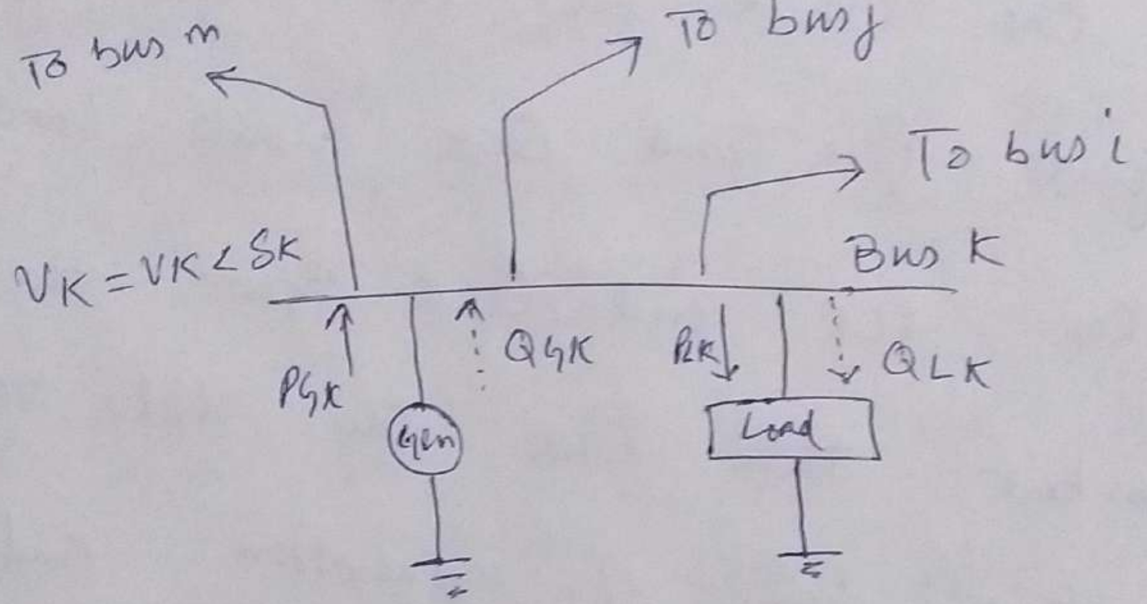
Bus Bar in Detail:-

Let take the bus bar (2) of the previous Lecture.



⇒ A generator is connected which inject P_{GK}, Q_{GK} to the bus bar.

⇒ A Load is connected which takes P_{LK}, Q_{LK} from the Busbar.

⇒ This bus bar is connected to other bus bars i-e to bus i, j And m through lines.

⇒ The voltage at bus bar is V_K, where V_K is equal to the magnitude V_K and the angle δ_K.

⇒ One think we see that generator injects P_{GK} and Q_{GK} while Load takes P_{LK} and Q_{LK} from the bus bar then we can take the algebric sum of generation and Loads i-e subtracts the loads from the generation

i-e

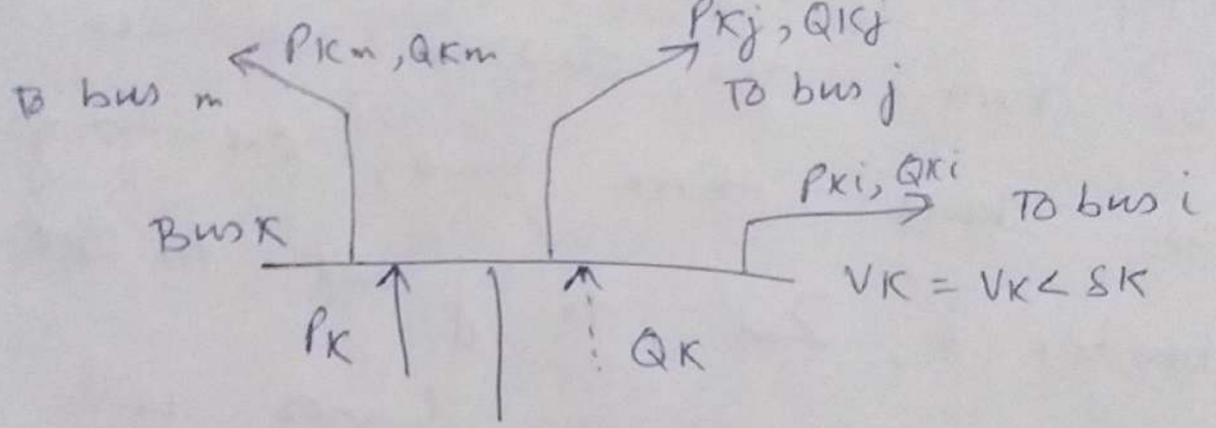
$$P_K = P_{GK} - P_{LK}$$

∵ Real Power Injection.

