$$B_{ik} = \frac{Y_{ik}}{Y_{ii}} \quad i = 2,3,\ldots n$$
$$k = 1,2,\ldots n$$
$$k \neq i$$

Now for the $(r+1)^{th}$ iteration, the voltage becomes

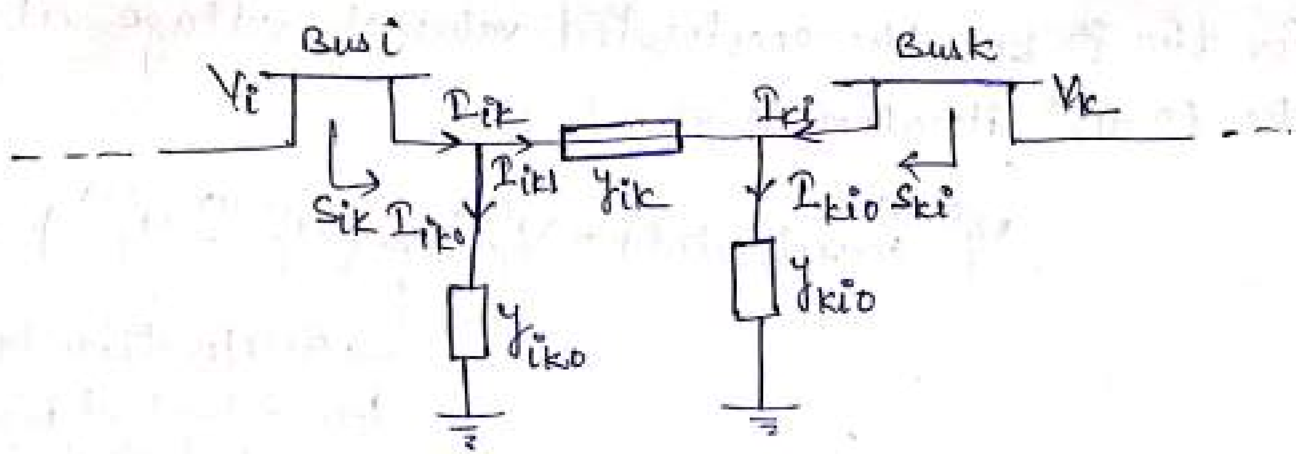
$$V_i^{(r+1)} = \frac{A_i}{(V_i^{(r)*})} - \sum_{k=1}^{i-1} B_{ik} V_k^{(r+1)} - \sum_{k=i+1}^{n} B_{ik} V_k^{(r)} \quad i = 2,3,\ldots n \qquad (13)$$

The iterative process is continued till the change in magnitude of bus voltage $|\Delta V_i^{(r+1)}|$, between two consecutive iterations is less than a certain tolerance for all bus voltages i.e.

$$|\Delta V_i^{(r+1)}| = |V_i^{(r+1)} - V_i^{(r)}| < \epsilon \; ; \quad i = 2,3,\ldots n$$

4. Computation of slack bus Power — Substitute all bus voltages computed in step 3 along with V_1 in eqn. (4) yields $S_1^* = P_1 - jQ_1$

5. Computation of line flows — Power flows on the various lines of the network are computed. Consider a line connecting buses i & k. The line and ~~transformes~~ transfomers at each end can be represented by a circuit with series admittance y_{ik} and two shunt admittances y_{ik0} & y_{ki0} as shown in fig.



π- representation of a line and transformers connected b/w two buses

The current fed by bus i into the line can be expressed as

$$I_{ik} = I_{ik1} + I_{iko} = (V_i - V_k) y_{ik} + V_i y_{iko} \quad \longrightarrow (14)$$

The power fed into the line from bus i is—

$$S_{ik} = P_{ik} + jQ_{ik}$$
$$= V_i I_{ik}^*$$
$$= V_i (V_i^* - V_k^*) y_{ik}^* + V_i V_i^* y_{iko}^* \quad \longrightarrow (15)$$

Similarly, the power fed into the line from bus 'k' is

$$S_{ki} = V_k (V_k^* - V_i^*) y_{ik}^* + V_k V_k^* y_{kio} \quad \longrightarrow (16)$$

The power loss in the $(i\text{-}k)^{th}$ line is the sum of the power flows determined from (15) & (16). Total transmission loss can be computed by summing all the line flows (i.e. $S_{ik} + S_{ki}$ for all i, k).

<u>Acceleration of Convergence</u> :- To speed up the convergence we use acceleration factor.

for the i^{th} bus. the accelerated value of voltage at the $(r+1)^{th}$ iteration is give by

$$V_i^{(r+1)}(\text{accelerated}) = V_i^{(r)} + \alpha\left(V_i^{(r+1)} - V_i^{(r)}\right) \longrightarrow (17)$$

↳ Acceleration factor.
found by trial ~~travel~~ load flow studies.
— Generally $\alpha = 1.6$
— Wrong value of α may indeed slow down convergence.

