MODULE-5 DISTRIBUTION

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Problems - V.K. Mehta pg - 313 - 317 (Theory)

Reliability and Quality of Distribution System

The Part of Power System which distributes electric power for local use is known as distribution system.

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Distribution

I) Primary AC Distribution.
(i) Radial feeder -
(ii) Parallel feeder. Dec-14 Jun-14
(iii) Loop feeder -
(iv) Interconnected N/w system.

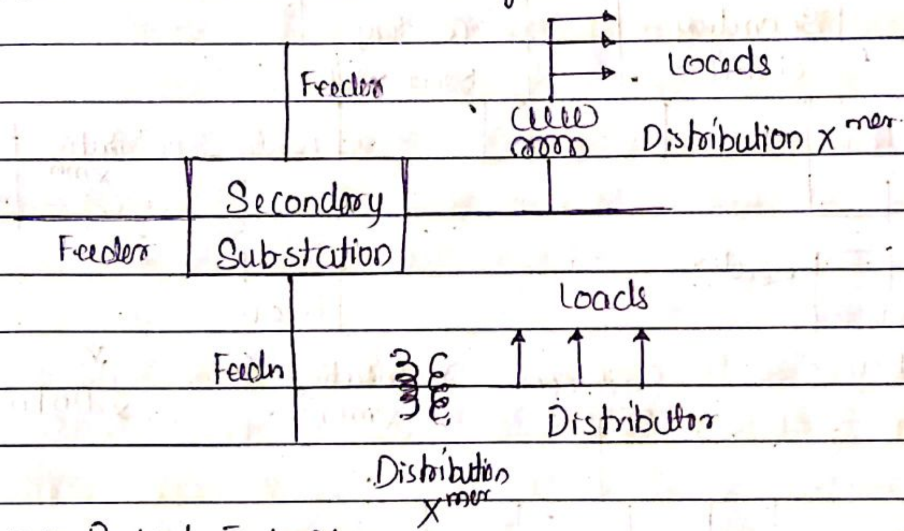

fig 5.1 Radial Feeder S/m

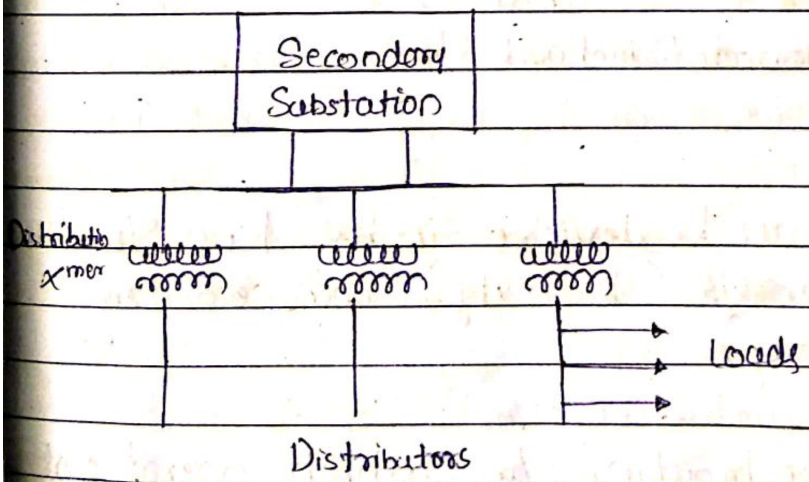

fig 5.2 Parallel Feeder S/m

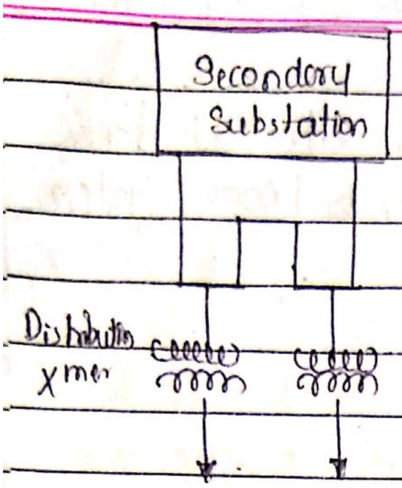

fig 5.3 Loop Feeder S/m

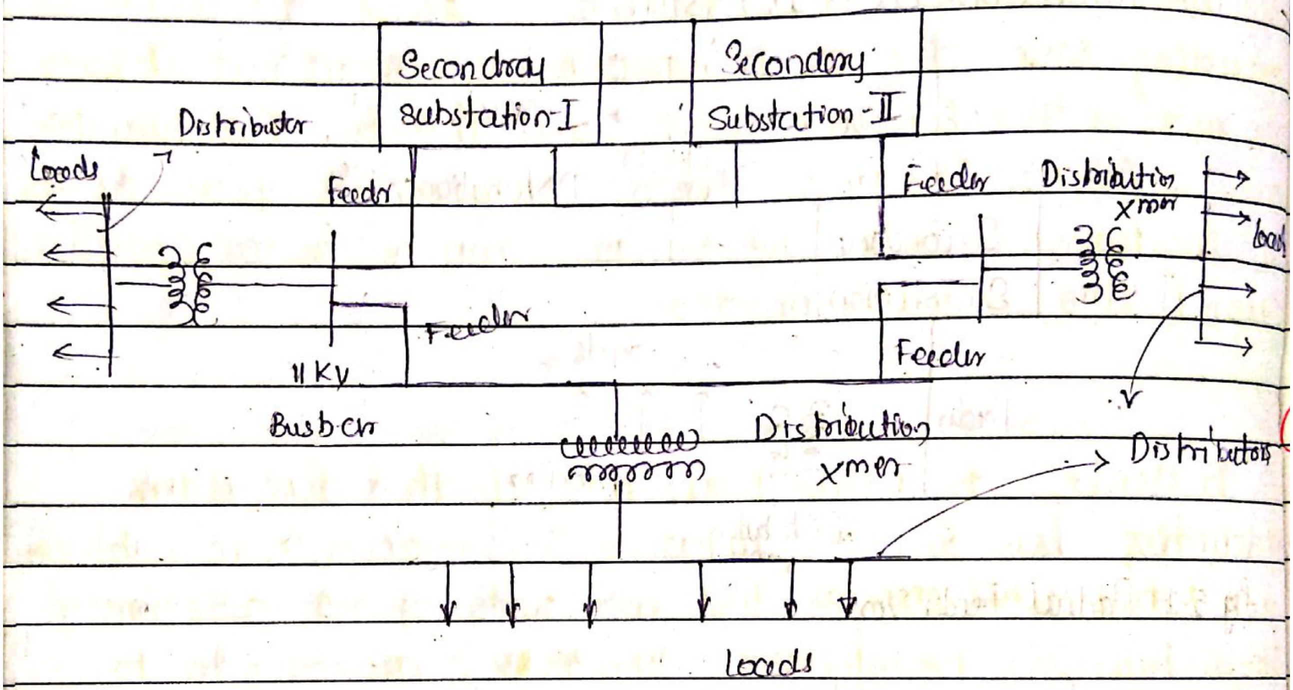

fig - 5.4 Interconnected Network S/m

Introduction

Distribution S/m may be devided in two S/m known as primary distribution S/m (High vtg) and secondary distribution S/m (Low vtg)

I) Primary A-C Distribution S/m

It is part of AC distribution S/m which operates at voltages such as (3.3 KV, 6.6 KV, 11 KV or higher even) some what higher than that of general utility (440 / 230 or 440 / 230) and handeled large blockes of power. The primary distribution is universly carried out by 3-phase, 3wire S/m

Electric power from Generating station is transmitted through extra high tension TLs vtgs 33KV to 440 KV to various substations near to the located cities at these 2° substation. The vtg is steped down to 11KV, 6.6KV or 33KV with help of power transformers for primary distribution

The 33/11KV 2° substations are usually located in the area having load requirement of the order 5MVA and normally a primary distribution line or a feeder is desined to carry a load of 1-2MVA so the no. of feeders originating from the 2° substation of 33/11KV is 3-4 MVA for the load exceeding MVA the 2° transmission is carried out at 66KV so as to reduce the line losses and therefore 2° substations are 66/11KV. The no. of feeders originating from the 66/11KV 2° substation is 6-8 the feeders may be radial, parellel, loop (ring) or interconnected

(1) Radial Feeders

It derives its name from the fact that the feeders radiating from the 2° substation and braches in to subfeeders and laterals which exceeds in to all parts of area subconnected. The distribution transformers (11KV/414 V) are connected to primary feeder, subfeeders and latrals, usually through fuse cutouts radical feeder is simplest and most economical & most commonly used one. It is advantageous for supply power to industrial load near the 2° SS, Isolated loads such as tube wells, and areas of low load density such as villages

