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Roll No. 26

EXPERIMENT No.1

Computation of Inductance of Single Phase and Three phase Transmission Line

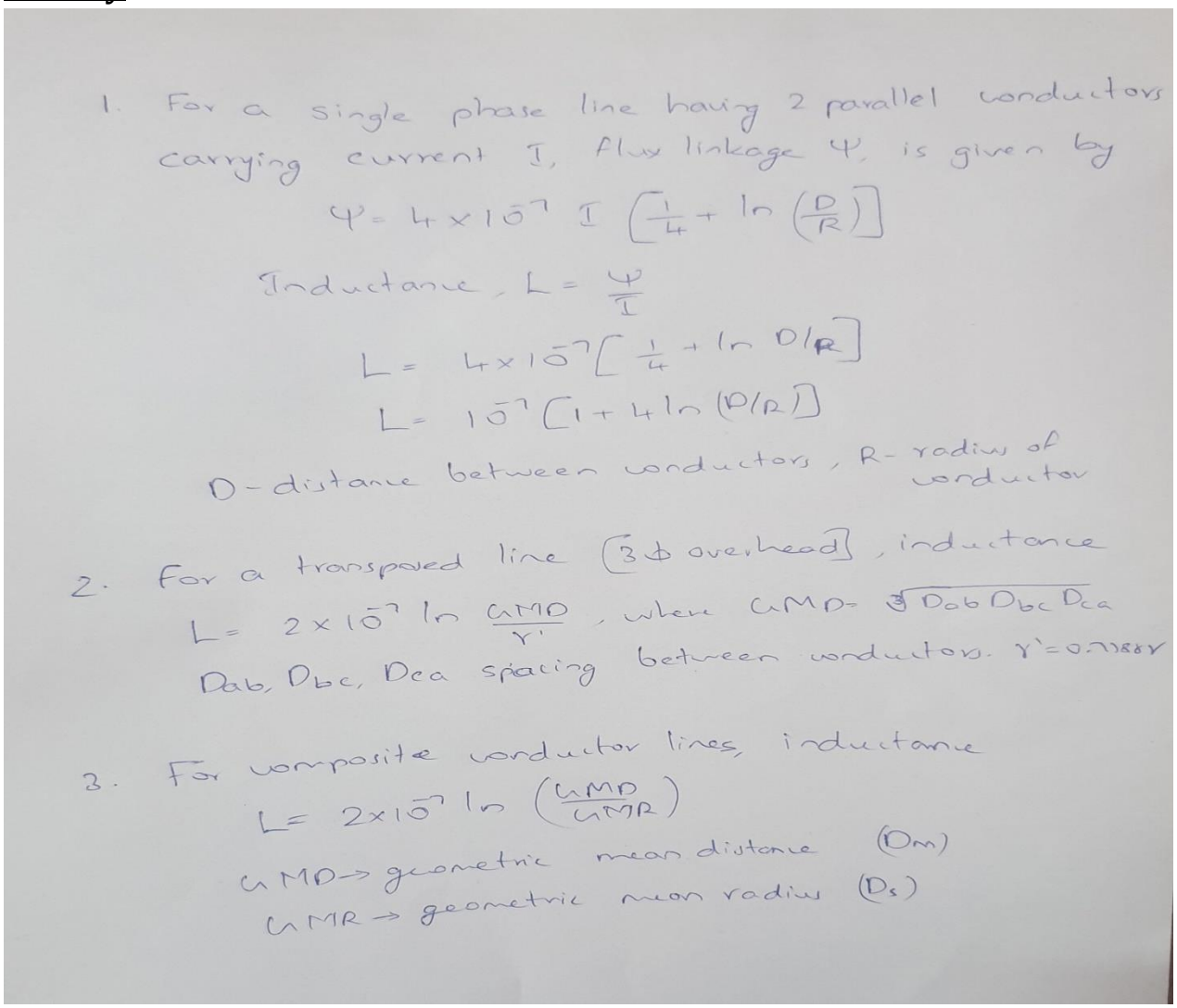
Aim

To compute the inductance of single phase and three phase transmission line.

