

Induction Machines Study 6

Wound Rotor (WR) and Squirrel Cage (SQ) Induction Machine Models

Motivation:

PSCAD library has two induction motor models:

- 1) A squirrel cage induction machine model representing a double cage design.
- 2) A wound rotor induction machine model.

Mathematically, the SQ cage machine can be represented by the WR machine. The WR model could also be used to represent a double cage SQ machine.

PSCAD users are encouraged to use the WR IM model for all the induction machine applications. The two examples below will describe relevant data entry considerations and also compare results for validation purposes.

System Overview:

A 0.6kV, 60 Hz source is connected to a 0.6 kV SQ cage and a WR induction machine. Both machines have identical ratings.

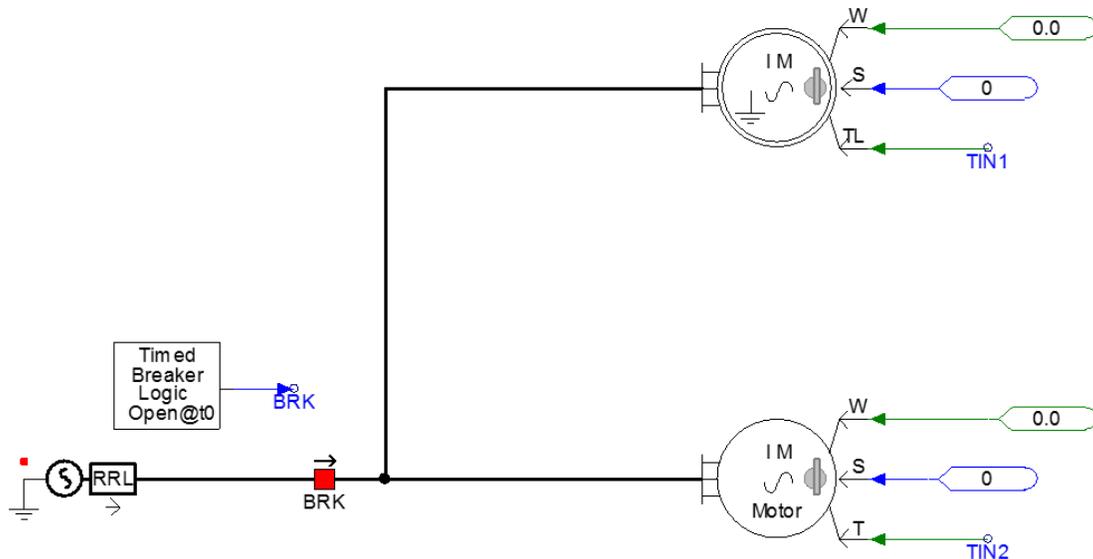


Figure 1: Circuit Diagram (WR – Top, SQ Cage – Bottom)

Example 1: Modeling a single cage induction machine.

The SQ cage machine model or the WR machine model may be used to represent a single cage (SQ) machine. (IM_study_06_A.pscx)

The equivalent circuit of a double cage design, squirrel-cage machine is shown below in Figure 2.

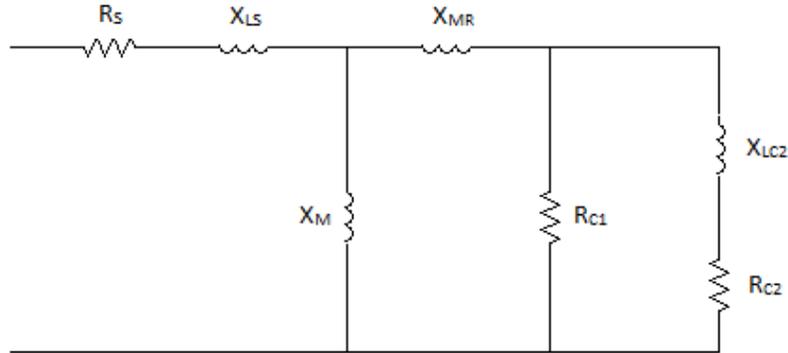


Figure 2: SQ Cage (Double Cage) Equivalent Circuit

The equivalent circuit of a wound rotor machine model (single rotor winding) is shown in Figure 3.

