(4) Characterization of Power Flow Equations:-

(1) Power Flow equations are Algebric equation b/c these are dealing with a static system.

(2) These equations since they involve cos and sin term as well as they have the multiplication of voltages involved therefore these equations are non linear equations and therefore in general we need Iterative methods to solve this. (i-e Gauss Siedal & Newton Raphson method.)

③ Power flow equations relate the injections i-e Real & Reactive Power injections at the bus in terms of Voltage magnitude and angle at various bus bars in the system and the admittance matrix of the system.

i-e $P, Q \longrightarrow f(V, \delta)$

— x — x — x —

(*) Characterization of Variables:-

(1) Loads (P_L, Q_L) → Uncontrolled (Disturbance variables) i-e no control from the operator.

(2) Generation (P_G, Q_G) → Controlled variables (i-e control from the operators) (Real and Reactive Power can always balance with the load).

(3) The voltage at various bus bars

Form the state variable i.e IF

We know the voltage magnitude and angle of the bus bar we can easily find out the power flow in each and every line and the power injections in different bus bars.

So:

⇒ For a given operating conditions the loads and generations at all buses are known (specified). Then to find voltage magnitude and angle (V, δ) at all the bus bars.

Problems in Power Flow Solutions:-

There is one problem in doing Power Flow solution that we cannot know all the generations. All the Loads are known to us but generations are in our control and one can say, that all generations are known to us but there is one Problem. The problem is still all the generations are available.

we don't Know what is the loss in the system? Since we Cannot Know the loss in the System,

we Cannot Know how much generation b/c the sum of load and the no of losses must be equal to the total generation.

Solution:-

To over Come the problem,

⇒ We Choose one bus as a reference

bus which takes up all these ~~buses~~ losses which can find after the solution. So at one bus we cannot specify the generation. Generally, this is a bus which have very large generation available so, that there will be no problem for it to take a losses. This bus in power system terminology is called a "Slack bus".

④ Classification of Busbars:-

In Power System Network we have different types of Bus bars. The solution of Power flow equations depends on the type of busbars.

① Swing Bus or Slack bus:-

(V and δ specified)

we donot specify the generation but we specify the voltage magnitude and angle. Since this bus is a reference bus and the angle is is specified normally zero. Since it is a generating bus which have its own voltage magnitude so the voltage level is fixed. i-e mostly 1 P.U.

So,
Swing bus has Voltage Magnitude & Angle specified.

② PV Bus (Voltage Control Bus)

(P and V specified)

The Bus bars in which we have voltage Magnitude and a Real Power is specified. Voltage regulators are

are installed which regularly check the voltage levels.

③ PQ Bus (Load Bus)

