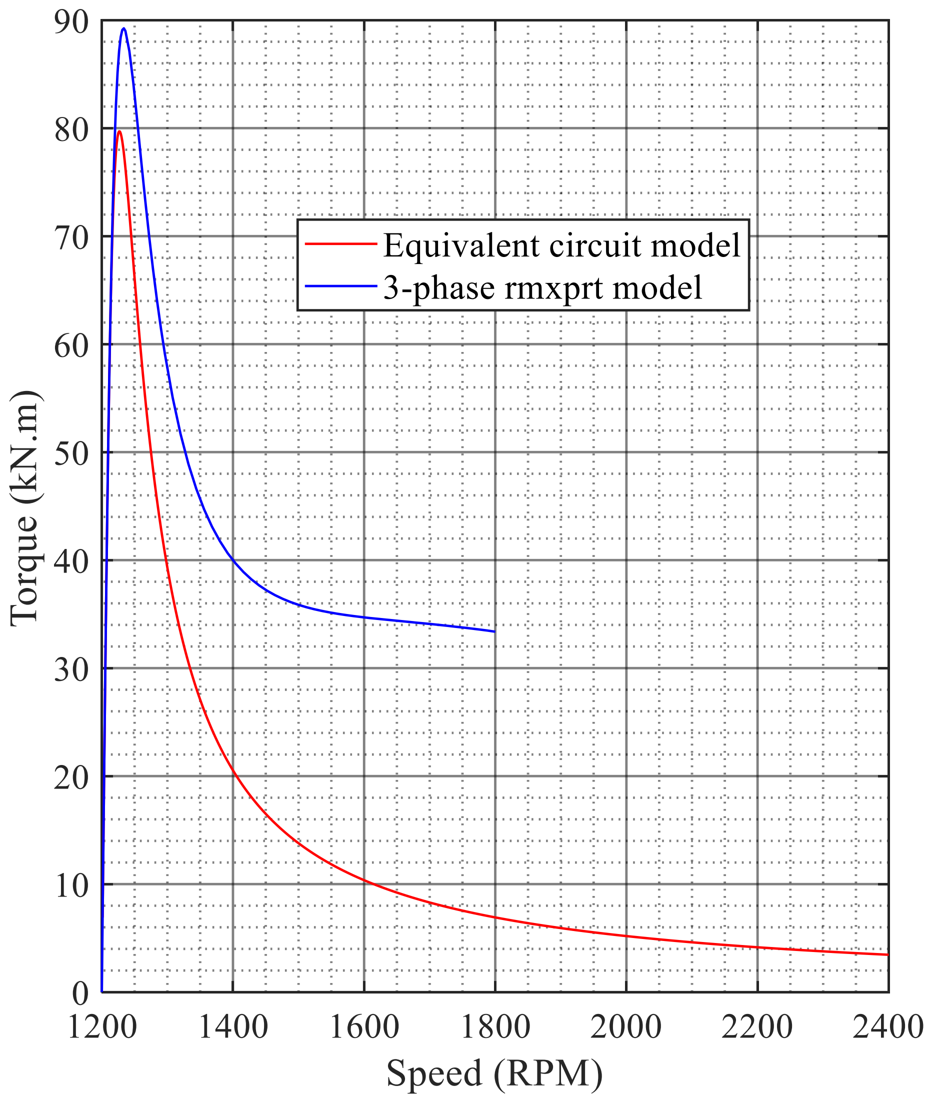
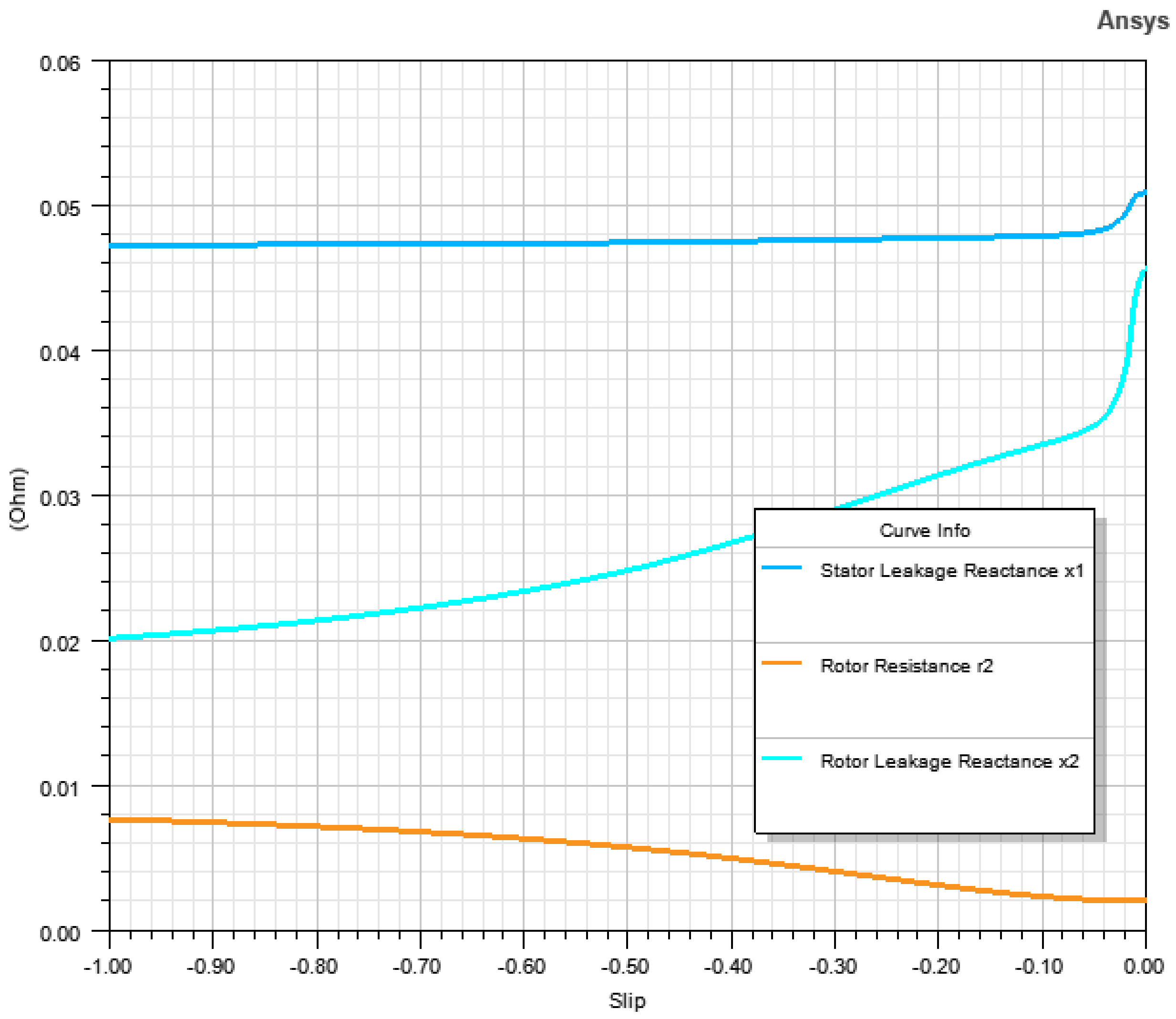
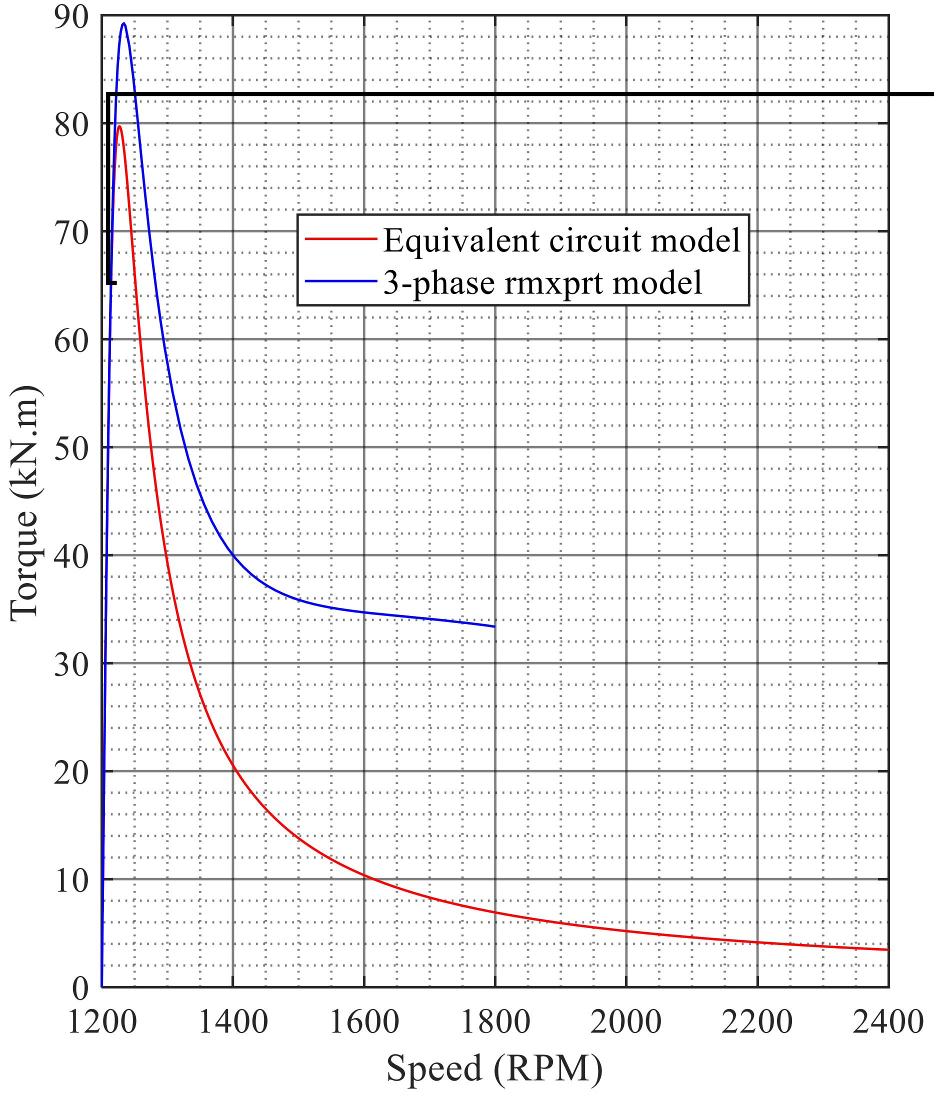
