

## 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.

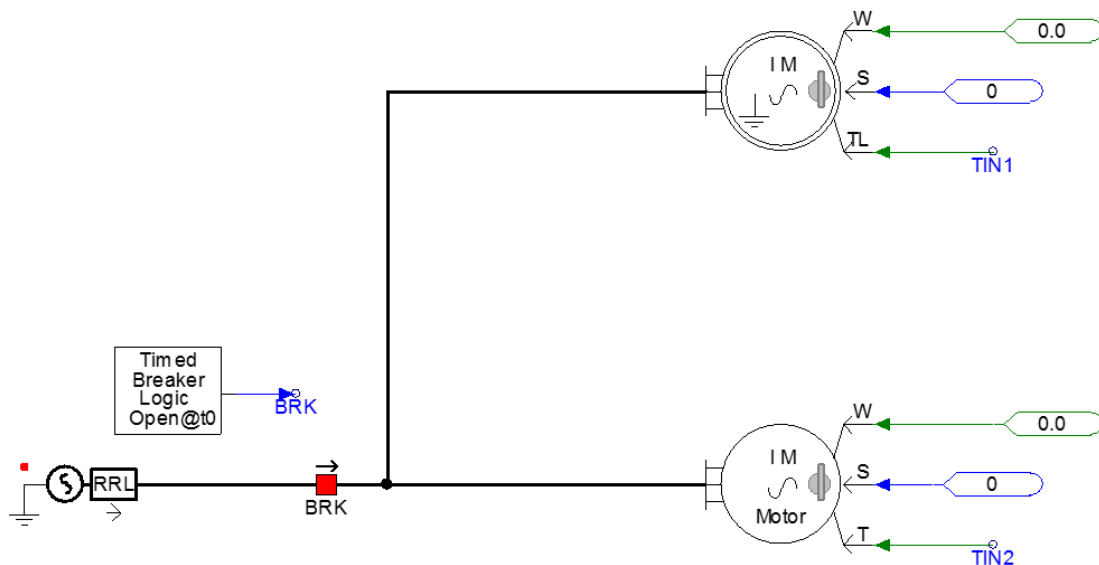


Figure 1: Circuit Diagram (WR – Top, SQ Cage – Bottom)

**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.

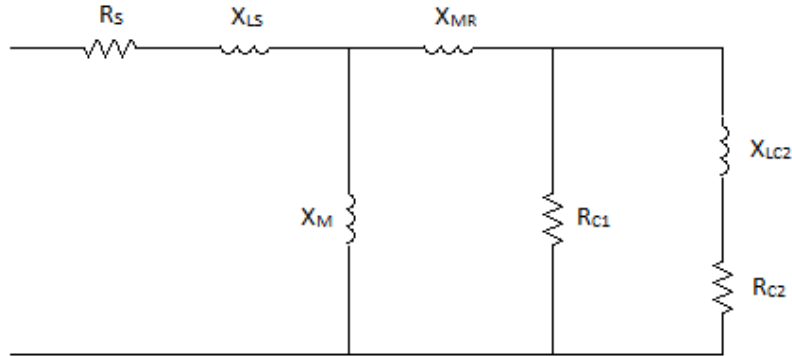


Figure 2: SQ Cage (Double Cage) Equivalent Circuit

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

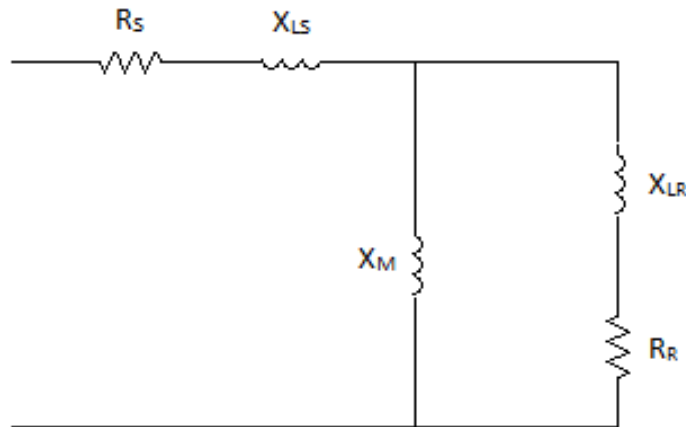


Figure 3: WR IM (Single Winding) Equivalent Circuit

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.