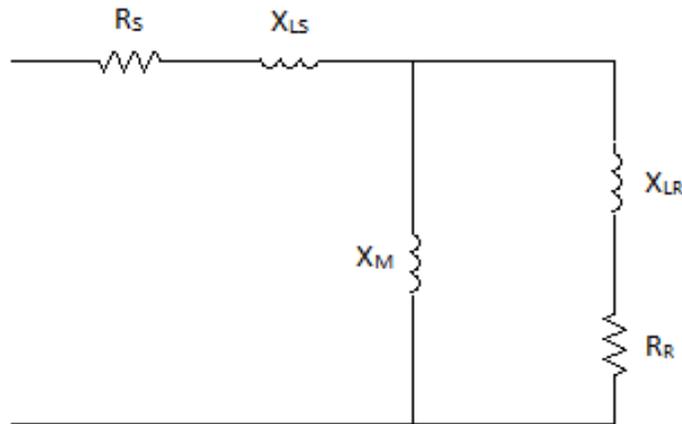


Figure 3: WR IM (Single Winding) Equivalent Circuit

To use the SQ cage machine model to represent a single cage machine:

- Make the 'second cage resistance' (R_{C2}) and the 'second cage unsaturated reactance' (X_{LC2}) relatively large (compared to the other leakage inductances/resistances). In this case they are changed to $R_{C2}=5$ PU and $X_{LC2}= 5$ PU, which is much larger than $R_{C1}=0.0507$ PU and $X_{MR}=0.091$ PU.
- Give the SQ cage 'rotor unsaturated mutual reactance' (X_{MR}) the value of the WR 'rotor leakage reactance' (X_{LR}).

Figure 4 shows the data entry for the SQ cage (left) and WR models (right). By using equivalent values, both models show comparable behaviour and represent a single cage machine design.