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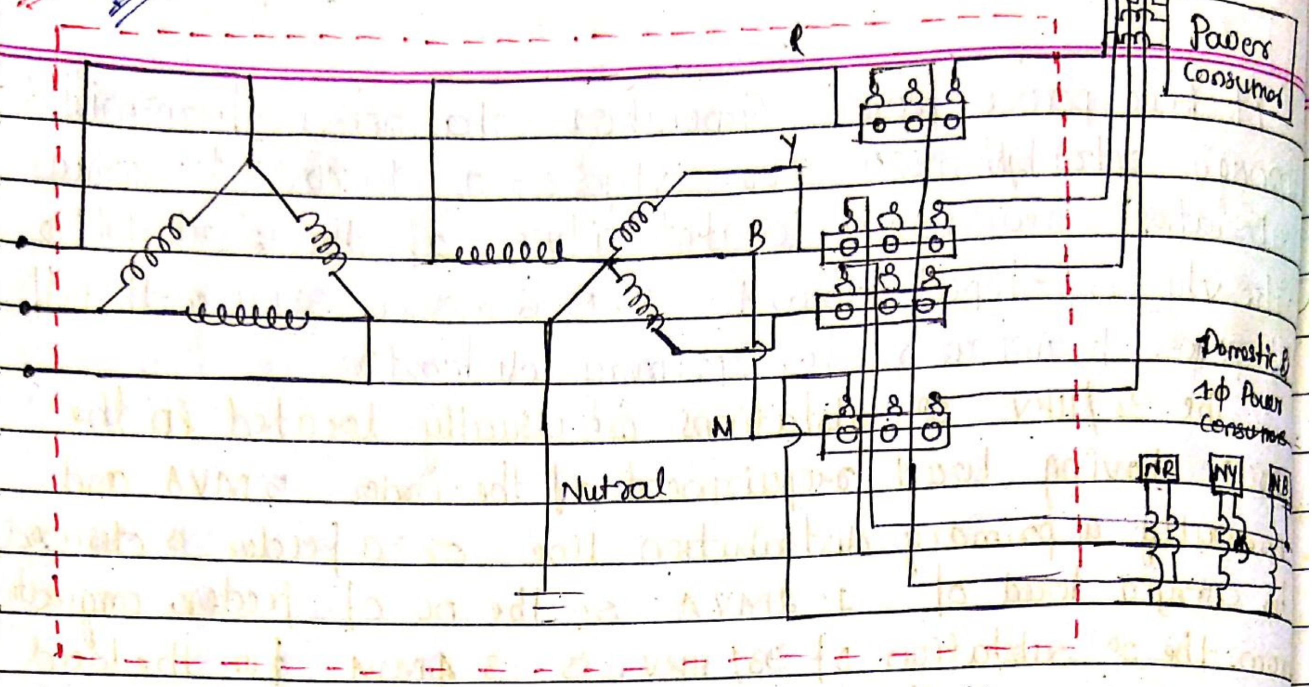

fig - 5.5 3-φ 4wire Distribution S/m

Consequenses of Disconnecting nutral In a 3φ 4wire S/m

AC Distribution Calculation

AC Distribution calculation differ from DC distribution in the following aspects

I) Incase of DC s/m the vtg drop is due to resistance alone. However in AC s/m the vtg drops are due to compined effect RLC

II) In DC s/m additions and substractions of c/n or voltages are done arithmatically but in case of AC s/m these operations are done vectorically

III) In AC ~~dc~~ S/m power factor has to be taken into account loads tapped off from the distributor are generally at different powerfactors

There are two ways of reffering power factor

a) It may be reffered to supply or recieving end vtg which is regarded as refference vector

b) It is reffered to the load point itself

There are several ways of solving AC distribution s/m However symbolic notation method has been found to be most convenient for this porpouse. In this method vtg, c/nts and impidences are expressed in complex notation & the calculations made exactly like in the DC distribution

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Methods of Solving AC Distribution Problems

In AC distribution calculation p.f of various load c/n^ts have to be considered since currents in diff sections of the distributor will be the vector sum of load currents and not arithmetic sum

The Pf of the load may be given

1) With respect recieving end or sending end vtg
2) wrt load vtg it self

Imp (case-I)

* Power factor reffered to recieving end vtg

Consider an AC distributor AB with concentrated loads of I_1 and I_2 tapped off at points C and B as shown in below fig - 5.6

Taking the recieving end voltage V_B as the refference vector, Let lagging p.f's at C and B be $\cos\phi_1$ and $\cos\phi_2$ wrt V_B