Software Platform

Scilab

Theory



Program

Q1. Single phase line has two parallel conductors 2 metres apart. The diameter of each conductor is 1·2 cm. Calculate the loop inductance per km of the line.

Sol.

Spacing of conductors, d = 2 m = 200 cm

Radius of conductor, r = 1·2/2 = 0·6 cm

Loop inductance per metre length of the line

$= 10^{-7} (1 + 4 \log_e d/r)$ H

$= 10^{-7} (1 + 4 \log_e 200/0{\cdot}6)$ H

$= 24{\cdot}23 \cdot 10^{-7}$ H

Loop inductance per km of the line

$=24{\cdot}23 \cdot 10{-}7 \cdot 1000 = 24{\cdot}23 \cdot 10{-}4$ H = 2·423 mH

Sample Program

```
1  //Program to find the inductance of a single phase
   transmission line//
2  // Scilab Version 6.1.0; OS: Windows
3  clc ;
4  clear ;
5  d=input("Enter the spacing between conductors in metres:
   ")
6  dia=input("Enter the diameter of the conductors in
   metres:")
7  r= dia/2
8  li =10^(-7)*(1+4*(log(d/r)))*1000
9  disp("The Inductance per kilometre of given transmission
   line in H is: ",li)
```

Sample Output

```
Enter the spacing between conductors in metres: 2

Enter the diameter of the conductors in metres: 1.2e-3

  "The Inductance per kilometre of given transmission line in
H is: "
    0.0024237
```

Q2. Calculate the inductance of each conductor in a 3-phase, 3-wire system when the conductors are arranged in a horizontal plane with spacing such that D31 = 4 m ; D12 = D23 = 2m. The conductors are transposed and have a diameter of 2·5 cm.

Sol:

$$\text{Equivalent equilateral spacing, } D_{eq} = \sqrt[3]{D_{12} \times D_{23} \times D_{31}} = \sqrt[3]{2 \times 2 \times 4} = 2 \cdot 52 \text{ m} = 252 \text{ cm}$$

$$\text{Inductance/phase/m} = 10^{-7}(0{\cdot}5 + 2 \log_e D_{eq}/r) \text{ H}$$
$$= 10^{-7}(0{\cdot}5 + 2 \log_e 252/1{\cdot}25) \text{ H}$$
$$= 11{\cdot}1 \times 10^{-7} \text{H}$$
$$\text{Inductance/phase/km} = 11{\cdot}1 \times 10^{-7} \times 1000$$
$$= 1{\cdot}11 \times 10^{-3} \text{ H} = \mathbf{1{\cdot}11 \text{ mH}}$$

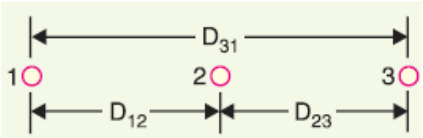


Fig. 9.13

Sample Program

```
1  //Program to find the inductance of a Three phase
   transmission line//
2  // Scilab Version 6.1.0; OS :Windows
3  clc ;
4  clear ;
5  d12=input("Enter the spacing between conductors 1 and 2
   in metres: ")
6  d23=input("Enter the spacing between conductors 2 and 3
   in metres: ")
7  d31=input("Enter the spacing between conductors 3 and 1
   in metres: ")
8  deq =(d12*d23*d31)^(1/3)
9  dia=input("Enter the diameter of the conductors in
   meter:")
10 r= dia/2
11 li =10^(-7)*(0.5+2*(log(deq/r)))*1000
12 disp("The Inductance per kilometre of given transmission
   line in H is: ",li)
```

Sample Output

```
Enter the spacing between conductors 1 and 2 in metres: 2

Enter the spacing between conductors 2 and 3 in metres: 2

Enter the spacing between conductors 3 and 1 in metres: 4

Enter the diameter of the conductors in meter: 2.5e-2

  "The Inductance per kilometre of given transmission line in
H is: "   0.0011112
```

Q3. Calculate the inductance per phase per metre for a three-phase double-circuit line whose phase conductors have a radius of 5·3 cm with the horizontal conductor arrangement as shown in Fig. 9.17

