

BIRZEIT UNIVERSITY

Electrical Engineering Department

 **ELECTRICAL MACHINES**

Assignment

Induction Motors

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**a))**

R1 = 0.150; %statore resistance

R2 = 0.154; %rotor resistance

X1 = 0.852; %statore reactance

X2 = 1.066; %rotor reactance

Xm = 20.0; % magnaization branch ractance

V\_phase=460/sqrt(3);

n\_sync=1800;

w\_sync=188;

%to find V\_th and Z\_th (R\_th&&X\_th ) by equation 1 && 2 :

Vth = (Xm/(sqrt(R1^2+(X1+Xm)^2)))\*V\_phase;

Zth = ((j\*Xm) \* (R1+ (j\*X1)))/(R1 + j\*(Xm+X1));

Rth = real(Zth); %thivenin impedance

Xth = imag(Zth); %thivenin reactance

s=(-100:1:200)/100; %slip

s(100)=0.0005; %Avoid division by-zero

n\_m=(1-s)\*n\_sync; % Mechanical speed

w\_m=(1 - s)\*w\_sync;

% calculate the motor torque and power converted for many slips

fori = 1:301

t\_ind(i) = (3 \* Vth^2 \* R2 / s(i)) / ...

 (w\_sync \* ((Rth + R2/s(i))^2 + (Xth + X2)^2) );

p\_conv(i) = t\_ind(i) \* w\_m(i);

end

**% Plot the torque - speed curve,**

figure(1);

plot(n\_m,t\_ind,'color','g','LineWidth',2);

xlabel('\bf\itn\_{m} \rm\bf(r/min)');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title ('\bfInduced Torque versus Speed');

gridon;

figure(2);

plot(s,t\_ind,'color', 'b','LineWidth',2);

xlabel('\its');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title('Induction motor torque- slip characteristic when VLL at rated');

gridon;

**% plot the converted output power versus slip,**

figure(3);

plot(s,p\_conv/1000,'color','c','LineWidth',2.0);

xlabel('\its');

ylabel('\bf\itP\rm\bf\_{conv} (kW)');

title ('\bfPower Converted versus slip');

gridon;







**b)**

Vth1=0.75\*Vth;

Vth2=0.50\*Vth;

Vth3=0.25\*Vth;

Vth4=0.10\*Vth;

for i=1:301 %VLL= reduced to 75%

 t\_ind1(i)= (3 \* Vth1^2 \* R2 / s(i)) / ...

 (w\_sync \* ((Rth + R2/s(i))^2 + (Xth + X2)^2) );

 p\_conv1(i) = t\_ind1(i) \* w\_m(i);

end

for i=1:301 %VLL= reduced to 50%

 t\_ind2(i)= (3 \* Vth2^2 \* R2 / s(i)) / ...

 (w\_sync \* ((Rth + R2/s(i))^2 + (Xth + X2)^2) );

 p\_conv2(i) = t\_ind2(i) \* w\_m(i);

end

for i=1:301 %VLL= reduced to 25%

 t\_ind3(i)= (3 \* Vth3^2 \* R2 / s(i)) / ...

 (w\_sync \* ((Rth + R2/s(i))^2 + (Xth + X2)^2) );

 p\_conv3(i) = t\_ind3(i) \* w\_m(i);

end

for i=1:301 %VLL= reduced to 10%

 t\_ind4(i)= (3 \* Vth4^2 \* R2 / s(i)) / ...

 (w\_sync \* ((Rth + R2/s(i))^2 + (Xth + X2)^2) );

 p\_conv4(i) = t\_ind4(i) \* w\_m(i);

end

% Plot the torque - speed curve,

figure(4);

plot(n\_m,t\_ind1,'color','m','linewidth',2.2);

hold on;

plot(n\_m,t\_ind2,'color','y','linewidth',2.2);

plot(n\_m,t\_ind3,'color','k','linewidth',2.2);

plot(n\_m,t\_ind4,'color','g','linewidth',2.2);

xlabel('\bf\itn\_{m} \rm\bf(r/min)');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title('Induction motor torque- speed characteristic');

legend('when VLL=75% of VLL rated ','when VLL=50% of VLL rated ','when VLL=25% of VLL rated ','when VLL=10% of VLL rated');

grid on;

hold off;

%plot torque versus S at rated voltage,

figure(5);

plot(s,t\_ind1,'color','k','linewidth',2.0);

hold on;

plot(s,t\_ind2,'color','g','linewidth',2.0);

plot(s,t\_ind3,'color','r','linewidth',2.0);

plot(s,t\_ind4,'color','b','linewidth',2.0);

xlabel('\its');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title('Induction motor torque- slip characteristic');

legend('when VLL=75% of VLL rated ','when VLL=50% of VLL rated ','when VLL=25% of VLL rated ','when VLL=10% of VLL rated');

grid on;

hold off;

% plot the converted output power versus slip,

figure(6);

plot(s,p\_conv1/1000,'color','k','LineWidth',2.0);

hold on;

plot(s,p\_conv2/1000,'color','g','LineWidth',2.0);

plot(s,p\_conv3/1000,'color','r','LineWidth',2.0);

plot(s,p\_conv4/1000,'color','b','LineWidth',2.0);

xlabel('\its');

ylabel('\bf\itP\rm\bf\_{conv} (kW)');

title ('\bfPower Converted versus slip');

legend('when VLL=75% of VLL rated ','when VLL=50% of VLL rated ','when VLL=25% of VLL rated ','when VLL=10% of VLL rated');

grid on;

hold off;