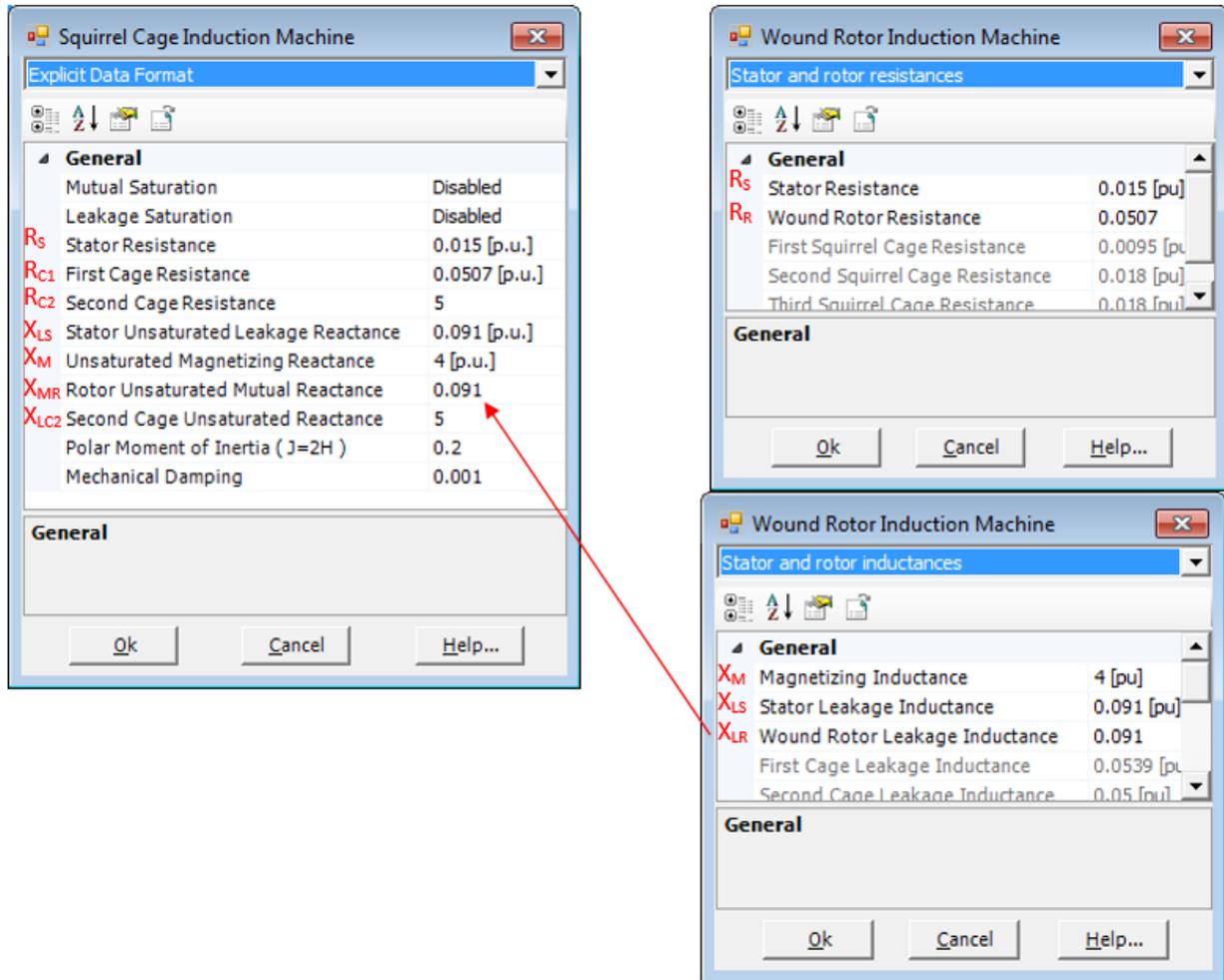


Figure 4: SQ Cage and WR Setup Configuration

The simulation results shown in Figure 5 show that the speed ($W - WR, W2 - SQ$ cage) and torque ($T - WR, T2 - SQ$ cage) of both machines are the same. Thus, any one of the induction machine models maybe used to represent a single cage induction machine.

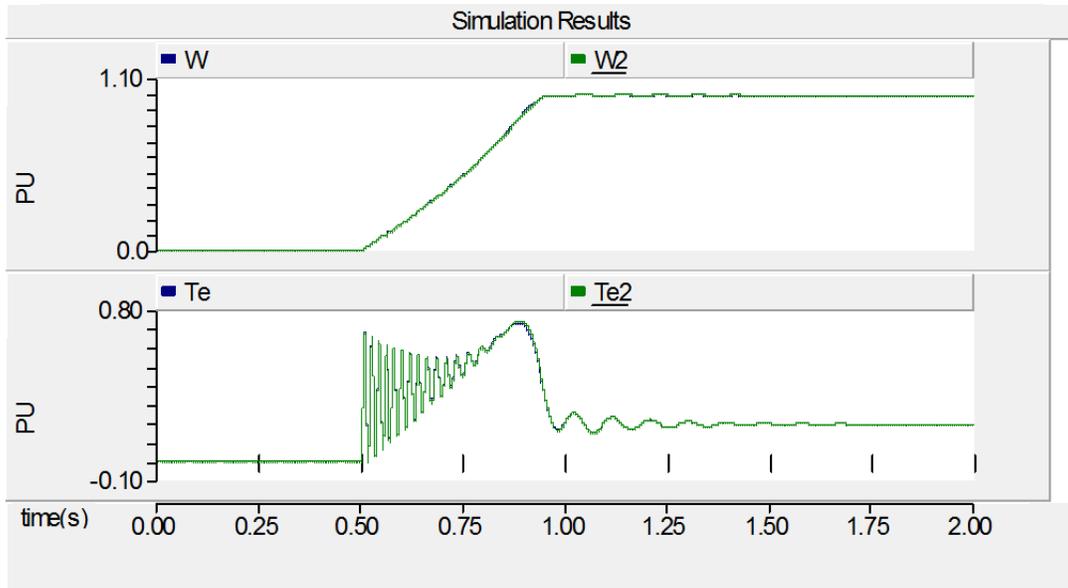


Figure 4: Simulation Results (IM_study_06_A.pscx)

Example 2: Modeling a double cage induction machine.

