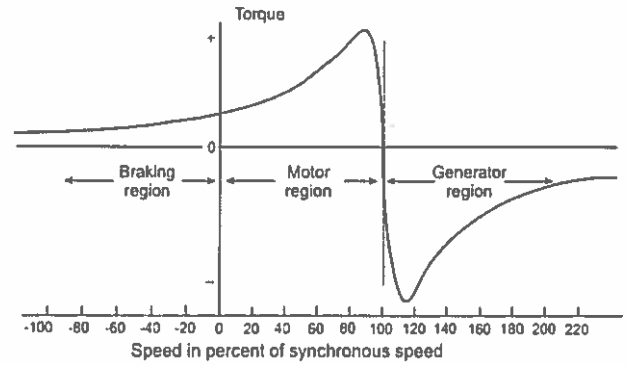
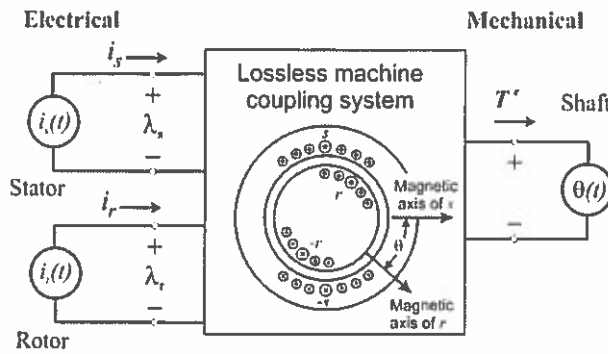


Quiz 9

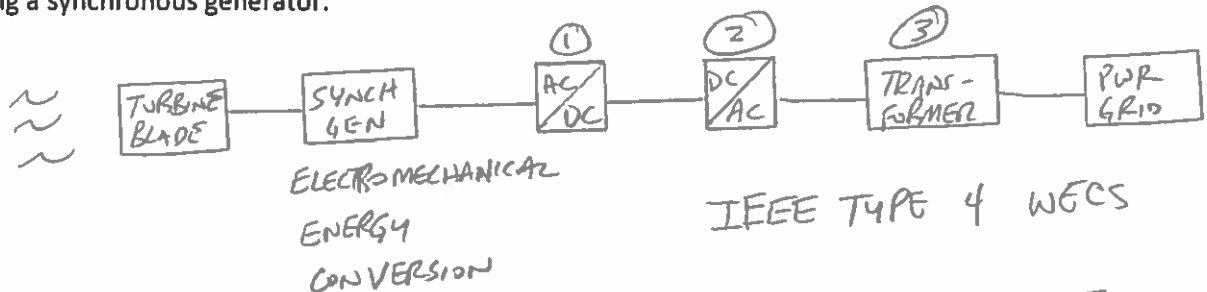


1. Synchronous machine operation

a. (5 pts) Explain synchronous generator power flows using the figures shown, machine conditions for average power conversion (choose the specific condition among the possible permutations), and the induction machine torque speed curve.