**c)**

R2\_1=0.1;

 R2\_2=0.2;

 R2\_3=0.6;

 R2\_4=1.2;

 R2\_5=2.8;

 R2\_6=4.5;

 R2\_7=8.0;

 R2\_8=15.0;

for i = 1:301

 t\_ind1(i) = (3 \* Vth^2 \* R2\_1 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_1/s(i))^2 + (Xth + X2)^2) );

 p\_conv1(i) = t\_ind1(i) \* w\_m(i);

end

for i = 1:301

 t\_ind2(i) = (3 \* Vth^2 \* R2\_2 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_2/s(i))^2 + (Xth + X2)^2) );

 p\_conv2(i) = t\_ind2(i) \* w\_m(i);

end

for i = 1:301

 t\_ind3(i) = (3 \* Vth^2 \* R2\_3 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_3/s(i))^2 + (Xth + X2)^2) );

 p\_conv3(i) = t\_ind3(i) \* w\_m(i);

end

for i = 1:301

 t\_ind4(i) = (3 \* Vth^2 \* R2\_4 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_4/s(i))^2 + (Xth + X2)^2) );

 p\_conv4(i) = t\_ind4(i) \* w\_m(i);

end

for i = 1:301

 t\_ind5(i) = (3 \* Vth^2 \* R2\_5 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_5/s(i))^2 + (Xth + X2)^2) );

 p\_conv5(i) = t\_ind5(i) \* w\_m(i);

end

for i = 1:301

 t\_ind6(i) = (3 \* Vth^2 \* R2\_6 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_6/s(i))^2 + (Xth + X2)^2) );

 p\_conv6(i) = t\_ind6(i) \* w\_m(i);

end

for i = 1:301

 t\_ind7(i) = (3 \* Vth^2 \* R2\_7 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_7/s(i))^2 + (Xth + X2)^2) );

 p\_conv7(i) = t\_ind7(i) \* w\_m(i);

end

for i = 1:301

 t\_ind8(i) = (3 \* Vth^2 \* R2\_8 / s(i)) / ...

 (w\_sync \* ((Rth + R2\_8/s(i))^2 + (Xth + X2)^2) );

 p\_conv8(i) = t\_ind8(i) \* w\_m(i);

end

% Plot the torque - speed curve,

figure(7);

plot(n\_m,t\_ind1,'color','k','linewidth',2.0);

hold on;

plot(n\_m,t\_ind2,'color','g','linewidth',2.0);

plot(n\_m,t\_ind3,'color','r','linewidth',2.0);

plot(n\_m,t\_ind4,'color','b','linewidth',2.0);

plot(n\_m,t\_ind5,'color','y','linewidth',2.0);

plot(n\_m,t\_ind6,'color','m','linewidth',2.0);

plot(n\_m,t\_ind7,'color','c','linewidth',2.0);

plot(n\_m,t\_ind8,'color','k','linewidth',3.0);

xlabel('\itn\_{m}');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title('Induction motor torque- speed characteristic when VLL at rated');

legend('when R2=0.1','when R2=0.2','when R2=0.6','when R2=1.2', 'when R2=2.8', 'when R2=4.5', 'when R2=8.0', 'when R2=15.0');

grid on;

hold off;

%plot torque versus S at rated voltage,

 figure(8);

plot(s,t\_ind1,'color','k','linewidth',2.0);

hold on;

plot(s,t\_ind2,'color','g','linewidth',2.0);

plot(s,t\_ind3,'color','r','linewidth',2.0);

plot(s,t\_ind4,'color','b','linewidth',2.0);

plot(s,t\_ind5,'color','y','linewidth',2.0);

plot(s,t\_ind6,'color','m','linewidth',2.0);

plot(s,t\_ind7,'color','c','linewidth',2.0);

plot(s,t\_ind8,'color','k','linewidth',3.0);

xlabel('\its');

ylabel('\bf\tau\_{ind} \rm\bf(N.m)');

title('Induction motor torque- slip characteristic when VLL at rated');

legend('when R2=0.1','when R2=0.3','when R2=0.8','when R2=1.0', 'when R2=2.0', 'when R2=5.0', 'when R2=8.0', 'when R2=20.0');

grid on;

hold off;

figure(9);

plot(s,p\_conv1/1000,'color','k','LineWidth',2.0);

hold on;

plot(s,p\_conv2/1000,'color','g','LineWidth',2.0);

plot(s,p\_conv3/1000,'color','r','LineWidth',2.0);

plot(s,p\_conv4/1000,'color','b','LineWidth',2.0);

plot(s,p\_conv5/1000,'color','y','LineWidth',2.0);

plot(s,p\_conv6/1000,'color','m','LineWidth',2.0);

plot(s,p\_conv7/1000,'color','c','LineWidth',2.0);

plot(s,p\_conv8/1000,'color','k','LineWidth',3.0);

xlabel('\its');

ylabel('\bf\itP\rm\bf\_{conv} (kW)');

title ('\bfPower Converted versus slip');

legend('when R2=0.1','when R2=0.2','when R2=0.6','when R2=1.2', 'when R2=2.8', 'when R2=4.5', 'when R2=8.0', 'when R2=15.0');

grid on;

hold off;