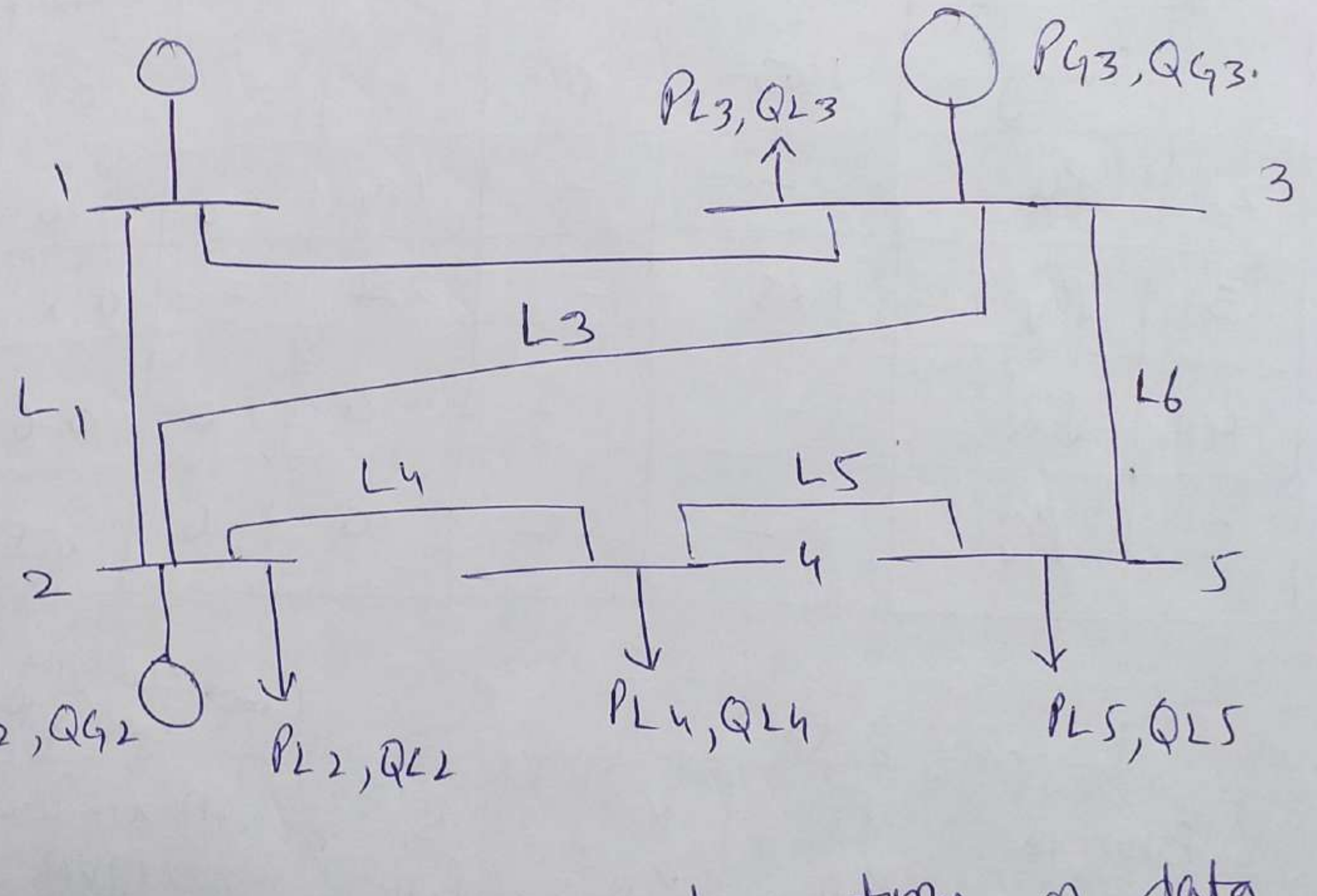
(P and Q specified)

Where both the Real and Reactive Powers are specified.

⇒ So each bus, 4 variables (P, Q, V and δ) are associated.

Depending on the type of bus two variables are known and two unknown variables are obtained from Power flow solution.

(*) 5 Bus Power System:-



We have normally two types of data provided.

(1) Bus Data (2) Line Data.

e.g The Bus Data provided for this system is

Bus Data

S.No	Bus Type	V P.U	δ Deg	PG P.U	QG P.U	PL P.U	QL P.U
1	Swing	1.03	0	—	—	0	0
2	PQ	—	—	1.4	0.8	3.0	1.2
3	PV	1.05	—	2.2	—	0.8	0.4
4	PQ	—	—	0	0	0.6	0.3
5	PQ	—	—	0	0	0.5	0.2

Line Data

Line charging susceptance

Bus to Bus	R P.U	X P.U	B P.U	Maximum MVA P.U
2-4	0.0090	0.100	1.72	12.0
2-5	0.0045	0.050	0.88	12.0
4-5	0.00225	0.025	0.44	12.0
1-5	0.00150	0.02	0	6.0
3-4	0.00075	0.01	0	10.0

This data is used for finding the Y_{bus} Matrix.

If we look at the system we find that.

Bus Type	No of Buses	Specified Quantities	No of Eqtns	No of (V, δ) state variables
1. Swing	1	V, δ	0	0
2. PQ	3	P, Q	$2\times3=6$	$2\times3=6$
3. PV	1	P, V	1	1
Total	5	10	7	7