The WR machine model can be set-up to represent a double cage SQ cage machine (IM_study_06_B.pscx).

In the WR model, select the “No. of Rotor Squirrel Cages = 1”, as shown in Figure 6.

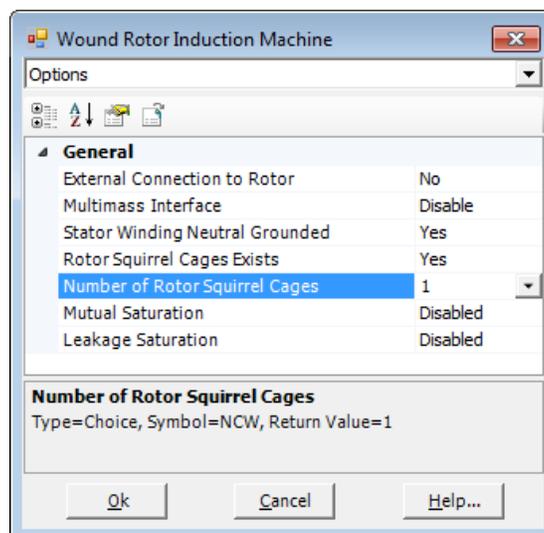


Figure 5: WR Configuration

When this is done the equivalent circuit representation is as in Figure 7.

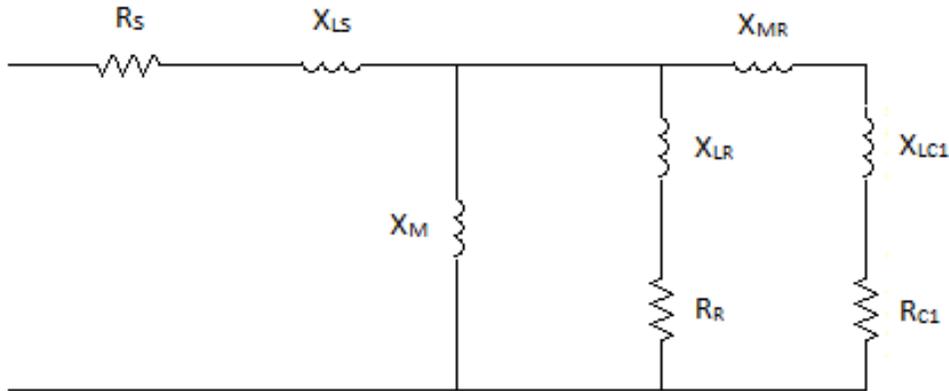


Figure 6: WR IM (Two Winding) Equivalent Circuit

Figure 8 shows the data entry for the WR model. With the appropriate data, the SQ cage and WR machine models will give similar results.

