ECE 320: Lecture 26

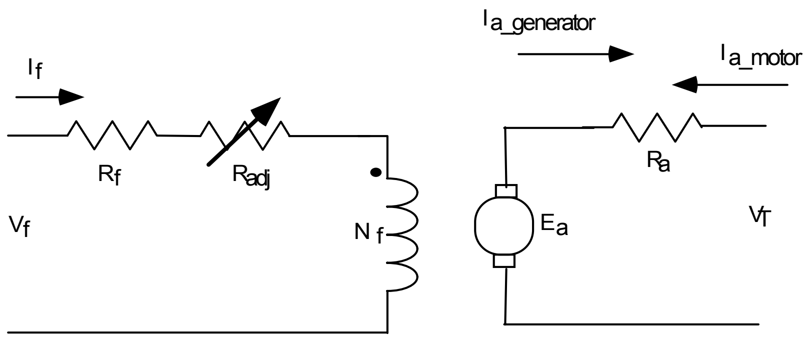
Notes

Field Excitation Options

- The field connection needs to be included in the circuit
- The flux: ϕ will be related to the field curent and the number of field turns and a constant.

Separately Excited Machine

Equivalent circuit:

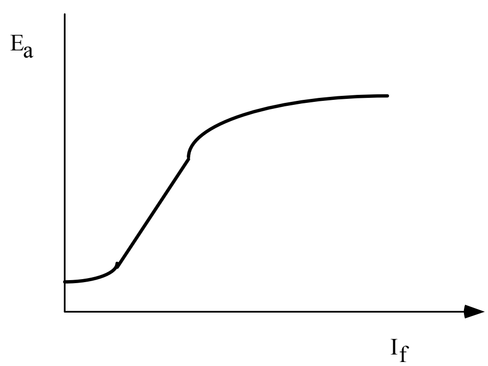


Now:

$$I_f = \frac{V_f}{R_f + Radj}$$

- Radj is a variable resistor (called a rheostat)

Determine Ea based on field current and rotor speed.



This won't necessarily start at zero Volts due to residual magnetism in the magnetic core material

We can always relate voltage and speed (assuming constant flux density) with:

$$\frac{Ea1}{\omega 1} = \frac{Ea2}{\omega 2}$$

where ω1 and ω2 are two different speeds in rad/sec or with:

$$\frac{Ea1}{n1} = \frac{Ea2}{n2}$$ where n1 and n2 are the rotor speeds in revolutions per minute

- Define armature current as leaving the machine.
- For a generator, armature current is greater than terminal voltage
- R_a is the armature resistance

$$I_a = \frac{E_a - V_t}{R_a}$$

- The electrical load connected to the terminals can be treated as a resistance, or a voltage source behind a resistance (usually another machine).
- In some of the labs, a generator will connected to the same shaft as a motor.
- The generator will have an electrical load, that will in turn cause it to require mechanical power (or torque) from the motor.

Electromagnetic Torque is applied to the rotor to make it turn faster than no-load speed

$$\tau = \frac{E_a \cdot I_a}{\omega_m}$$ ω_m must be in rad/sec for this calculation

Motor Case:

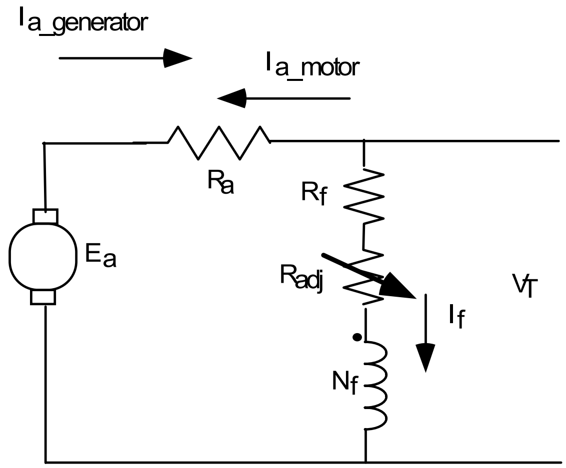
- Now define the current as entering the machine from the terminals
- The motor now appears as a load to the electrical circuit and will supply mechanical work to rotor shaft.
- For the seperately excited case, the field circit will be exactly the same, except there will be l field current, since the armature voltage will now be smaller than the terminal voltage.

$$Ia = \frac{V_t - E_a}{R_a}$$

Now treat the torque, or the mechanical power (now power will be given in HP in North America instead of Watts) as the output

Shunt Excited:

- Now we see $V_f = V_t$
- This is more significant for generators than motors in many cases.
- Now the field current is varied by varying the field resistance

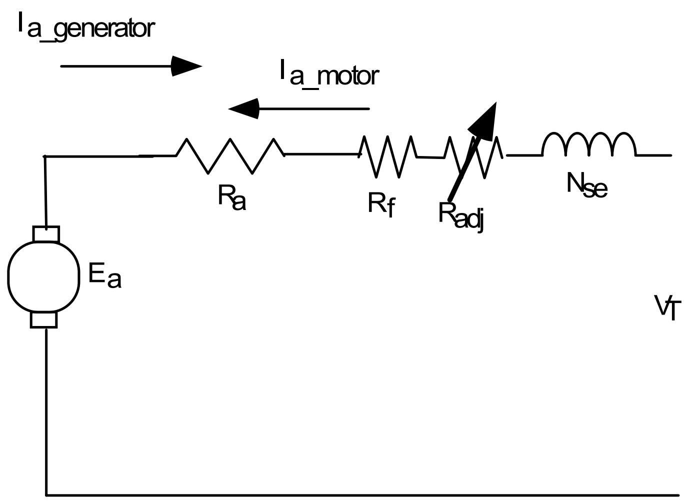


- In the generator case, V_t will depend on E_a, so it will be necessary to vary I_f to keep the terminal voltage at a desired level.

Series Excited:

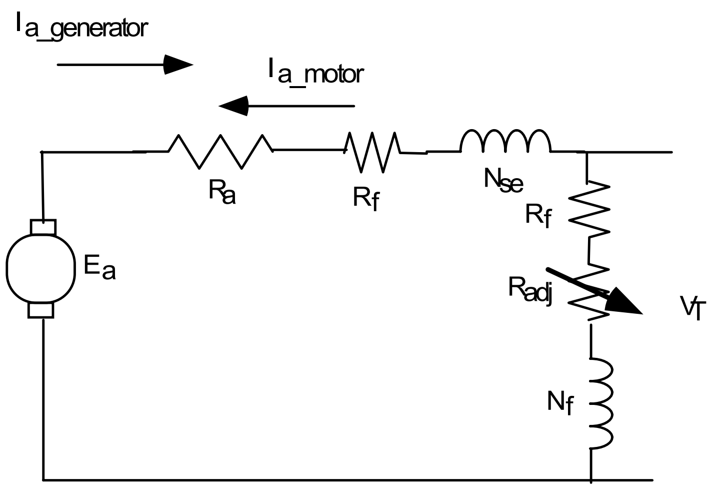
- Now we have $I_f = I_a$
- Small number of turns on the field circuit, to minimize added resistance to the circuit
- Also the "field" current will now be large.
- The shunt field has a lot of turns and small current, the series field has few turns and a lot of current

- Series excited machines tend to produce very high starting Torques, since the armature curre large when machine isn't turning (no armature voltage)
- They do not perform well as generators



Combined Series/Shunt excitation:

- Referred to as compounding
- Can be cumulative compounded where the two field components add, this is more common



- Shunt field can be connected between series field and armature winding (short shunt) or between the series field and terminal voltage (long shunt).