**Wind Turbine**

1. Simulink Permanent Magnet Synchronous Machine (PMSM)

The following outline has the different specifications needed for the PMSM. Section I.A are the specifications needed for the parameter calculator. Section I.B shows Block Parameters that are needed directly without the need of the parameter calculator. With this information it is possible to obtain all the values needed.

* 1. Back EMF waveform:
     1. Sinusoidal
        1. Rotor type-Round:
           1. Resistance (ph-ph) [R]
           2. Inductance (ph-ph) [Lab]
           3. Specify (at least one of the following)

Torque constant [kt]

Units: (oz•in,lb•in,lb•ft,N•m,N•cm)/(Apeak,Arms)

Voltage constant [ke]

Units: (Vrms,Vpeak)/(krpm,rad/s)

* + - * 1. Inertia [J]

Units: (lb•in•s2, kg•m2, kg•cm2,g•cm2, lb•in2, oz•in•s2, g•cm2)

* + - * 1. Viscous damping [F]

Units: (oz•in/krpm,N•m•s,N•m/rpm, oz•in/krpm)

* + - * 1. Pole pairs [p]
      1. Rotor type-Salient Pole:
         1. Resistance (ph-ph) [R]
         2. D-axis inductance (ph) [Ld]
         3. Q-axis inductance (ph) [Lq]
         4. Specify (at least one of the following)

Torque constant [kt]

Units: (oz•in,lb•in,lb•ft,N•m,N•cm) /(Apeak,Arms)

Voltage constant [ke]

Units: (Vrms,Vpeak)/(krpm,rad/s)

* + - * 1. Inertia [J]

Units: (lb•in•s2, kg•m2, kg•cm2,g•cm2, lb•in2, oz•in•s2, g•cm2)

* + - * 1. Viscous damping [F]

Units: (oz•in/krpm,N•m•s,N•m/rpm, oz•in/krpm)

* + - * 1. Pole pairs [p]
    1. Trapezoidal
       1. Round Specifications needed
       2. Resistance (ph-ph) [R]
       3. Inductance (ph-ph) [Lab]
       4. Specify (at least one of the following)
          1. Torque constant [kt]

Units: (oz•in,lb•in,lb•ft,N•m,N•cm)/(Apeak,Arms)

* + - * 1. Voltage constant [ke]

Units: (Vrms,Vpeak)/(krpm,rad/s)

* + - 1. Inertia [J]

Units: (lb•in•s2, kg•m2, kg•cm2,g•cm2, lb•in2, oz•in•s2, g•cm2)

* + - 1. Viscous damping [F]

Units: (oz•in/krpm,N•m•s,N•m/rpm, oz•in/krpm)

* + - 1. Pole pairs [p]
  1. Block Parameters
     1. Sinusoidal
        1. Rotor type-Round:
           1. Stator phase resistance Rs [ohm]
           2. Armature Inductance [H]
           3. Flux linkage established by magnets [V•s]
           4. Voltage Constant [Vpeak L-L/krpm]
           5. Torque Constant [N•m/Apeak]
           6. Inertia, fiction factor, pole pairs [kg•m2, N•m•s, poles no units]
        2. Rotor type-Salient Pole:
           1. Stator phase resistance Rs [ohm]
           2. Inductances Ld [H], Lq [H]
           3. Flux linkage established by magnets [V•s]
           4. Voltage Constant [Vpeak L-L/krpm]
           5. Torque Constant [N•m/Apeak]
           6. Inertia, fiction factor, pole pairs [kg•m2, N•m•s, poles no units]
     2. Trapezoidal
        + 1. Stator phase resistance Rs [ohm]
          2. Stator phase inductance Ls [H]
          3. Flux linkage established by magnets [V•s]
          4. Voltage Constant [Vpeak L-L/krpm]
          5. Torque Constant [N•m/Apeak]
          6. Inertia, fiction factor, pole pairs [kg•m2, N•m•s, poles no units]

1. Approach for transfer-function simulation

Section II presents the different steps to obtain the transfer function beginning from the *Wind Energy Conversion* ending with the rectifier/DC to Ac converter.

1. Wind Energy Conversion [1,2,3,4]
   1. Notations/Terms:

* – wind power
* – air density
* – wind velocity
* – area the covered surface of the turbine
* – radius of turbine which the wind passes
* – power coefficient
* – tip ratio speed
* – blade pitch angle
* – mechanical power
* – rotor torque
* – rotor speed
* – total inertia
* – electric torque
* – viscous friction
  1. Equations:

By substituting (1) in (2) it can be obtained (mechanical power):

By substituting (5) in (6) it can be obtained (turbine torque):

The wind power generator dynamic equation:

1. PMSG Model
   1. Notations/Terms

* – number of pole pairs
* – magnetic flux
* – q-axis current flowing through stator
* – d-axis current flowing through stator
* – resistance of stator
* – inductance
* –input voltage of the stator’s q-axis
* –input voltage of the stator’s d-axis
  1. Equations:

For this part I skipped the process of substitution (*see references for more information*) to get the following [1,2,3,4]:

1. Rectifier/DC to AC converter

For the Bergy 15 WT the manufacturers use a passive full-wave rectifier this may vary between manufacturers. Figure 1 shows a 3phase circuit with a rectifier. Figure 2 shows the voltage of the 3 phases as an input to the rectifier, at the bottom presents the output voltage waveform from the rectifier.

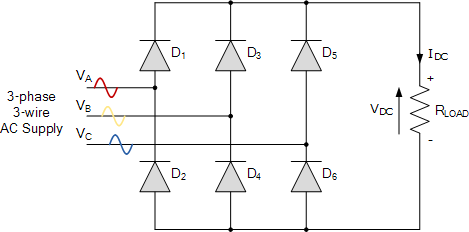


Figure 1: Full-wave circuit for a 3-phase system.

A picture containing diagram

Description automatically generated

Figure 2: Voltage wave of a 3-phase system and output of a passive full-wave 3-phase rectifier.

The following equations are not of the dynamic system of a passive full-wave 3-phase rectifier:

By substituting (10), (11) in (12) is possible to obtain the following equation:

References

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