

**Week 9: Assignment**

1) A compound DC generator has an armature resistance of 0.04Ω, shunt field resistance of 48Ω and series field resistance of 0.02Ω. The field excitation is adjusted to get a rated terminal voltage of 220V. Find out the internal generated voltage, \( E \) (in Volts), when the motor is supplying 4.4kW at rated voltage for long shunt connection? [Enter only the numerical value. Do not enter the unit]

**Accepted Answers:**

(Type: Range) 219,223

10 points

2) A 230V, 50kW short-shunt compound generator has an armature resistance of \( R_a = 0.06Ω \), series winding resistance of 0.04Ω and shunt field winding of resistance 120Ω. Calculate the induced armature voltage \( E \) (in Volts) at rated load and terminal voltage. The total brush contact drop is 2V? [Enter only the numerical value. Do not enter any units]

**Accepted Answers:**

(Type: Range) 250,255

10 points

3) A 440V dc machine supplies 40A at 400V as a generator. The armature resistance is 0.8Ω. If the machine is now operated as a motor at same terminal voltage and current but with the flux increased by 10%, the ratio of motor speed to generator speed is________ . [Enter only the numerical value]

**Accepted Answers:**

(Type: Range) 0.7,0.82

10 points

4) A 10 hp, 230V DC shunt motor has an armature resistance of 0.1Ω and field resistance of 180Ω. At no-load and rated voltage, the speed is 1200 rpm and the armature current is 5A. At full-load
and rated voltage, the line current is 60A, and the flux is reduced by 6% due to armature reaction effects from its value at no-load. What is the full-load speed?

- 1197 rpm
- 1200 rpm
- 1208 rpm
- 1247 rpm

Accepted Answers:

1247 rpm

5) A 250V shunt motor is driving a load at 600rpm and the armature draws a current of 20A. What resistance should be inserted in series to the shunt field if the speed is to be raised from 600rpm to 800rpm? The armature resistance and shunt field resistance are 0.5ohm and 250ohm respectively

- 88ohm
- 112ohm
- 63ohm
- 43ohm

Accepted Answers:

88ohm

6) A 220V shunt motor with armature resistance of 0.5ohm, runs at 500rpm and draws 30A at full load. The shunt field is excited to give constant main field. What will be the speed at full load if a 1ohm resistor is placed in series with the armature circuit?

- 427rpm
- 453rpm
- 557rpm
- 401rpm

Accepted Answers:

427rpm

7) A 220V shunt motor has armature resistance of 0.5ohm and takes a full load current of 40A. By what percentage should the main field flux be reduced to raise the speed by 50%, if the developed torque remains constant?

Note: Please enter only the numeric value without any units. Decimal approximations can be made

Accepted Answers:

(Type: Range) 35-40

10 points

8) Two identical shunt generators are running in parallel, each having a armature resistance of 0.02ohm and field resistance of 50ohm. The combined load current is 5000A. The fields are so excited that the generated voltages of one machine is 610V and the other is 600V. What will be the terminal voltage of this parallel combination?

Note: Please enter only the numeric value without any units. Decimal approximations can be made
Accepted Answers:
(Type: Range) 550-560

10 points
Q1.Solution

The load current \( I_L = \frac{4400}{220} = 20\, A \)

The shunt-field current, \( I_{f,sh} = \frac{220}{48} = 4.58\, A \)

Armature current, \( I_a = I_L + I_{f,sh} = 24.58\, A \)

The internal generated voltage, \( E = V_L + I_a(R_{sc} + R_a) \)

\[ = 220 + 24.58(0.02 + 0.04) = 221.47\, V \]

Q2.Solution

The internal generated voltage, \( E = V_L + I_a(R_{sc} + R_a) \)

\[ = 500 + 50(0.06 + 0.06) = 512\, V \]
The load current \( I_L = \frac{50,000}{230} = 217.4A \)

\( I_L R_{se} = 217.4 \times 0.04 = 8.696V \)

Voltage across shunt-field winding, \( V_f = 230 + 8.696 = 238.696V \)