Similarly Reactive Power Injection is

$$Q_K = Q_{GK} - Q_{LK}$$

then the diagram becomes.



∴ Now we will say the injections into the bus bar rather saying the generation and loads.

If at a particular bus bar there is no generation input and only load is connected then the injection to that bus bar will be

$$\therefore \quad P_K = 0 - P_{LK}$$

$$P_K = -P_{LK}$$

$$\therefore Q_K = 0 - Q_{LK}$$

$$Q_K = -Q_{LK}$$

So, Loads can be considered as Negative injections.

⇒ From the diagram we see that we have three lines, one going to bus bar i, 2nd to j and the 3rd one to m. These Lines will carry the Power P_{Ki}, Q_{Ki} to bus i, P_{Kj}, Q_{Kj} to bus j and P_{Km}, Q_{Km} to bus m.

⇒ Some of these power may be in the reverse directions i-e they may be coming from bus j to bus K, in that case the value of P_{Kj}, Q_{Kj} will be negative.

So,

$$P_K = P_{Ki} + P_{Kj} + P_{Km}$$

$$Q_K = Q_{Ki} + Q_{Kj} + Q_{Km}$$

$\therefore$ Real and Reactive Power is equal to the algebraic sum of P, & Q Power going out.

Power Flow Equation:-

We showed that Power flow equations are coming from the Network equations.

i-e $$I_{Bus} = Y_{Bus} \cdot V_{Bus} \longrightarrow (1)$$

where I_{Bus} is the vector of current injections into the bus bars

Y_{Bus} is the $n \times n$ matrix of the admittance and V_{Bus} is the voltage phasor at the n buses of the Power system.

⇒ For a particular bus K, we can write the equation as,

$$I_K = \sum_{n=1}^{N} Y_{Kn} V_n \longrightarrow (2)$$

where N = no of bus bar.

Y_{Kn} = addmittance of the Kn element.

V_n = Voltage Phasor at bus n.

From equation we can write the complex Power injection at bus bar K is

$$S_K = P_K + jQ_K = V_K I_K^* \longrightarrow (3)$$

Now we know the value of I_K from eq (2). Substituting I_K in eq (3).

$$P_K + jQ_K = V_K \left[\sum_{n=1}^{N} Y_{Kn} V_n \right]^* \text{ where } K = 1, 2, \ldots N$$

V_n is a phasor which has a magnitude and an angle.

$$V_n = V_n e^{j\delta_n}$$

and $$Y_{Kn} = Y_{Kn} e^{j\theta_{Kn}}, \quad K, n = 1, 2, \ldots N.$$

Substituting V_n and Y_{Kn} values in eq (3).

$$P_K + jQ_K = V_K \sum_{n=1}^{N} Y_{Kn} V_n e^{j(\delta_K - \delta_n - \theta_{Kn})}$$

$\therefore$ All angles δ_K with V_K
δ_n with V_n
θ_{Kn} with Y_{Kn}

All Negative b/c of conjugates.

We can separate out the real & Imaginary parts. Then we can write the real Power Injection into Bus K as.

$$P_K = V_K \sum_{n=1}^{N} Y_{Kn} V_n \cos(\delta_K - \delta_n - \theta_{Kn}) \quad (4)$$

Similarly the Reactive Power Injection is

$$Q_K = V_K \sum_{n=1}^{N} Y_{Kn} V_n \sin(\delta_K - \delta_n - \theta_{Kn}) \quad (5)$$

So, we can see that these injections is related to the voltage magnitude and angle at various bus bars.

Eq (4) & (5) is said as the Power flow equations for the Power Network.