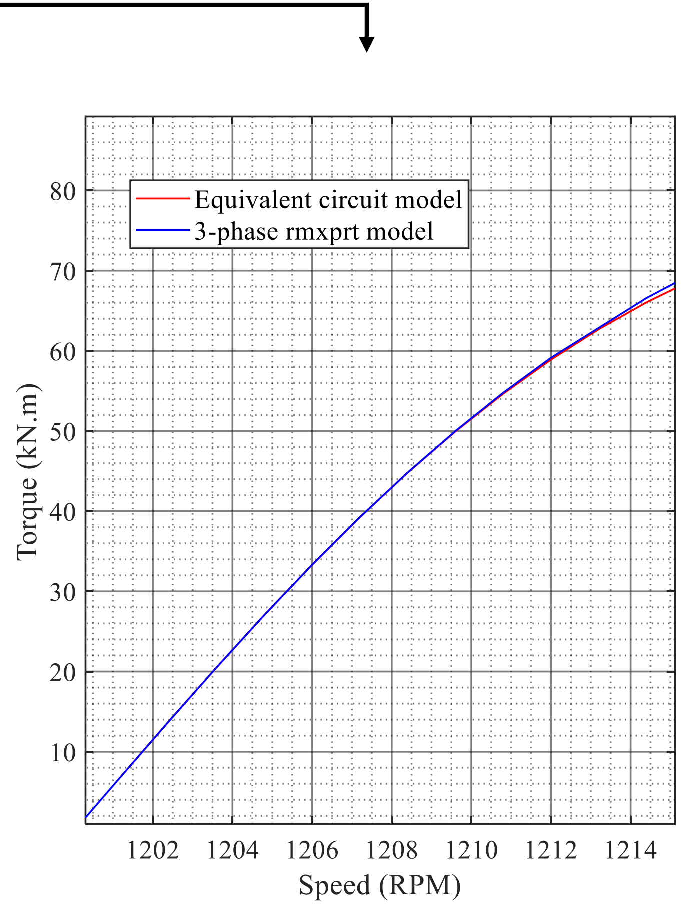
# Rmxprt and equivalent circuit models Torque-Speed Characteristics