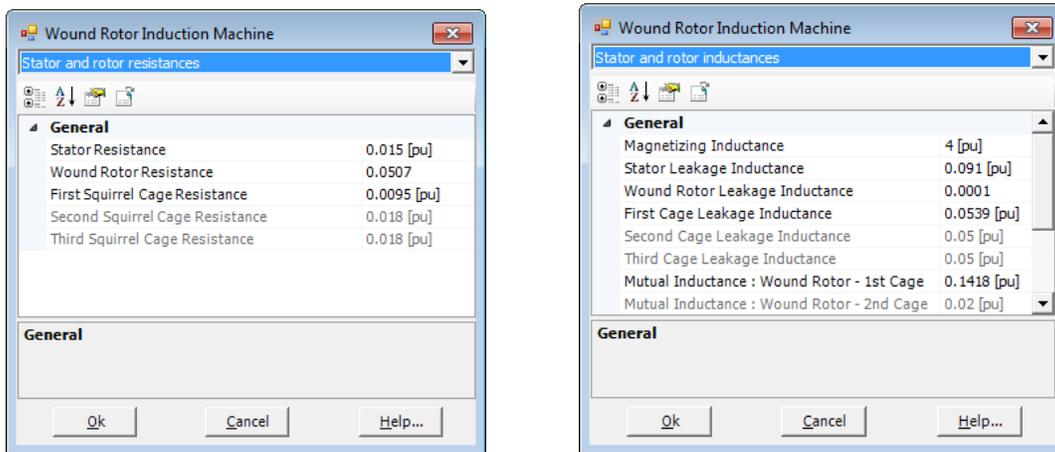


Figure 7: WR Setup Configuration

The simulation results shown in Figure 9 show that the speed (W – WR, W2- SQ cage) and torque (T – WR, T2 – SQ cage) of both machines are the identical. Therefore, a double cage SQ machine can be accurately modeled using the WR induction machine model in PSCAD.

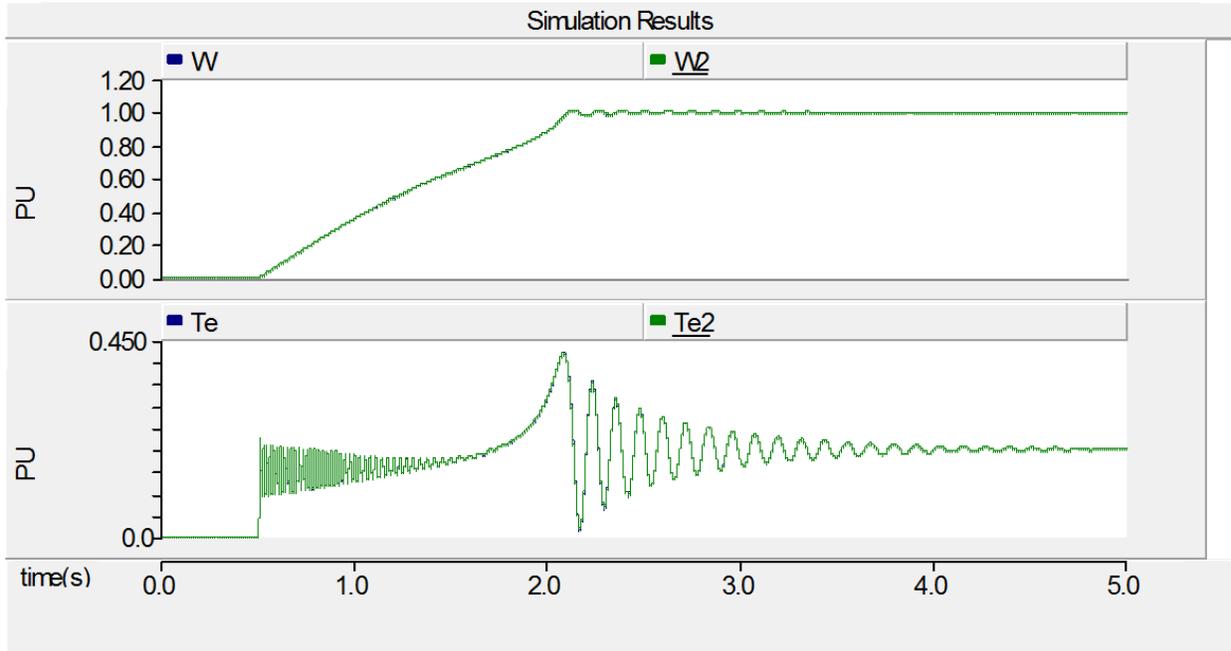


Figure 8: Simulation Results (IM_study_06_B.pscx)

Discussion:

As can be seen from the results, a SQ cage and WR machine model deliver equivalent results when configured properly. Hence, a SQ cage machine model can be accurately represented using a WR machine model. PSCAD users are encouraged to use the WR IM model for all the induction machine applications.

PSCAD:

Refer to PSACD case: IM_study_06_A.pscx and IM_study_06_B.pscx