Algorithm Modification when PV Buses are also Present :

At the PV buses, P & |V| are specified and Q & δ are the unknowns to be determined. Therefore, the values of Q and δ are to be updated in every GS iteration through appropriate bus equations.

1. From eqn. (6)

$$Q_i = -\text{Im}\left\{V_i^* \sum_{k=1}^{n} Y_{ik} V_k\right\}$$

revised value of Q_i is obtained by above eqn. by substituting most updated values of voltages on right hand side.

for $(r+1)^{th}$ iteration

$$Q_i^{(r+1)} = -\text{Im}\left\{\left(V_i^{(r)}\right)^* \sum_{k=1}^{i-1} Y_{ik} V_k^{(r+1)} + \left(V_i^{(r)}\right)^* \sum_{k=i}^{n} Y_{ik} V_k^{(r)}\right\}$$

$\longrightarrow$ (18)

2. The revised value of δ_i is obtained from equ. (13)

$$\delta_i^{(r+1)} = \angle V_i^{(r+1)}$$

$$= \text{Angle of}\left[\frac{A_i^{(r+1)}}{V_i^{(r)*}} - \sum_{k=1}^{i-1} B_{ik} V_k^{(r+1)} - \sum_{k=i+1}^{n} B_{ik} V_k^{(r)}\right] \longrightarrow (19)$$

where

$$A_i^{(r+1)} = \frac{P_i - jQ_i^{(r+1)}}{Y_{ii}} \longrightarrow (20)$$

The algorithm for PQ buses remains unchanged.

Flow Chart :-

Read
1. Primitive Y matrix
2. Bus Incidence Matrix A
3. Slack Bus voltage ($|V_1|, \delta_1$)
4. Real Bus Powers P_i for $i = 2, 3, 4 \ldots n$
5. Reactive Bus Powers Q_i for $i = m+1, \ldots n$ (PQ Buses)
6. Voltage magnitude $|V_i^s|$ for $i = 2, \ldots m$ (PV Buses)
7. Voltage magnitude Limits $|V_i|_{min}$ & $|V_i|_{max}$ for PQ Buses
8. Reactive Power Limits $Q_{i\,min}$ & $Q_{i\,max}$ for PV buses.