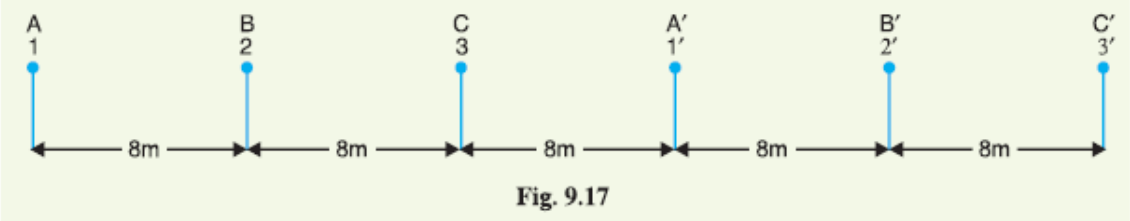


Fig. 9.17

Solution.

G.M.R. of conductor $= 0{\cdot}7788\,r = 0{\cdot}7788 \times 5{\cdot}3 \times 10^{-2} = 0{\cdot}0413$ m

Equivalent self-G.M.D. of one phase is

$$D_s = (D_{s1} \times D_{s2} \times D_{s3})^{1/3}$$

where $D_{s1} = (D_{AA} \times D_{AA'} \times D_{A'A'} \times D_{A'A})^{1/4} = (0{\cdot}0413 \times 24 \times 0{\cdot}0413 \times 24)^{1/4} = 0{\cdot}995$ m

$D_{s2} = (D_{BB} \times D_{BB'} \times D_{B'B'} \times D_{B'B})^{1/4} = (0{\cdot}0413 \times 24 \times 0{\cdot}0413 \times 24)^{1/4} = 0{\cdot}995$ m

Similarly $D_{s3} = 0{\cdot}995$ m

$\therefore$ $D_s = \sqrt[3]{0{\cdot}995 \times 0{\cdot}995 \times 0{\cdot}995} = 0{\cdot}995$ m

Equivalent mutual G.M.D. is

$$D_m = (D_{AB} \times D_{BC} \times D_{CA})^{1/3}$$

where $D_{AB} = (D_{AB} \times D_{AB'} \times D_{A'B} \times D_{A'B'})^{1/4} = (8 \times 32 \times 16 \times 8)^{1/4}$

$= 13{\cdot}45 = D_{BC}$

$D_{CA} = (D_{CA} \times D_{CA'} \times D_{C'A} \times D_{C'A'})^{1/4} = (16 \times 8 \times 40 \times 16)^{1/4}$

$= 16{\cdot}917$ m

$\therefore$ $D_m = (13{\cdot}45 \times 13{\cdot}45 \times 16{\cdot}917)^{1/3} = 14{\cdot}518$ m

Inductance/phase/m $= 10^{-7} \times 2 \log_e D_m/D_s$ H/m

$$= 10^{-7} \times 2 \log_e \frac{14{\cdot}518}{0{\cdot}995} \text{ H/m}$$

$$= \mathbf{5{\cdot}36 \times 10^{-7}\ H/m}$$

Sample Program

```
1. //Program to find the inductance per phase per metre for
   a 3 phase double circuit line
2. clc;
3. clear;
4. format('v',20)
5. r=input("Enter the radius of the conductors in cm: ")
6. GMR=0.7788*r*10^-2
7. dab=input("Enter the spacing of A and B in ms: ")
8. dbc=input("Enter the spacing of B and C in ms: ")
9. dca1=input("Enter the spacing of C and A'' in ms: ")
10. da1b1=input("Enter the spacing of A'' and B'' in ms: ")
11. db1c1=input("Enter the spacing of B'' and C'' in ms: ")
12. daa1=dab+dbc+dca1
13. dbb1=dbc+dca1+da1b1
14. dcc1=dca1+da1b1+db1c1
15. Ds1=(GMR^2*daa1^2)^(1/4)
```

```
Ds2=(GMR^2*dbb1^2)^(1/4)
Ds3=(GMR^2*dcc1^2)^(1/4)
Ds=(Ds1*Ds2*Ds3)^(1/3)
dab1=daa1+da1b1
dba1=dbc+dca1
dac=dab+dbc
dac1=dab1+db1c1
dc1a1=da1b1+db1c1
dbc1=dbb1+db1c1
dcb1=dcc1-db1c1
Dab=(dab*dab1*dba1*da1b1)^(1/4)
Dca=(dac*dca1*dac1*dc1a1)^(1/4)
Dbc=(dbc*dbc1*dcb1*db1c1)^(1/4)
Dm=(Dab*Dbc*Dca)^(1/3)
L=10^(-7)*2*(log(Dm/Ds))
disp("The inductance per phase per metre of given
  transmission line in H/m is:",L)
```