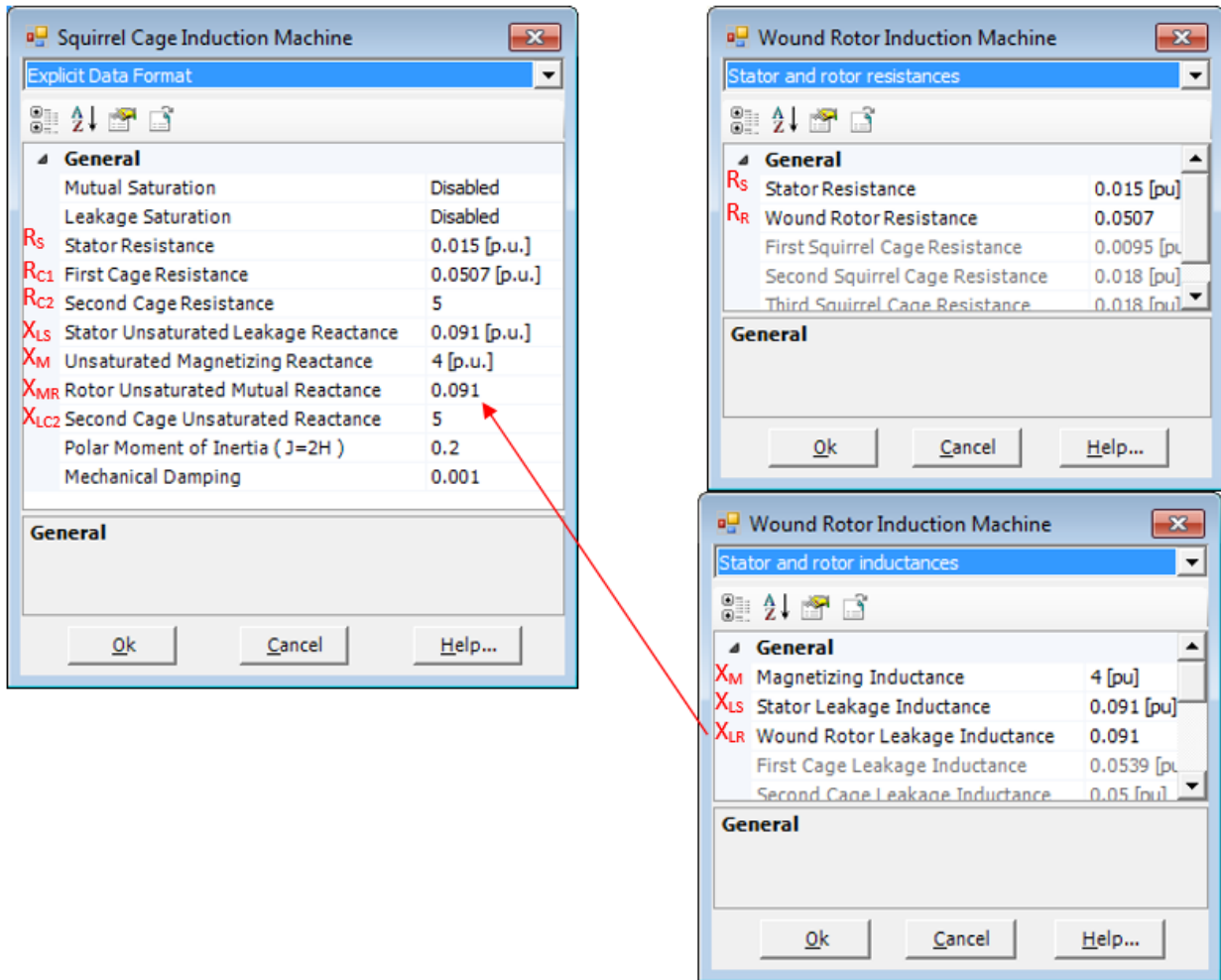


Figure 4: SQ Cage and WR Setup Configuration

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.