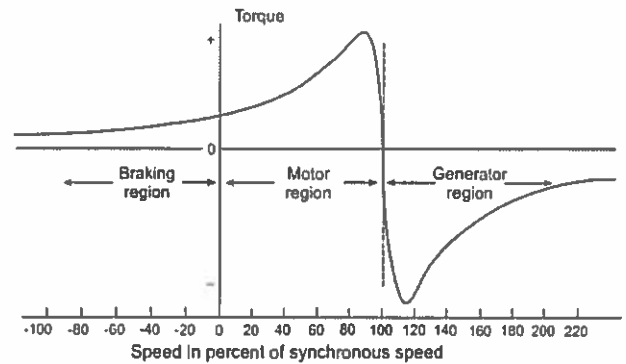
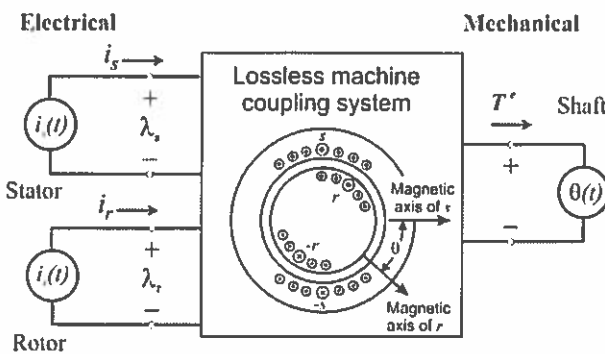
- $W_r = 0$; $W_s = W_m + W_r$ (in) $\Rightarrow W_s = W_m$
- MECHANICAL POWER APPLIED TO MECHANICAL TERMINALS -
- ELECTRICAL POWER OUT OF ELECTRICAL TERMINALS - $W_m = W_s$
- FIELD CURRENT APPLIED (IN) TO ROTOR WINDING
- $W_s =$ FREQUENCY SYSTEM IS CONNECTED TO (60 Hz in U.S.)

b. (5 pts) Draw a sequence of power condition components of a nominal wind energy conversion system using a synchronous generator.



- ① CONVERT GENERATED POWER FREQUENCIES FROM SYNCH GEN TO DC.
- ② CONVERT DC POWER TO MATCH POWER GRID (60 Hz) FREQUENCY
- ③ STEP 60 Hz SIGNAL UP TO POWER GRID VOLTAGE LEVEL

NAME SOLUTION



2. Induction Machine operation

a. (5 pts) Describe induction generator (for simplicity a 3 phase, 2-pole machine) power flows and how it meets the frequency conditions for non-zero average power conversion (choose the specific condition among the possible permutations); include an explanation of the Faraday's law role in electromechanical power conversion.

• PRIME MOVER (MECH PWR SOURCE) TURNS ROTOR FASTER THAN THE STATOR'S

- TORQUE → ROTATING MAGNETIC FIELD (WHICH MATCHES GRID FREQUENCY (60 HZ))

PER • ELECTRICAL POWER IS DRAWN OUT OF THE STATOR TERMINALS

DIAGRAM • ELECTRICAL POWER INTO THE ROTOR WINDING. DUE TO ROTOR TURNING FASTER THAN STATOR MAGNETIC FIELD, VOLTAGES ARE INDUCED IN THE ROTOR WINDING THAT CAUSE CURRENT FLOW; $P_{ROTOR} = V_{ROTOR} I_{ROTOR}$

• $\omega_m = \omega_s + \omega_r$

b. (5 pts) Describe induction motor (for simplicity a 3 phase, 2-pole machine) power flows and how it meets the frequency conditions for non-zero average power conversion (choose the specific condition among the possible permutations); include an explanation of the Faraday's law role in electromechanical power conversion.

+ TORQUE • POWER INTO THE SYSTEM THROUGH THE STATOR ELECTRIC TERMINALS

PER • POWER OUT OF THE SYSTEM VIA MECHANICAL SHAFT - PROVIDING MECHANICAL POWER TO DO SOMETHING USEFUL

• ω_s IS THE POWER SYSTEM FREQUENCY. ⇒ MAGNETIC FIELD ROTATES AT THIS SPEED.

• ELECTRICAL POWER INTO THE ROTOR VIA VOLTAGES INDUCED IN ROTOR WINDING BECAUSE $\omega_m < \omega_s$; INDUCED VOLTAGE CAUSES CURRENT FLOW IN ROTOR WINDING; $P_{ROTOR} = V_{ROTOR} I_{ROTOR}$

• $\omega_s = \omega_m + \omega_r \Rightarrow \omega_m = \omega_s - \omega_r$

BONUS (2 pts) Define leadership

LEADERSHIP IS INFLUENCING PEOPLE TO ACT TO COMMON PURPOSE.