Shunt field current, \( I_f = \frac{238.696}{120} = 1.99A \)

Armature current, \( I_a = I_L + I_f = 217.4 + 1.99 = 219.39A \)

Induced armature voltage, \( E = V_f + I_a R_a + e_b \)

\( = 238.696 + (219.39 \times 0.06) + 2 = 253.86V \)

### Q3. Solution

![Diagram](image)

**Figure 3:**

Rated load \( = 4.4kW \)

No-load terminal voltage \( V_{NL} = 110V = V_{FL} \)

Full load current, \( I_{L,FL} = \frac{4400}{110} = 40A \)

Shunt-field current at full-load \( I_{sh,FL} = \frac{110}{63} = 1.746A \)

Shunt-field current at No-load \( I_{sh,NL} = \frac{110}{63} = 1.746A \)
Armature current at full load, \( I_a = I_{L,FL} + I_{sh,FL} = 40 + 1.746 = 41.746 A \)

Internal generated voltage at full-load 
\[
E_{FL} = V_{FL} + I_a(R_a + R_{se}) + E_b
\]
\[
110 + 41.746(0.1 + 0.02) + 2 = 117 V
\]

From the magnetization data, the shunt-field current for \( E = 117 V \) \( = 2.1 A \)

For a long-shunt machine 
\[
I_{sh,eff} = I_{sh} + \frac{N_{se}}{N_{sh}} I_a
\]
\[
2.1 = 1.746 + \frac{N_{se}}{1400} \times 41.746
\]
\[
N_{se} = 11.87 \approx 12 \text{ turns}
\]

Q4. Solution

\[
T = 180 = k_a \phi I_a
\]
\[
E_a = 440 - I_a \times 0.3 = k_a \phi \omega_m
\]
\[
\omega_m = \frac{1500 \times 2\pi}{60} = 157.079 rad/s
\]
\[
I_a = \frac{180}{440 - I_a \times 0.3} = \frac{157.079}{157.079}
\]

Solving the above equation, we get; \( I_a = 67.39 A \) or \( 1399.26 A \)

Q5. Solution

For generator 
\[
E = V + I_a R_a
\]
\[
= 400 + (40 \times 0.8) = 432 V
\]

For motor 
\[
V = E - I_a R_a
\]
\[
E = 400 - (40 \times 0.8) = 368 V
\]

Hence 
\[
\frac{E_1}{E_2} = \frac{N_1}{N_2} \times \frac{\phi_1}{\phi_2}
\]
\[
\frac{432}{368} = \frac{N_1}{N_2} \times \frac{1}{1.1}
\]
\[
\frac{N_2}{N_1} = \frac{368}{432 \times 1.1} = 0.77
\]
Q6. Solution

\[ E_{NL} = 230 - (5 \times 0.1) = 229.5V \]

Field current, \( I_f = \frac{230}{180} = 1.2778\text{A} \)

\[ E_{FL} = 230 - (60 - 1.2778) \times 0.1 = 224.13V \]

\[ E \propto \phi\omega_m \]

\[ \frac{E_1}{E_2} = \frac{N_1}{N_2} \times \frac{\phi_1}{\phi_2} \]

\[ N_2 = N_1 \times \frac{E_2}{E_1} \times \frac{\phi_1}{\phi_2} \]

\[ = 1200 \times \frac{224.13 \times \frac{1}{1 - 0.06}}{229.5} = 1246.73\text{rpm} \]

Q7. Solution

Torque(T) \( \propto \) flux(\( \phi \)) \times Armature current

\[ T \propto \phi I \]

Here the torque remains constant and hence

\[ \phi_2 I_2 = \phi_1 I_1 \]

Also the flux is proportional to the shunt field current (assuming linear magnetization curve)

\[ \therefore I_{sh2} I_2 = I_{sh1} I_1 \]

\[ I_{sh1} I_2 = \frac{250}{250} = 1 \]

\[ \implies I_{sh2} I_2 = 20 \text{ (Since armature current before change is 20A)} \]

\[ E_{b1} = 250 - 0.5 \times 20 = 240V \]

\[ E_{b2} = 250 - 0.5 I_2 \]