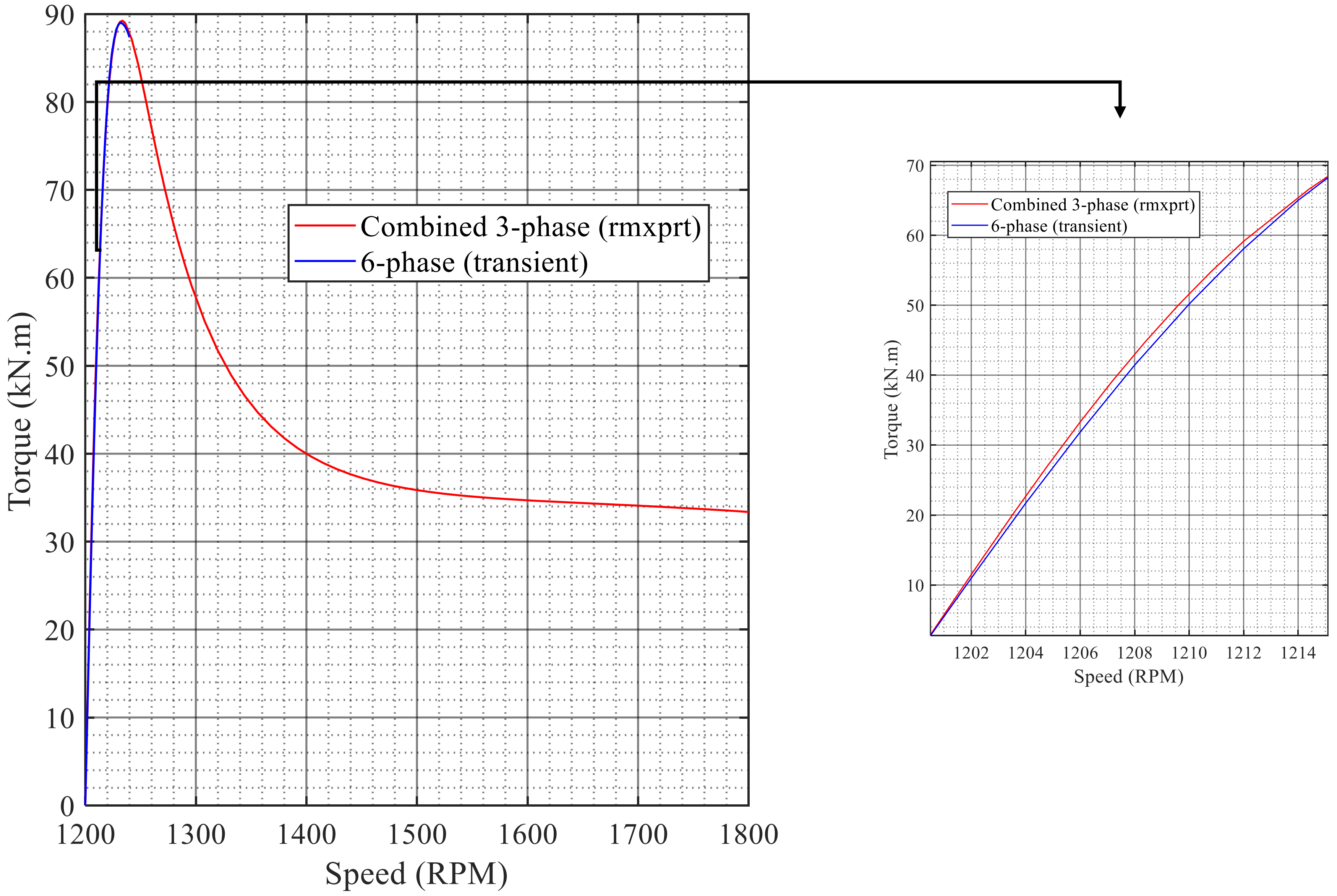



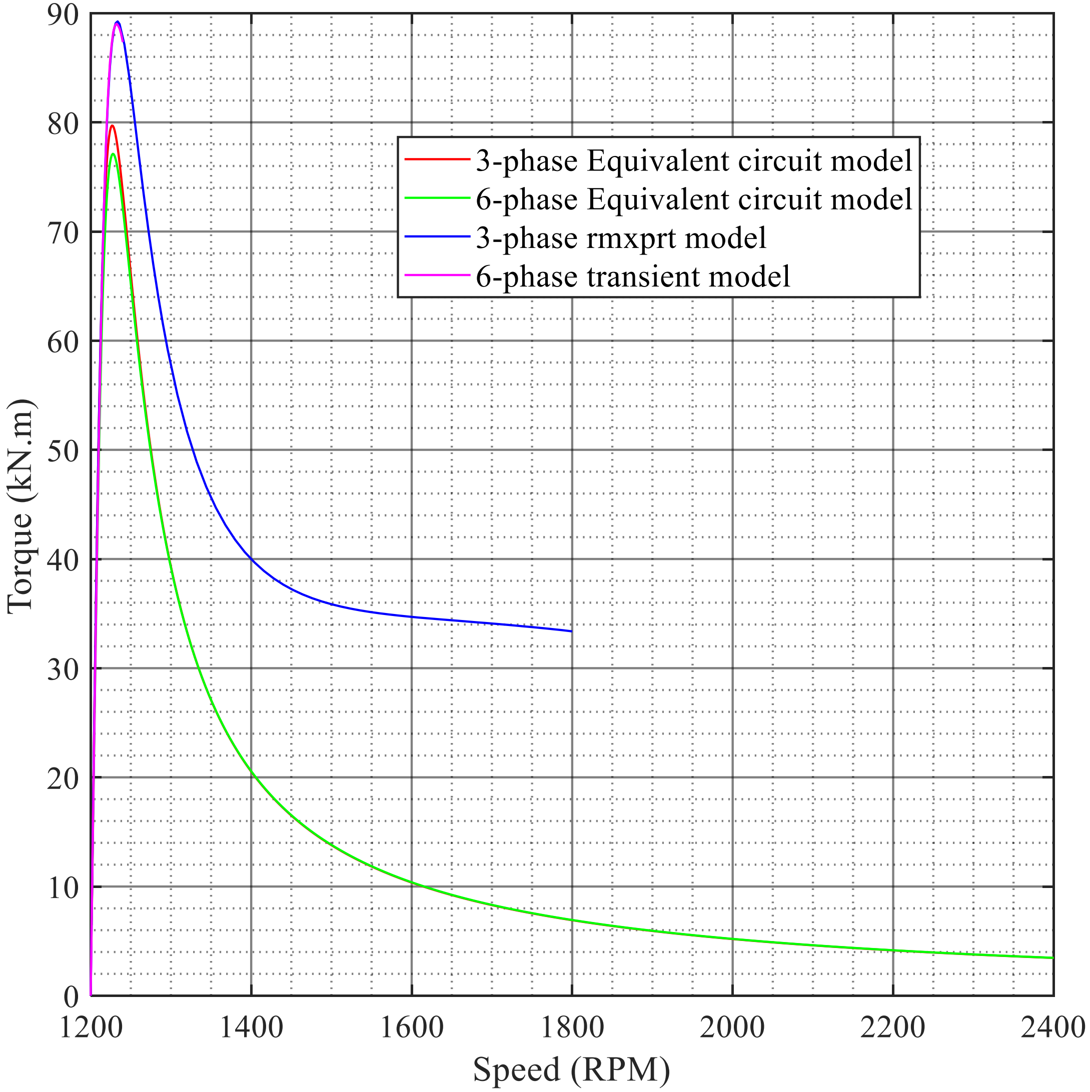
# Rmxprt and equivalent circuit models Torque-Speed Characteristics

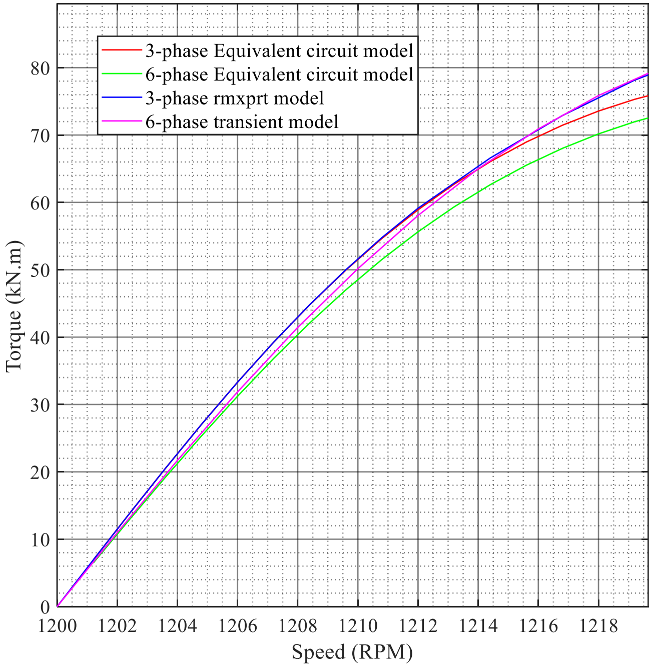


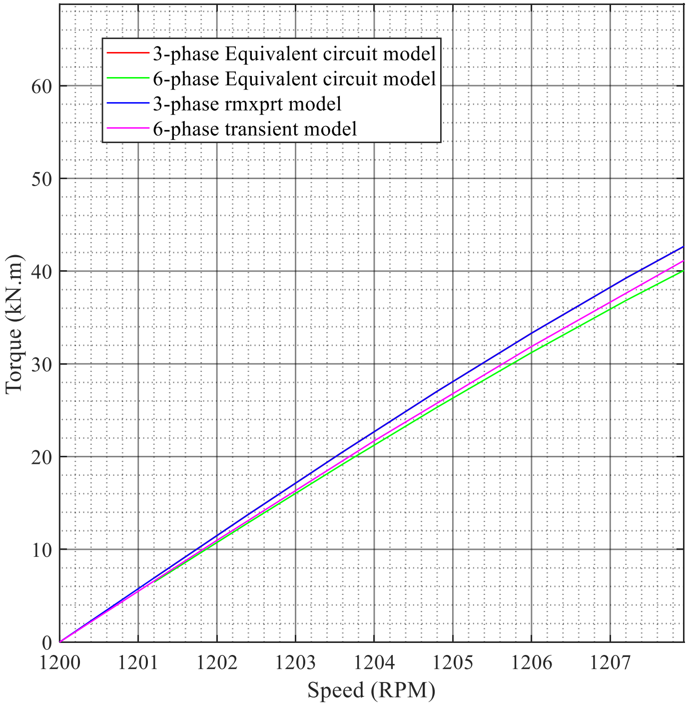



# 3-phase combined and 6-phase machines Torque-Speed Characteristics




3-phase Equivalent circuit model
6-phase Equivalent circuit model
3-phase rmxprt model
6-phase transient model
Torque (kN.m)
Speed (RPM)
0
10
20
30
40
50
60
70
80
90
1200
1400
1600
1800
2000
2200
2400