Sample Output

```
Enter the radius of the conductors in cm: 5.3

Enter the spacing of A and B in ms: 8

Enter the spacing of B and C in ms: 8

Enter the spacing of C and A' in ms: 8

Enter the spacing of A' and B' in ms: 8

Enter the spacing of B' and C' in ms: 8

"The inductance per phase per metre of given transmission line
in H/m is:" 0.00000053607295167
```

Q4. Fig. 9.15 shows the spacing of a double circuit 3-phase overhead line. The phase sequence is ABC and the line is completely transposed.The conductor radius in 1·3 cm. Find the inductance per phase per kilometre.

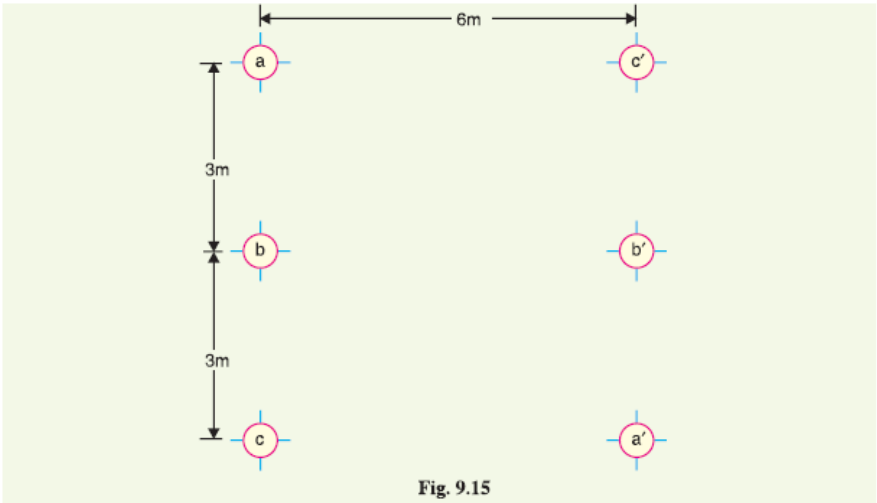


Fig. 9.15

Solution.

G.M.R. of conductor $= 1{\cdot}3 \times 0{\cdot}7788 = 1{\cdot}01$ cm

Distance a to b' $= \sqrt{6^2 + 3^2} = 6{\cdot}7$ m

Distance a to a' $= \sqrt{6^2 + 6^2} = 8{\cdot}48$ m

Equivalent self G.M.D. of one phase is

$$D_s = \sqrt[3]{D_{s1} \times D_{s2} \times D_{s3}}$$

where D_{s1}, D_{s2} and D_{s3} represent the self-G.M.D. in positions 1, 2 and 3 respectively. Also D_s is the same for all the phases.

$$\text{Now } D_{s1} = \sqrt[4]{D_{aa} \times D_{aa'} \times D_{a'a'} \times D_{a'a}}$$

$$= \sqrt[4]{(1{\cdot}01 \times 10^{-2}) \times (8{\cdot}48) \times (1{\cdot}01 \times 10^{-2}) \times (8{\cdot}48)}$$

$$= 0.292 \text{ m} = D_{s3}$$

$$D_{s2} = \sqrt[4]{D_{bb} \times D_{bb'} \times D_{b'b'} \times D_{b'b}}$$

$$= \sqrt[4]{\left(1{\cdot}01 \times 10^{-2}\right) \times (6) \times \left(1{\cdot}01 \times 10^{-2}\right) \times (6)} = 0{\cdot}246 \text{ m}$$

$$D_s = \sqrt[3]{0{\cdot}292 \times 0{\cdot}246 \times 0{\cdot}292} = 0{\cdot}275 \text{ m}$$

Equivalent mutual G.M.D., $D_m = \sqrt[3]{D_{AB} \times D_{BC} \times D_{CA}}$

where D_{AB}, D_{BC} and D_{CA} represent the mutual G.M.D. between phases A and B, B and C and C and A respectively.