Speed (N) \( \propto \) \[ \frac{E_b}{\phi} \implies \frac{E_{b2}}{E_{b1}} = \frac{I_{sh2} N_2}{I_{sh1} N_1} \]

\[ \therefore \frac{250 - 0.5 I_2}{240} = \frac{I_{sh2} \times 800}{1 \times 600} \]

But, \( I_{sh1} I_2 = 20 \)

Combining the above two equations, we get

\[ 32 I_{sh2}^2 - 25 I_{sh2} - 1 = 0 \]

Solving the above equation for \( I_{sh1} \) gives

\[ I_{sh1} = 0.7389\text{A} \]

\[ \therefore \text{Corresponding shunt resistance } = \frac{250}{0.7389} = 338\text{ohm} \]

\[ \therefore \text{Resistance to be added } = 338 - 250 = 88\text{ohm} \]
Q8. Solution

\[ T \propto \phi I_a \propto I_a \text{ (Since flux is constant)} \]

Since torques is constant, armature current remains constant

\[ E_{b1} = 220 - 0.5 \times 30 = 205V \]
\[ E_{b2} = 220 - 1.5 \times 30 = 175V \]

\[ \text{Speed } \propto \frac{E_b}{\phi} \]

\[ \therefore \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \text{ (Since flux is constant)} \]
\[ N_2 = \frac{175}{205} \times 500 = 427 \text{ rpm} \]

Q9. Solution

Torque (T) remains constant, which implies \( T \propto \phi I_a \)

\[ \therefore \frac{\phi_1 I_{a1}}{\phi_2 I_{a2}} = 1 \]

Also the speed (N) is raised by 150 %

\[ N \propto \frac{E_b}{\phi} \]

\[ \implies \frac{N_2}{N_1} = 1.5 = \frac{E_{b2} \phi_1}{E_{b1} \phi_2} \]
\[ E_{b2} = 300 \frac{\phi_2}{\phi_1} \]
\[ E_{b1} = 220 - 0.5 \times 40 = 200V \]
\[ E_{b2} = 220 - 0.5 \times I_{a2} \]
\[ \text{But } I_{a2} = \frac{\phi_1 I_{a1}}{\phi_2} = \frac{40 \times \phi_1}{\phi_2} \]

Substituting in equation for \( E_{b2} \)

\[ E_{b2} = 220 - 0.5 \times \frac{40 \times \phi_1}{\phi_2} \implies 300 \frac{\phi_2}{\phi_1} = 220 - 20 \frac{\phi_1}{\phi_2} \]

Let \( \phi_2 / \phi_1 \) be equal to \( 'x' \)

\[ \therefore 300x = 220 - \frac{20}{x} \]

Rearranging, we get \( 300x^2 - 220x + 20 = 0 \)

Solving for \( x \), we get \( x = 0.625 \)

\[ \implies \phi_2 \text{ is 37.5% less than } \phi_1 \]
Q10. Solution

\[ E_{b1} = 600V, R_{a1} = 0.02\,\text{ohm} \]
\[ E_{b2} = 610V, R_{a2} = 0.02\,\text{ohm} \]

Converting voltage sources in series with resistance into current sources in parallel to resistance

\[ I_1 = \frac{600}{0.02} = 30000\,\text{A} \]
\[ I_2 = \frac{610}{0.02} = 30500\,\text{A} \]

The equivalent resistance \( R_{eq} \) of \( R_{sh1}, R_{sh2}, R_{a1} \) and \( R_{a2} = \frac{50||50||0.02||0.02}{1/100} = 1/100\,\text{ohm} \)

The two parallel current sources can be combined to single current source \( I \) of value \( = 30000 + 30500 = 60500\,\text{A} \)
\[ \therefore \text{Current through } R_{eq} = 60500 - 5000 = 55500 \text{A} \]

\[ \therefore \text{Voltage across the load} = 55500 \times R_{eq} = 55500 \times \frac{1}{100.04} = 554.778 \text{V} \]