3-phase Equivalent circuit model
6-phase Equivalent circuit model
3-phase rmxprt model
6-phase transient model
Torque (kN.m)
Speed (RPM)
0
10
20
30
40
50
60
70
80
1200
1202
1204
1206
1208
1210
1212
1214
1216
1218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Torque (kN.m)
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0
10
20
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1201
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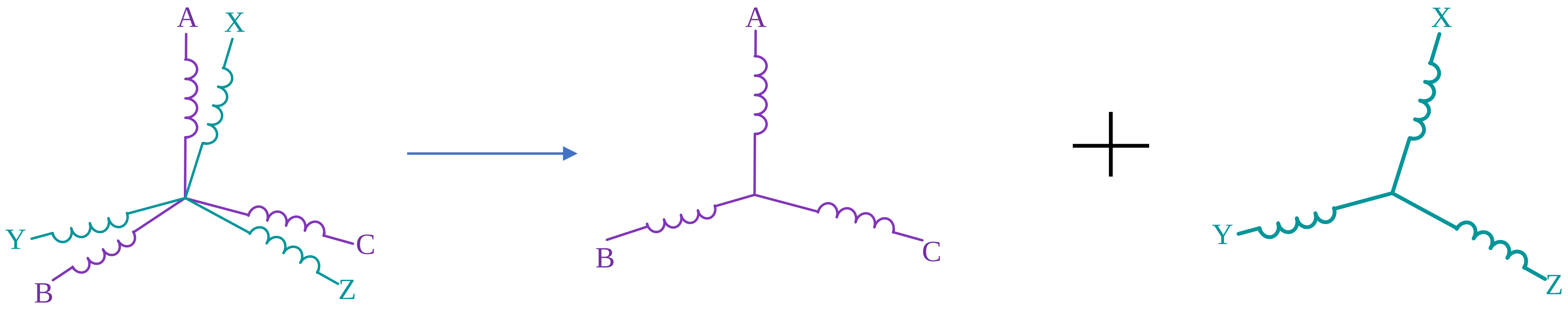
1203
1204
1205
1206
1207



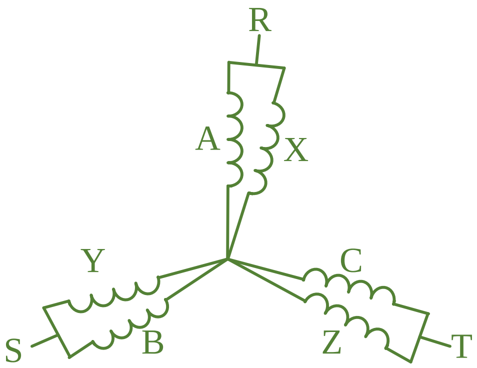

1 x 6-phase

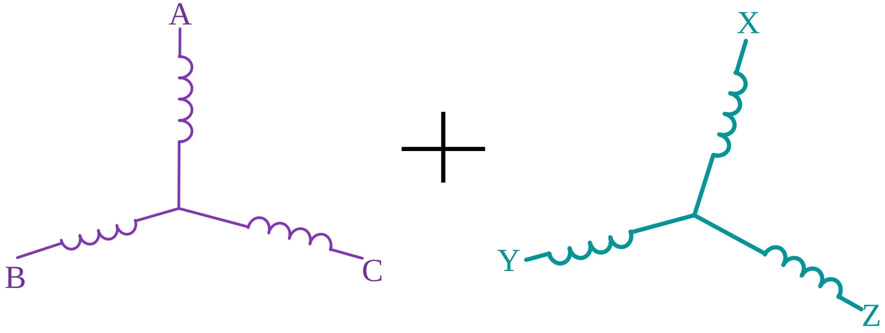
2 x 3-phase

If there is no phase difference between the machines of ABC and XYZ, our circuit parameters change as given below.

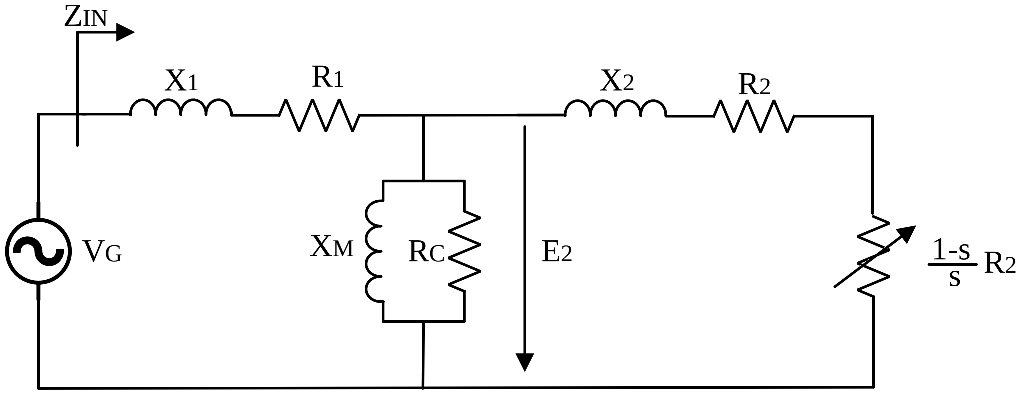
| Combined 3-phase series model (Per phase equivalent) | Combined 3-phase parallel model (Per phase equivalent) | Six-phase model (Per phase equivalent) |
|---|---|---|
| $2R_1$ | $\frac{R_1}{2}$ | $R_1$ |
| $2R_2$ | $\frac{R_2}{2}$ | $R_2$ |
| $2X_1$ | $\frac{X_1}{2}$ | $X_1$ |
| $2X_2$ | $\frac{X_2}{2}$ | $X_2$ |
| $2X_m$ | $\frac{X_m}{2}$ | $X_m$ |
| $2R_C$ | $\frac{R_C}{2}$ | $R_C$ |