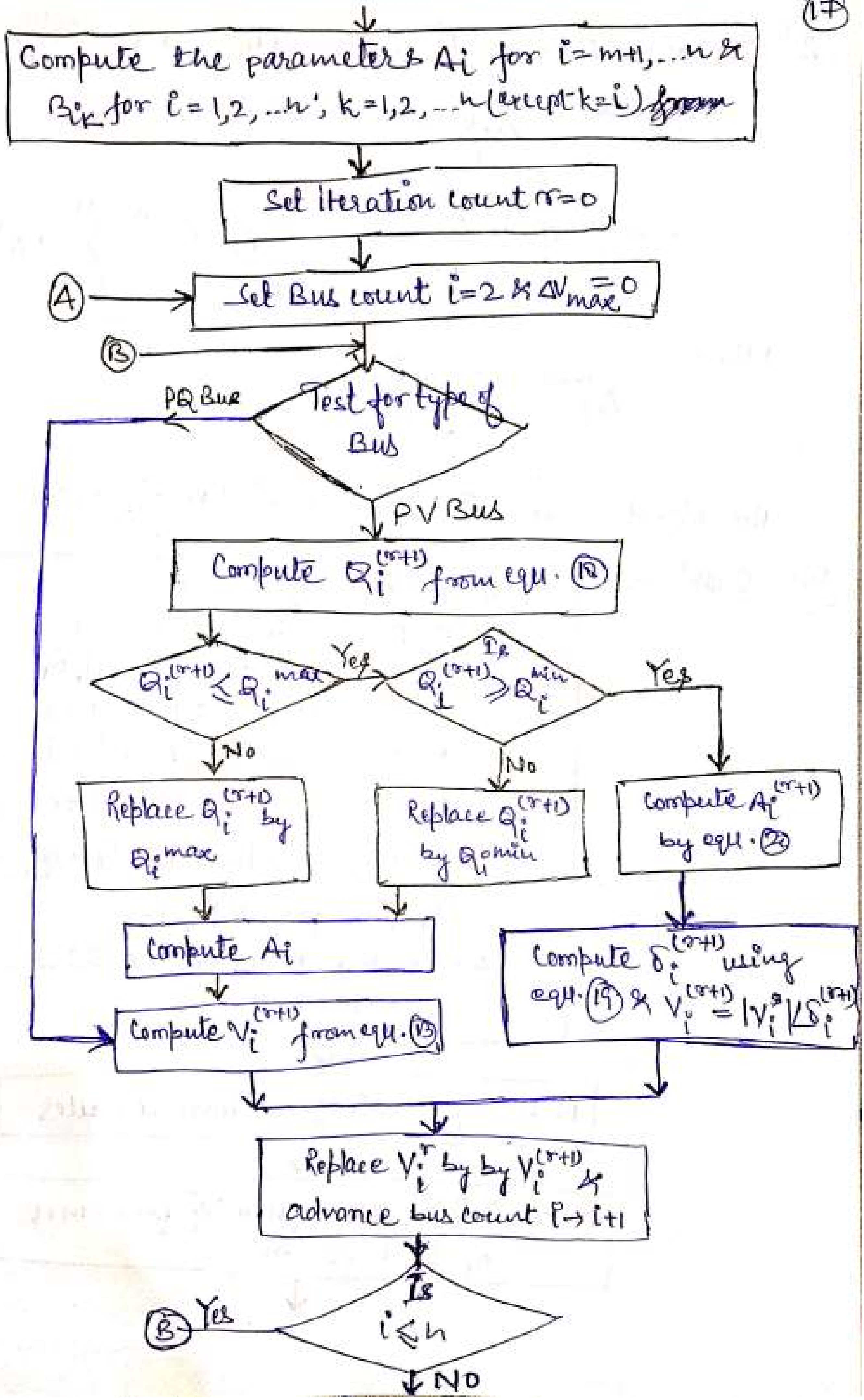
↓

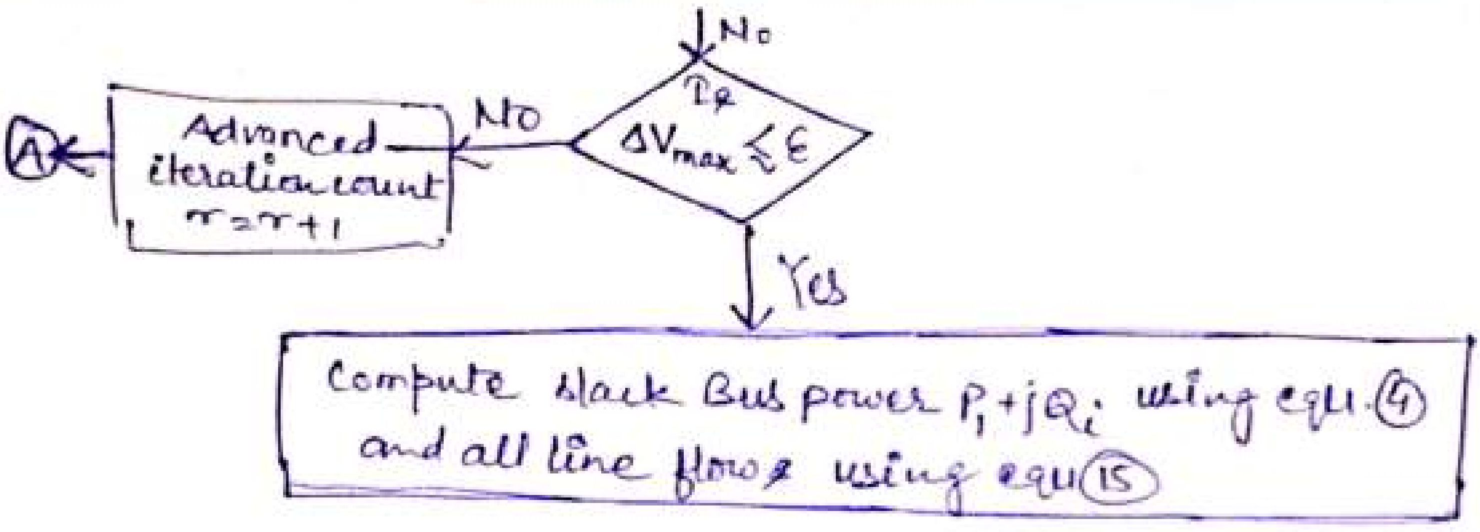
Form Y_{Bus} using relevant rules

↓

Make initial assumption V_i^0 for $i = m+1, \ldots n$ & δ_i^0 for $i = 2, \ldots m$

↓


Compute the parameters Ai for i=m+1,...n & Bik for i=1,2,...n; k=1,2,...n (except k=i) from
Set iteration count r=0
A
Set Bus count i=2 & ΔVmax=0
B
Test for type of Bus
PQ Bus
PV Bus
Compute Qi(r+1) from eqn. 18
Qi(r+1) ≤ Qimax
Yes
Is Qi(r+1) ≥ Qimin
Yes
No
No
Replace Qi(r+1) by Qimax
Replace Qi(r+1) by Qimin
Compute Ai(r+1) by eqn. 20
Compute Ai
Compute δi(r+1) using eqn. 19 & Vi(r+1) = |Vi|∠δi(r+1)
Compute Vi(r+1) from eqn. 13
Replace Vir by Vi(r+1) & advance bus count i→i+1
Is i≤n
Yes
B
NO



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