Now $D_{AB} = \sqrt[4]{D_{ab} \times D_{ab'} \times D_{a'b} \times D_{a'b'}} = \sqrt[4]{3 \times 6{\cdot}7 \times 6{\cdot}7 \times 3}$

$= 4{\cdot}48 \text{ m} = D_{BC}$

$D_{CA} = \sqrt[4]{D_{ca} \times D_{ca'} \times D_{c'a} \times D_{c'a'}} = \sqrt[4]{6 \times 6 \times 6 \times 6} = 6 \text{ m}$

$\therefore \quad D_m = \sqrt[3]{4{\cdot}48 \times 4{\cdot}48 \times 6} = 4{\cdot}94 \text{ m}$

$\therefore$ Inductance per phase per metre length

$= 10^{-7} \times 2 \log_e D_m/D_s = 10^{-7} \times 2 \log_e 4{\cdot}94/0{\cdot}275$

$= 5{\cdot}7 \times 10^{-7}$ H

Inductance /phase/km $= 5{\cdot}7 \times 10^{-7} \times 1000 = 0{\cdot}57 \times 10^{-3}$ H $=$ **0·57 mH**

Sample Program

```
1. //Program to find the inductance per phase per metre for
   a 3 phase double circuit line
2. clc;
3. clear;
4. format('v',20)
5. r=input("Enter the radius of the conductors in cm: ")
6. GMR=0.7788*r*10^-2
7. dab=input("Enter the spacing of A and B in ms: ")
8. dbc=input("Enter the spacing of B and C in ms: ")
9. dac1=input("Enter the spacing of A and C'' in ms: ")
10. dbb1=input("Enter the spacing of B and B'' in ms: ")
11. dca1=input("Enter the spacing of C and A'' in ms: ")
12. da1b1=input("Enter the spacing of A'' and B'' in ms: ")
13. db1c1=input("Enter the spacing of B'' and C'' in ms: ")
14. daa1=(dac1^2+(dab+dbc)^2)^1/2
15. dab1=(dab^2+dac1^2)^1/2
16. dcc1=daa1
17. dba1=dab1
18. dbc1=dab1
19. dcb1=dab1
20. dac=dab+dbc
21. dc1a1=dac
22. Ds1=(GMR^2*daa1^2)^(1/4)
23. Ds2=(GMR^2*dbb1^2)^(1/4)
24. Ds3=(GMR^2*dcc1^2)^(1/4)
25. Ds=(Ds1*Ds2*Ds3)^(1/3)
26. Dab=(dab*dab1*dba1*da1b1)^(1/4)
27. Dca=(dac*dca1*dac1*dc1a1)^(1/4)
28. Dbc=(dbc*dbc1*dcb1*db1c1)^(1/4)
29. Dm=(Dab*Dbc*Dca)^(1/3)
30. L=10^(-7)*2*(log(Dm/Ds))*1000
31. disp("The inductance per phase per metre of given
   transmission line in H/Km is:",L)
```

Sample Output

```
Enter the radius of the conductors in cm: 1.3

Enter the spacing of A and B in ms: 3

Enter the spacing of B and C in ms: 3

Enter the spacing of A and C' in ms: 6

Enter the spacing of B and B' in ms: 6

Enter the spacing of C and A' in ms: 6

Enter the spacing of A' and B' in ms: 3
```

```
Enter the spacing of B' and C' in ms: 3
"The inductance per phase per metre of given transmission line
in H/Km is:"   0.00056091325230290
```

Result

The inductance of the given single phase and three phase transmission lines were calculated through Scilab and the results were compared with manual calculations.