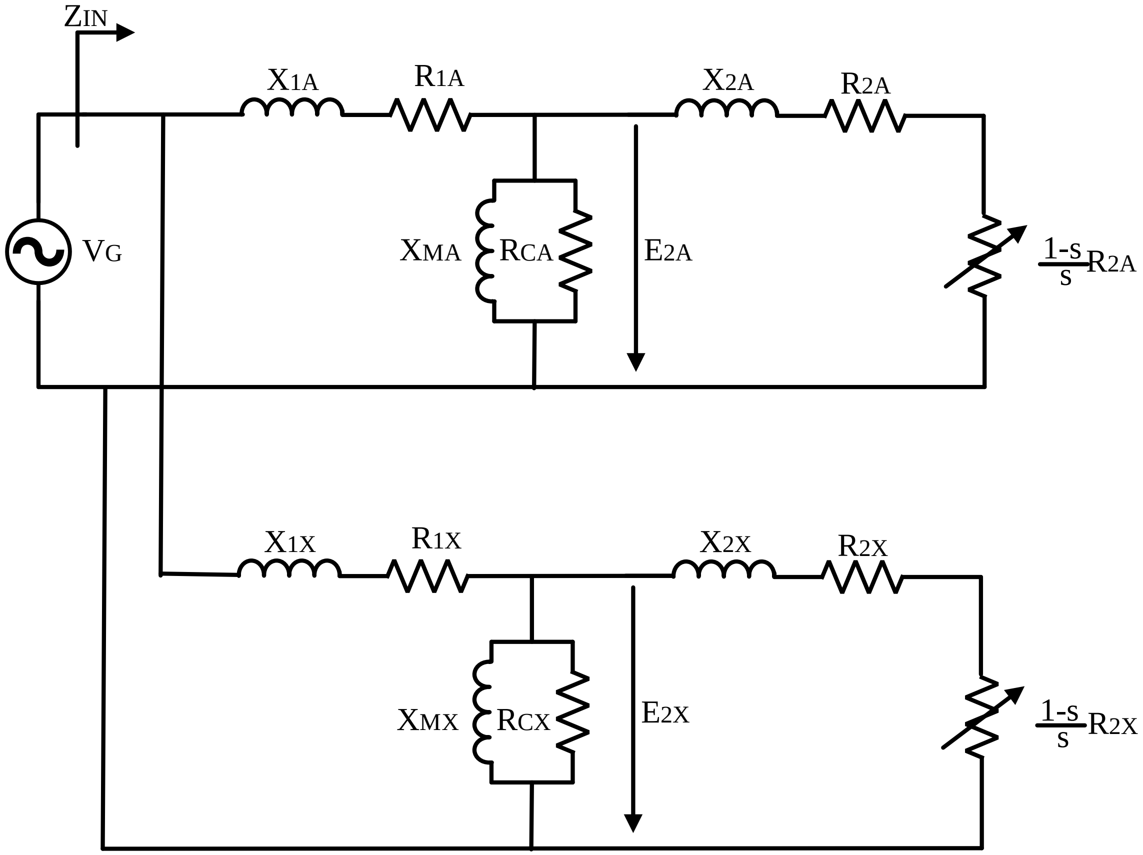
1 x 3-phase  parallel



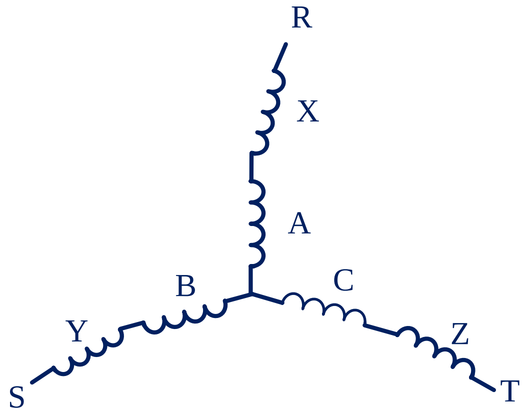



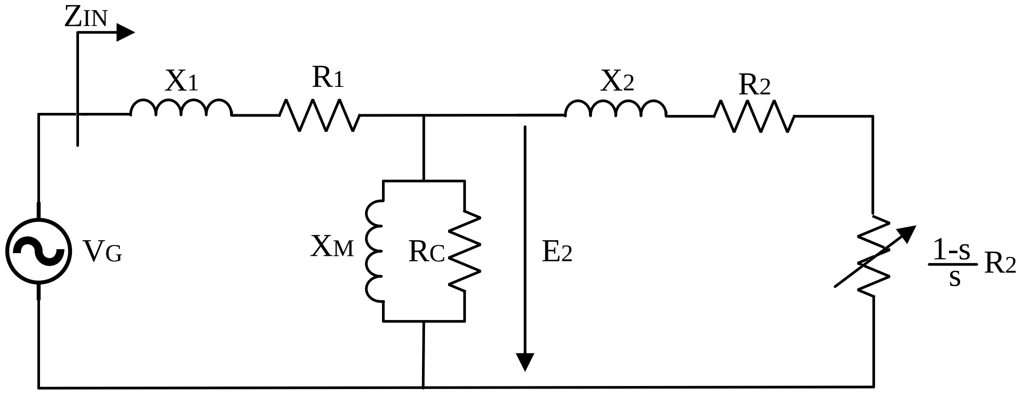

2 x 3-phase

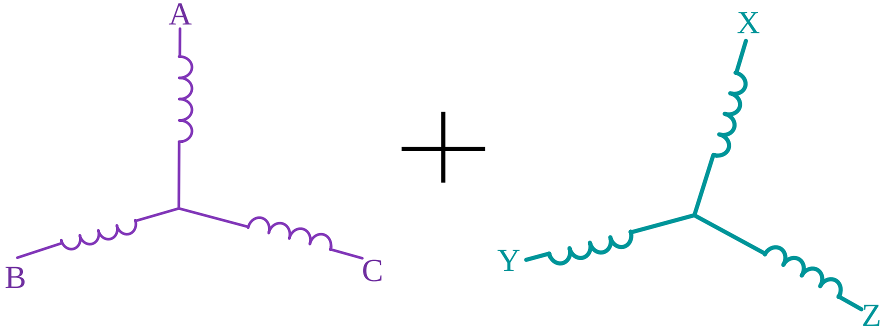


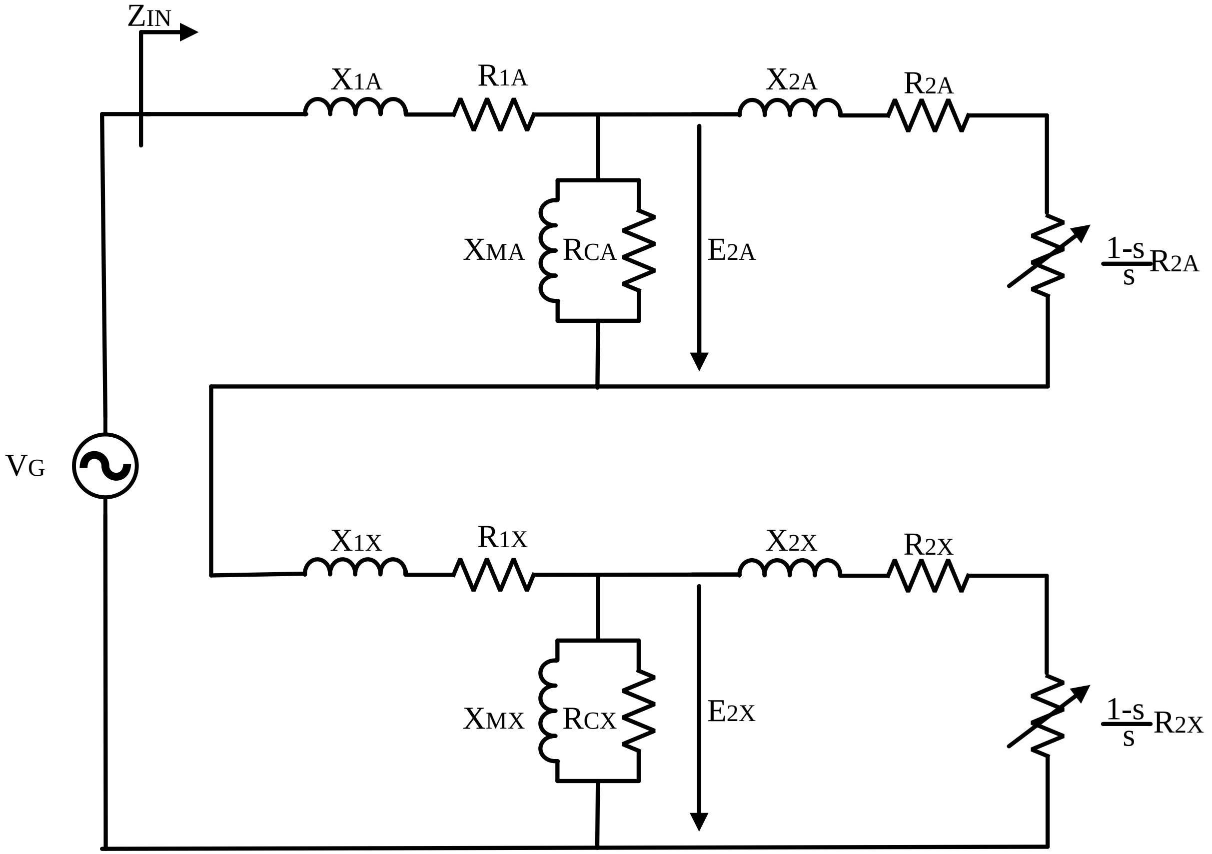
1 x 3-phase series