Let R_1, X_1 and R_2, X_2 be the resistance & reactance of sections 'AC' and 'CB' of the distributor

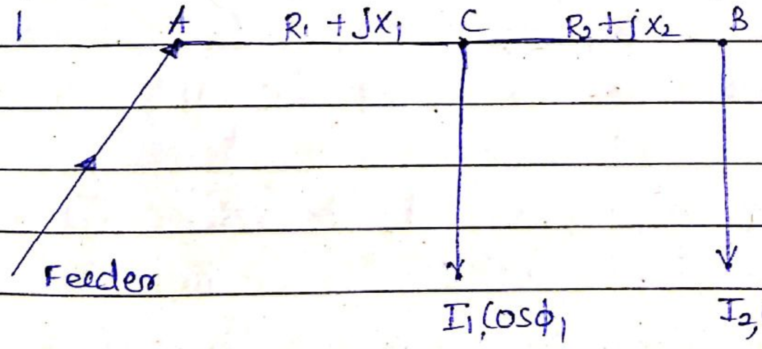

fig 5.6

Impidence of section AC is

$\vec{Z_{AC}} = R_1 + jX_1$ — (5.1)

Impidence of section CB is

$\vec{Z_{CB}} = R_2 + jX_2$ — (5.2)

Load Current at point C

$\vec{I_1} = I_1(\cos\phi_1 - j\sin\phi_1)$ — (5.3)

Load Current at point B

$$\vec{I_2} = I_2(\cos\phi_2 - j\sin\phi_2) \quad \text{——} (5.4)$$

Current in section CB

$$\vec{I_{CB}} = \vec{I_2} = I_2(\cos\phi_2 - j\sin\phi_2) \quad \text{——} (5.5)$$

Current in section AC

$$\vec{I_{AC}} = \vec{I_1} + \vec{I_2}$$

$$\therefore \vec{I_{AC}} = I_1(\cos\phi_1 - j\sin\phi_1) + I_2(\cos\phi_2 - j\sin\phi_2) \quad \text{——} (5.6) \quad \Big|\because 5.3, 5.4$$

Voltage drop in section CB

$$\vec{V_{CB}} = \vec{I_{CB}} \cdot \vec{Z_{CB}}$$

$$= I_2(\cos\phi_2 - j\sin\phi_2)(R_2 + jX_2) \quad \text{——} (5.7) \quad \Big|\because (5.5) \,\&\, (5.2)$$

Voltage drop in section AC

$$\vec{V_{AC}} = \vec{I_{AC}} \; \vec{Z_{AC}}$$

From eq^n 5.6 and 5.1

$$\therefore \vec{V_{AC}} = (\vec{I_1} + \vec{I_2})(R_1 + jX_1) \quad \text{——} (5.8)$$

$$= \left[I_1(\cos\phi_1 - j\sin\phi_1) + I_2(\cos\phi_2 - j\sin\phi_2)\right] \cdot (R_1 + jX_1) \quad \text{——} (5.9)$$

