Date :

Q1:- Let bus voltage $V_b(t) = V_m \sin(\omega_b t)$

generator voltage $V_g(t) = V_m \sin(\omega_g t + \phi)$

ϕ : Initial phase difference.

for phase A;

$V_{lamp}(t) = V_g(t) - V_b(t)$

$= V_m \sin(\omega_g t + \phi) - V_m \sin(\omega_b t)$.

using $\sin A - \sin B = 2\cos\left(\frac{A+B}{2}\right)\cdot\sin\left(\frac{A-B}{2}\right)$.

$$V_{lamp}(t) = 2V_m \cos\left(\frac{\omega_g t + \omega_b t + \phi}{2}\right)\sin\left(\frac{\omega_g t + \phi - \omega_b t}{2}\right)$$

So, the lamp voltage oscillates at the beat frequency.

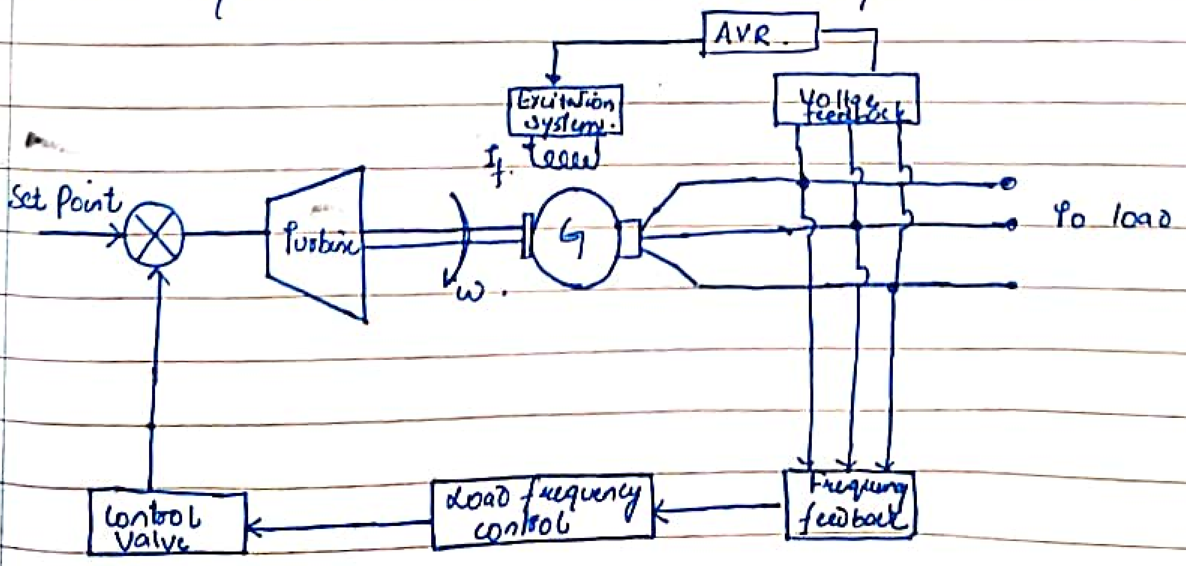
$f_{beat} = |f_g - f_b|$

And the brightness of the lamp varies periodically, cycling b/w bright and dark.

- All the three lamps blink simultaneously.
- The blinking rate = twice the slip frequency $2\times|f_g - f_b|$.
- Maximum brightness is when phase difference is 180°.
- Darkness when the phase difference is 0°.

- Phase sequence is correct all 3 lamps blink ~~there~~ together.

Q2.



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Excitation System :-

- Controls the field current I_f of the generator.
- Affects the terminal voltage of the generator.

AVR :-

- Uses ~~f~~ voltage feedback to regulate the terminal voltage.
- Adjusts the excitation system accordingly.

- Load frequency control.
- Uses ~~feedback~~ frequency feedback to maintain system frequency.
- Adjusts the control valve to modify the input to the turbine
- Ensure active power balance and stabilizes frequency.

Voltage feedback → AVR → Excitation → Controls terminal voltage.

Frequency feedback → LFC → Turbine Control valve → controls Generator Speed.

$S_b = 10\,MVA$

$E_f = 11\,kVA$.

$X_S = 1.2\,pu$

$X_L = 0.6\,pu$

$X_t = j1.8\,pu$

$$Z_{base} = \frac{V_{base}^2}{S_{base}} = \frac{(11000)^2}{(10\times10^6)} = 12.1\,\Omega.$$

(a) Star Connected $R = 24\,\Omega$

$$Z_{Load(pu)} = \frac{24}{12.1} = 1.9835\,pu$$

Let Generator voltage be $E_f = 1.0\angle0^\circ\,pu$

$$Z_{total} = X_S + X_{Line} + Z_{Load}$$
$$= j1.8 + 1.935\,pu$$

$$|Z| = \sqrt{1.935^2 + 1.8^2}$$
$$= 2.688$$

$$\theta = \tan^{-1}\left(\frac{1.8}{1.935}\right) = 42.38^\circ$$

$$I = \frac{E}{Z} = \frac{1\angle0^\circ}{2.688\angle42.38}$$

$$I = 0.372\angle-42.38^\circ\,pu$$

Voltage across Load:

$$V_{Load}^{pu} = I\times R = 0.372\angle-42.38^\circ \times 1.9835$$
$$= 0.738\angle-42.38^\circ\,pu$$

$$\boxed{V_{Load,Phase} = 0.738\times\frac{11000}{\sqrt{3}} = 4688\,V}$$

(b) C load $X = 24\,\Omega$

$$X_C = \frac{1}{j24}$$

$$X_C = -j\,1.985$$

$$Z_{total} = -j1.9835 + j1.8$$

$$= -j\,0.1835$$

$$I = \frac{1\angle 0^\circ}{-j\,0.1835} = j5.45\ pu.$$

$$V_{Load} = I \cdot Z_{Load}$$

$$= j5.45\,(-j\,1.9835)$$

$$= 5.45 \times 1.9835$$

$$= 10.81\ pu$$

$$V_{pu} = \frac{V_{act}}{V_{base}}$$

$$V_{act.} = V_{pu} \times V_{base}$$

$$= 10.81 \times \frac{11k}{\sqrt{3}}$$

$$V_{Load\ Phase} = 68643\,V$$

$$= 68.643\,kV$$