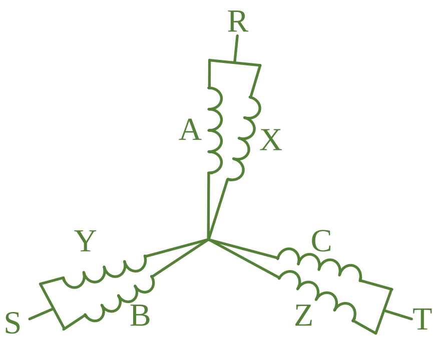



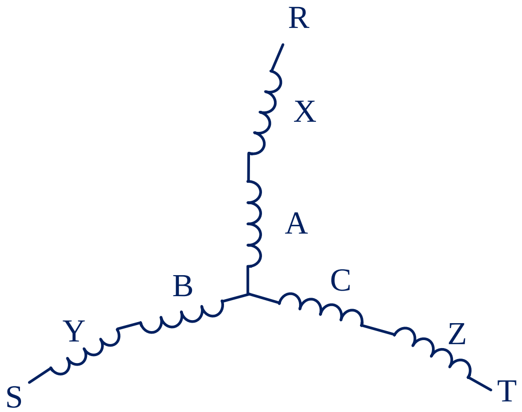



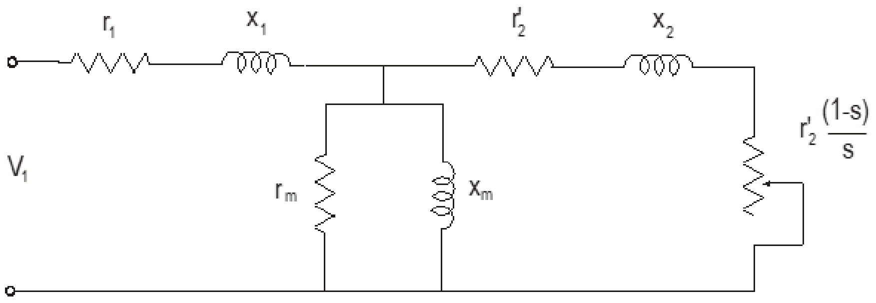

2 x 3-phase



We have actually 30-deree phase difference at the induced voltage. It means that actually distribution factor should become involved.