Sanisodeal voltage

$$\vec{V_A} = \vec{V_B} + \vec{V_{BC}} + \vec{V_{AC}} \quad \text{——} (5.10)$$

$$\vec{I_A} = \vec{I_1} + \vec{I_2}$$

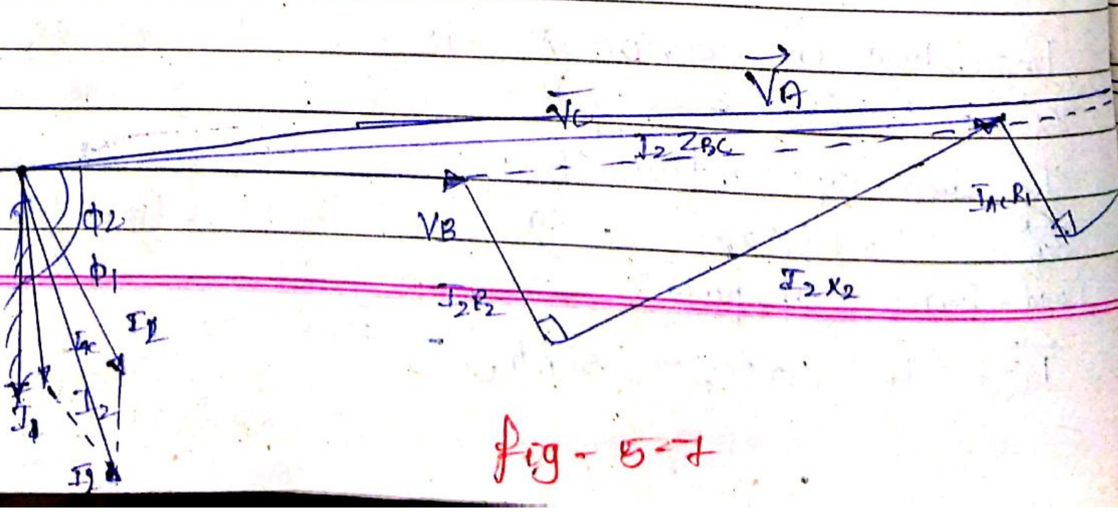

fig - 5-7

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(ii) Power fa

Suppose th

are reffered

phase angle

between V_b

shown in fig

Voltage d

$\vec{I_2} \, \vec{Z_{CB}}$

Voltage

$\vec{V_C} =$

$\vec{V_C} =$

Now $\vec{I_1}$

also I_1

$\vec{I_1}$

Now, $\vec{I_A}$

Voltage

$\vec{V_{AC}} =$

$I_{AC} X_1$

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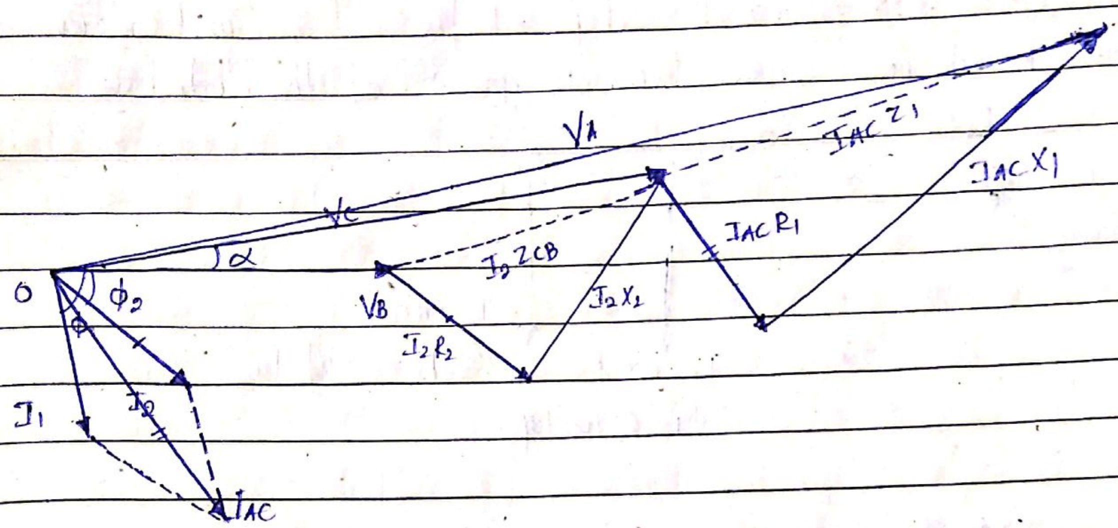
(ii) Power factors referred to respective load voltages

Suppose the power factor of loads in the previous fig-5.7 are reffered to their respective load voltages. ϕ_1 is the phase angle between V_C & I_1 and ϕ_2 is the phase angle between V_B & I_2. The vector diagram under these cond^ns are shown in fig-5.8



Voltage drop in section CB

$\vec{I_2}\,\vec{Z_{CB}} = I_2(\cos\phi_2 - j\sin\phi_2)(R_2 + jX_2)$

Voltage at point C

$\vec{V_C} = V_B +$ drop in the section CB

$\vec{V_C} = V_C \angle\alpha$ (say)

Now $\vec{I_1} = I_1 \angle -\phi_1$ with respect to voltage V_C

also $I_1 = I_1 \angle -(\phi_1 - \alpha)$ wrt voltage V_B

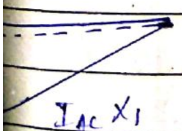
$\vec{I_1} = I_1(\cos(\phi_1 - \alpha) - j\sin(\phi_1 - \alpha))$

Now, $\vec{I_{AC}} = \vec{I_1} + \vec{I_2}$

Voltage drop in section AC

$\vec{V_{AC}} = \vec{I_{AC}} \cdot \vec{Z_{AC}}$

$\therefore$ Voltage at point A = V_A



i.e $\vec{V_A} = \vec{V_B} +$ drop in section CB + drop in section AC

VK - Pg - 359 (14.1)