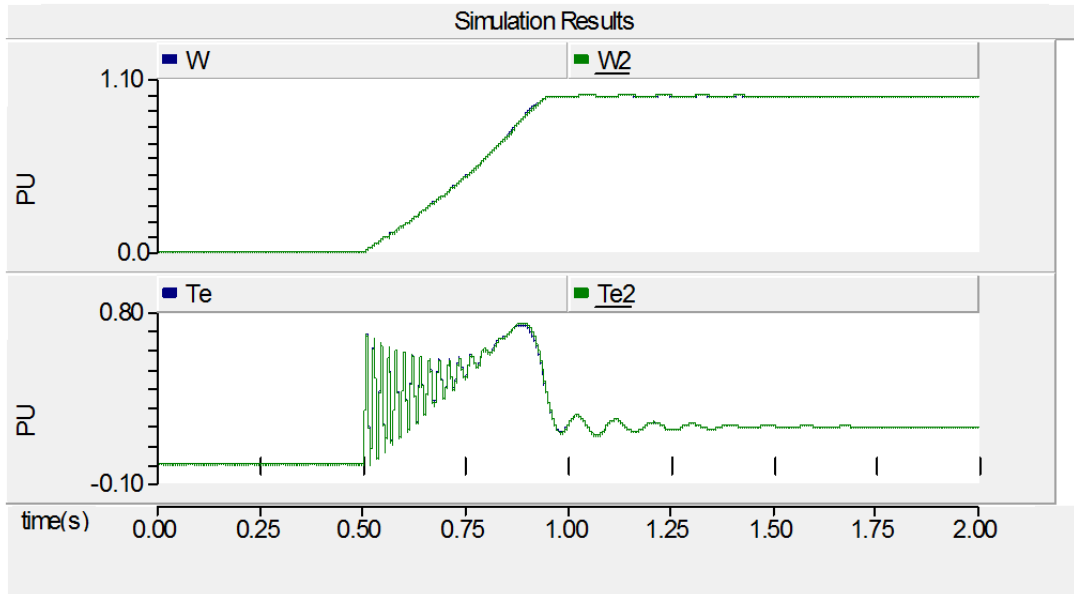


Figure 4: Simulation Results (IM\_study\_06\_A.pscx)

**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.

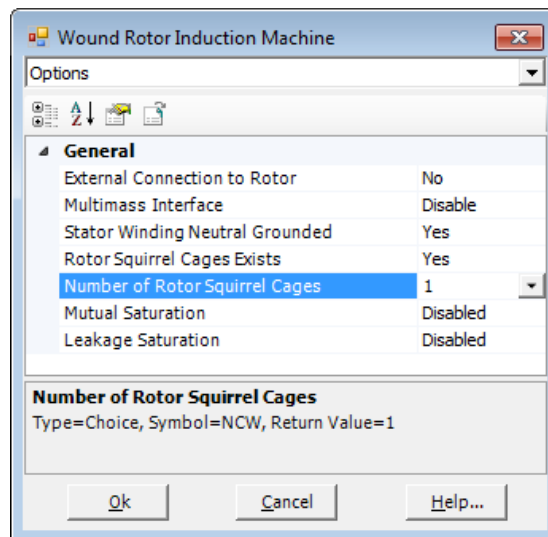


Figure 5: WR Configuration

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

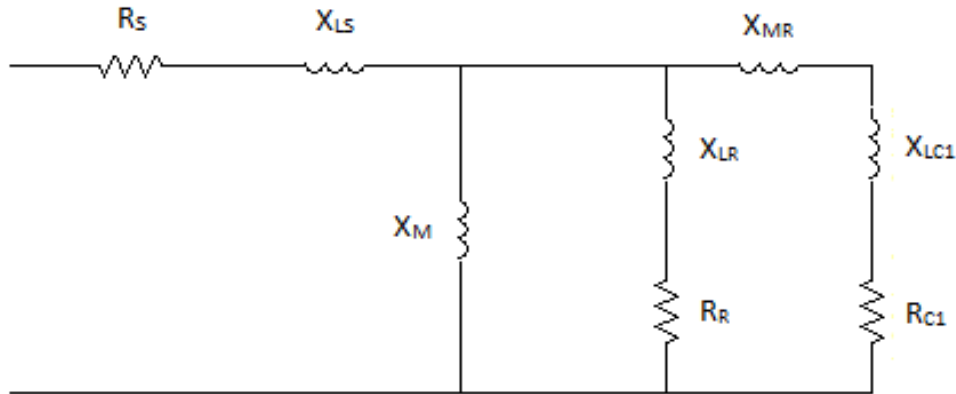


Figure 6: WR IM (Two Winding) Equivalent Circuit

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.