Where,

$r_1$ = stator winding resistance

$x_1$ = stator winding leakage reactance

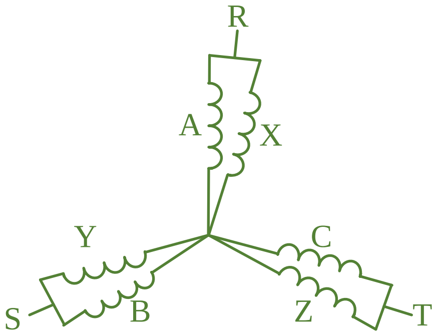
$r_c$ = resistance-representing core losses

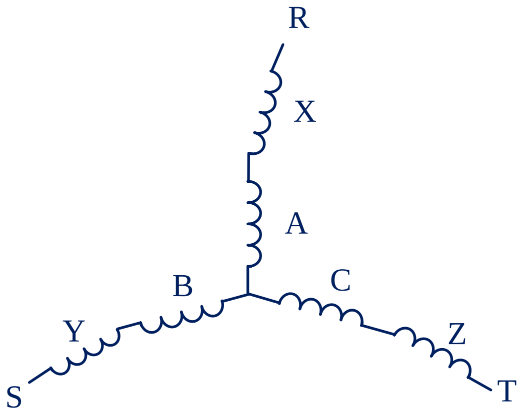
$x_m$= magnetising reactance

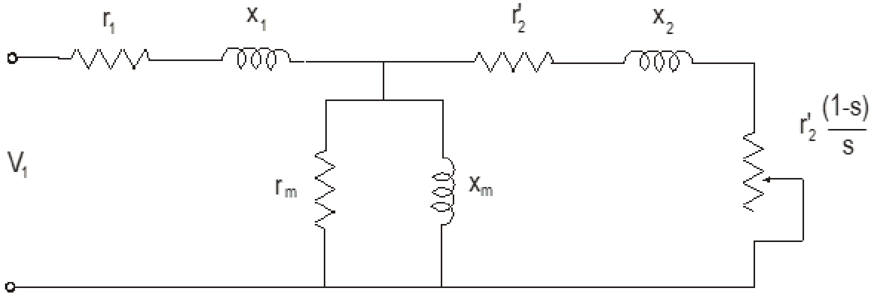
$r_2$'= rotor winding resistance referred to the primary

$x_2$'= rotor winding reactance referred to the primary

We have actually 30-deree phase difference at the induced voltage. It means that actually distribution factor should become involved.




Where,

$r_1$ = stator winding resistance

$x_1$ = stator winding leakage reactance

$r_c$ = resistance-representing core losses

$x_m$= magnetising reactance

$r_2'$= rotor winding resistance referred to the primary

$x_2'$= rotor winding reactance referred to the primary

# Resistance Calculation in Induction Motor

$$R = L\frac{\rho}{A}$$

| Combined 3-phase series model (Per phase equivalent) | Combined 3-phase parallel model (Per phase equivalent) | Six-phase model (Per phase equivalent) |
|---|---|---|
| $2R_1$ | $\frac{R_1}{2}$ | $R_1$ |
| $2R_1$ | $\frac{R_1}{2}$ | $R_1$ |

# Stator Rotor Turns Ratio

$$\text{Turns ratio} = \frac{\text{rotor turns / phase}}{\text{stator turns / phase}} \cdot \frac{k_{wr}}{k_{ws}}$$

$$k_w = k_d k_p = \frac{sin\left(\frac{q\lambda}{2}\right)}{q sin\left(\frac{\lambda}{2}\right)} \cos\left(\frac{\alpha}{2}\right)$$

| Combined 3-phase series model (Per phase equivalent) | Combined 3-phase parallel model (Per phase equivalent) | Six-phase model (Per phase equivalent) |
|---|---|---|
| 0.9659 $k_{ws}$ | 0.9659 $k_{ws}$ | $k_{ws}$ |
| 0.9659 $k_{wr}$ | 0.9659 $k_{wr}$ | $k_{wr}$ |

# Stator Rotor Turns Ratio

$$\text{Turns ratio} = \frac{\text{rotor turns / phase}}{\text{stator turns / phase}} \cdot \frac{k_{wr}}{k_{ws}}$$

$$k_w = k_d k_p = \frac{sin\left(\frac{q\lambda}{2}\right)}{q sin\left(\frac{\lambda}{2}\right)} \cos\left(\frac{\alpha}{2}\right)$$

| Combined 3-phase series model (Per phase equivalent) | Combined 3-phase parallel model (Per phase equivalent) | Six-phase model (Per phase equivalent) |
|---|---|---|
| 0.9659 $k_{ws}$ | 0.9659 $k_{ws}$ | $k_{ws}$ |
| 0.9659 $k_{wr}$ | 0.9659 $k_{wr}$ | $k_{wr}$ |

# Cage Rotor Parameters

$$R_2^{'} = \frac{Q_2 \, i_b^2 \, R_{ber}}{m_s \, i_2^{\copyright 2}} = \frac{4 m_s (N_s . k_{ws})^2}{Q_2} . R_{ber}$$

| Combined 3-phase series model<br>(Per phase equivalent) | Combined 3-phase parallel model<br>(Per phase equivalent) | Six-phase model<br>(Per phase equivalent) |
|---|---|---|
| $(k_{ws}^2)2R_2' = 0.933x2xR_2'$ | $\frac{(k_{ws}^2)R_2'}{2} = 0.933\frac{R_2'}{2}$ | $R_2'$ |
| $(k_{ws}^2)2X_2' = 0.933x2xX_2'$ | $\frac{(k_{ws}^2)X_2'}{2} = 0.933\frac{X_2'}{2}$ | $X_2'$ |

# Magnetizing Reactance

$$X_m = \frac{phase \quad voltage}{magnetizing \quad current}$$

| Combined 3-phase series model (Per phase equivalent) | Combined 3-phase parallel model (Per phase equivalent) | Six-phase model (Per phase equivalent) |
|---|---|---|
| $k_{ws} 2R_2' = 0.9659x2xX_m'$ | $\frac{k_{ws} X_m'}{2} = 0.9659 \frac{X_m'}{2}$ | $X_m'$ |