm(i) ;
end

plot (s,Pconv,'-g');
%axis([-1.0001 2.0001
hold on
%Pconv vs s at R2=1.2
R2= 1.2;
s=-1.0001:.01:2.0001;
for i = 1:length(s)
    Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
    wm=(1-s)*wsync ;
    Pconv(i)=Tind(i)*wm(i) ;
end

```

```

plot (s,Pconv, '-r');
hold on
%Pconv vs s at R2=2.8
R2=2.8;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

```

```

plot (s,Pconv, '-y');
hold on
%Pconv vs s at R2=4.5
R2=4.5;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

```

```

plot (s,Pconv, '-m');
hold on
%Pconv vs s at R2=8
R2=8;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

```

```

plot (s,Pconv, '-c');
hold on
%Pconv vs s at R2=15
R2=15;
s=-1.0001:.01:2.0001;
    for i = 1:length(s)
        Tind(i)=3*(Vth.^2)*(R2./s(i))/(wsync*((Rth+(R2./s(i))).^2+(Xth+X2).^2));
        wm=(1-s)*wsync ;
        Pconv(i)=Tind(i)*wm(i) ;
    end

```

```

plot (s,Pconv, ':k');

```