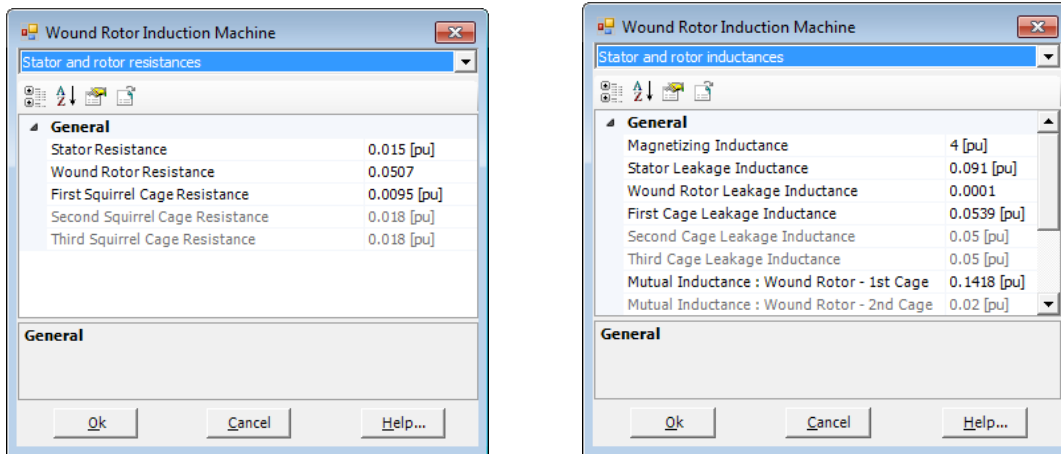


Figure 7: WR Setup Configuration

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.

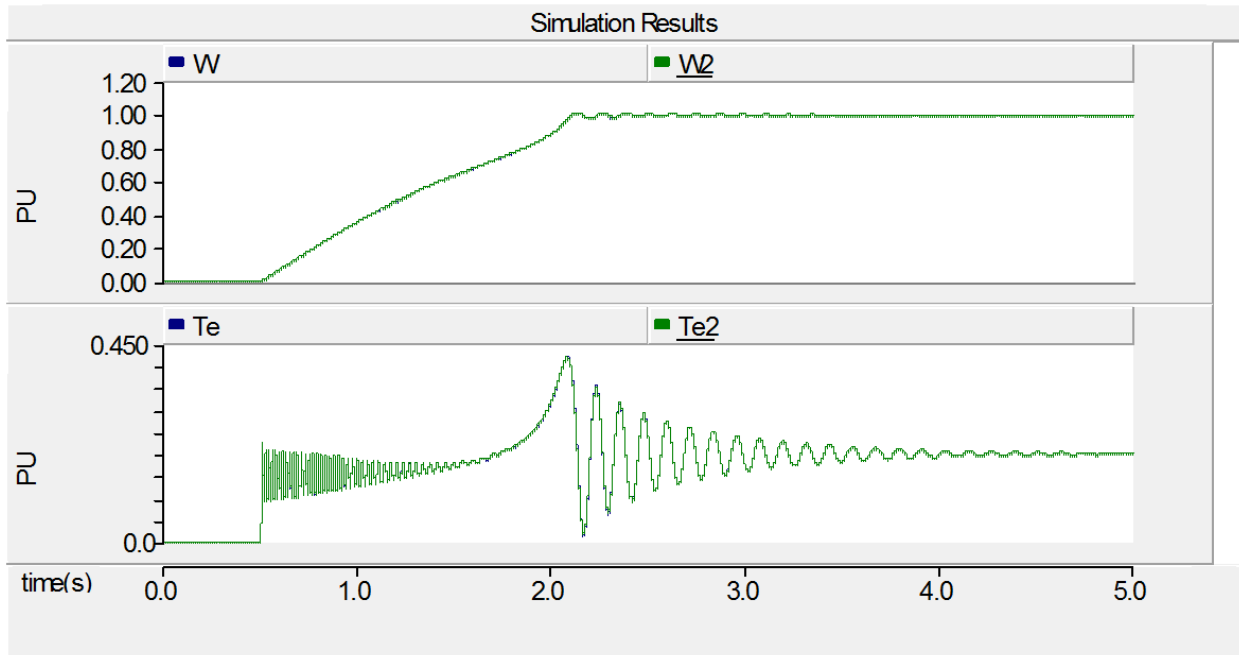


Figure 8: Simulation Results (IM\_study\_06\_B.pscx)

**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 PSCAD case: IM\_study\_06\_A.pscx and IM\_study\_06\_B.pscx