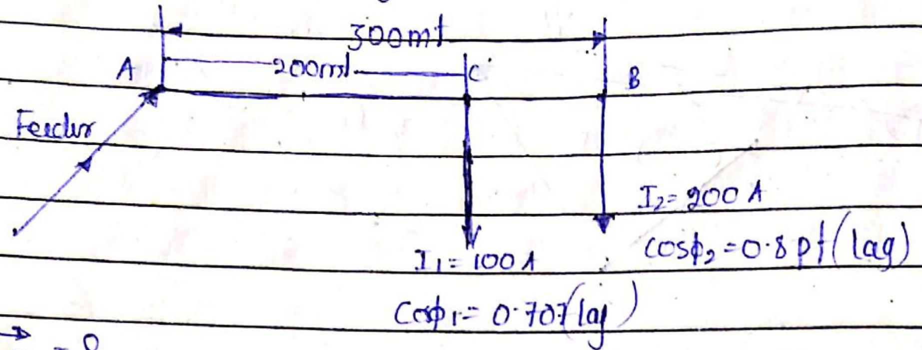
A 3ϕ AC distributor AB 300mt long is fed from end A and is loaded as under

I) 100 A at point 707 pf lagging . 200mt from point A

II) 200 A at 0.8 pf 300 mt from point A.

The load resistance & reactance of the distributor is 0.2 Ω and 0.1 Ω / km calculate the total vtg drop in the distributor. The load pfs reffered to the vtg at far end (wrt receiving end case I)

below Fig show single line diagram of the distributor



$\vec{V_{AB}} = ?$

$\vec{V_{AB}} = \vec{V_{AC}} + \vec{V_{BC}}$

$\vec{V_{AB}} = \vec{V_{BC}} + \vec{V_{AC}}$

$= \vec{I_{BC}}\vec{Z_{CB}} + \vec{I_{AC}}\,\vec{Z_{AC}}$

But $\vec{I_{AC}} = \vec{I_1} + \vec{I_2}$

Now $I_1 = I_1(\cos\phi_1 \mp j\sin\phi_1)$

$I_2 = I_2(\cos\phi_2 - j\sin\phi_2)$

also

$\vec{Z_{AC}} = (0.2 + j0.1) \times \frac{200}{1000} = (0.04 + j0.02)\,\Omega$

$\vec{Z_{CB}} = (0.2 + j0.1) \times \frac{100}{1000} = (0.02 + j0.01)\,\Omega$

Taking voltage at the far end V_B as the refference vector we have load c/n at point B

i.e $\vec{I_2} = I_2(\cos\phi_2 - j\sin\phi_2)$

$= 200(0.8 - j0.6)$

$= (160 - j120)$ A

$I_2 = 200 \angle -36.86$ A

Load c/n at point C

i.e $\vec{I_1} = I_1(\cos\phi_1 - j\sin\phi_1)$

$= 100(0.707 - j0.707)$

$\vec{I_1} = (70.7 - j70.7)$ A

$I_1 = 99.98 \angle -45$ A

$\vec{I_{CB}} = \vec{I_2} = (160 - j120)$ A $= 200 \angle -36.86$

Current in section AC

$\vec{I_{AC}} = \vec{I_1} + \vec{I_2}$

$= 200 \angle -36.86 + 99.98 \angle -45^\circ$

$\vec{I_{AC}} = 230.71 - j190.66$ A

$I_{AC} = 299.307 \angle 39.574$ A

Voltage drop at section CB

$\vec{V_{CB}} = \vec{I_{CB}} \cdot \vec{Z_{CB}}$

$= (200 \angle -36.86)(0.02 + j0.01)$.

$\vec{V_{CB}} = (4.47 - j0.799)$ V

$\vec{V_{CB}} = 4.47 \angle -10.3$

Voltage drop at section AC

$\vec{V_{AC}} = \vec{I_{AC}} \cdot \vec{Z_{AC}}$

$= 299 \angle -39.570 \times (0.04 + 0.02)$

$= 13.385 \angle -13.01$.

$\vec{V_{AB}} = \vec{V_{AC}} + \vec{V_{BC}}$

$= (13.385 \angle -13.01) + (4.47 \angle -10.3)$

$= 17.85 \angle -12.33$

$\boxed{V_{AB} = 17.85}$