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Roll No. 26

# EXPERIMENT No.2

# Computation of Capacitance of Single Phase and Three phase Transmission Line

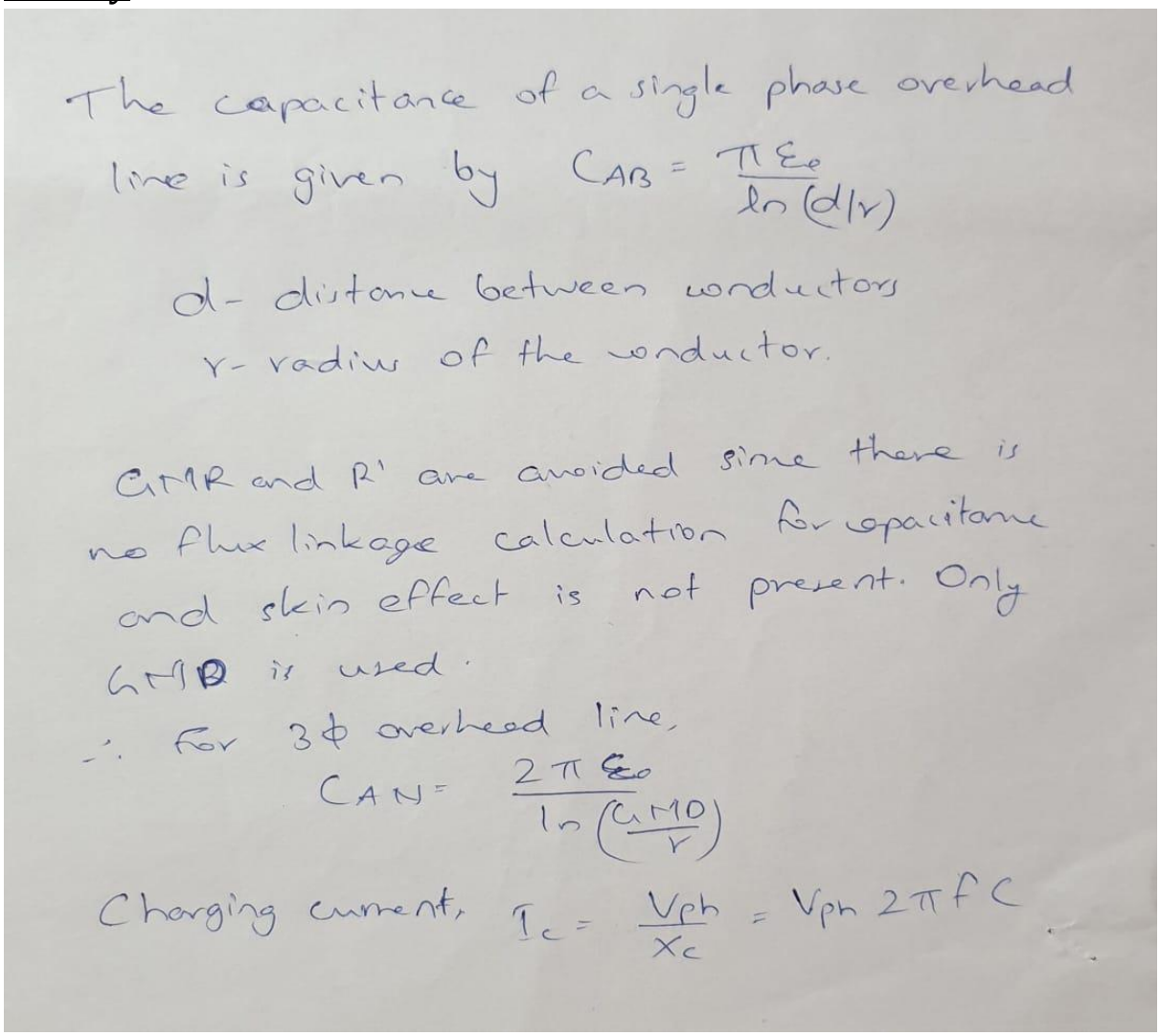
## Aim

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

## Software Platform

Scilab

## Theory



## Program

Q1. Single phase line has two parallel conductors 3 metres apart. The diameter of each conductor is 2 cm. Calculate the capacitance per km of the line.

Sol.

Conductor radius, $r = 1$ cm

Spacing of conductors, $d = 3\text{ m} = 300$ cm

Capacitance of the line

$$= \frac{\pi \varepsilon_0}{\log_e d/r}\text{ F/m} = \frac{\pi \times 8{\cdot}854 \times 10^{-12}}{\log_e 300/1}\text{ F/m}$$

$$= 0{\cdot}4875 \times 10^{-11}\text{ F/m} = 0{\cdot}4875 \times 10^{-8}\text{ F/km}$$

$$= 0{\cdot}4875 \times 10^{-2}\ \mu\text{F/km}$$

## Sample Program

```
1. //Program to find the capacitance of a single phase
   transmission line//
2. // Scilab Version 6.1.0; OS :Windows
3. clc ;
4. clear ;
5. dia=input('Enter the diameter of the conductor in
   meter:')
6. r=dia/2
7. d=input('Enter the spacing between the conductors in
   meter:')
8. c=((%pi*8.854*10^(-12)*1000)/log(d/r))
9. disp('The capacitance of the line per kilometre in micro
   Farad is:',c)
```

## Sample Output

```
Enter the diameter of the conductor in meter:2e-2

Enter the spacing between the conductors in meter:3

  "The capacitance of the line per kilometre in micro Farad
is:"

   4.877D-09
```

Q2. A 3-phase, 50 Hz, 132 kV overhead line has conductors placed in a horizontal plane 4 m apart. Conductor diameter is 2 cm. Calculate the capacitance per phase per km assuming complete transposition.

**Solution.** Fig 9.27 shows the conditions of the problem. The diameter of each conductor is 2 cm so that conductor radius $r = 2/2 = 1\text{ cm} = 1\times 10^{-2}\text{ m}$.

Fig. 9.27

Now $d_1 = AB = 4\text{m};\ d_2 = BC = 4\text{ m};\ d_3 = AC = 8\text{ m}$

$$\therefore \quad D_{eq} = \sqrt[3]{d_1 \times d_2 \times d_3} = \sqrt[3]{4\times 4\times 8} = 5{\cdot}04\text{ m}$$

Capacitance of each conductor to neutral

$$= \frac{2\pi\varepsilon_0}{\log_e D_{eq}/r}\text{ F/m} = \frac{2\pi\times 8{\cdot}85\times 10^{-12}}{\log_e 5{\cdot}04/1\times 10^{-2}}\text{ F/m}$$

$$= 0{\cdot}00885\times 10^{-6}\text{ F/km}$$

Capacitance/phase for 100 km line is

$$C_n = 0{\cdot}00885\times 10^{-6}\times 100 = 0{\cdot}885\times 10^{-6}\text{ F}$$

## Sample Program

```
1. //Program to find the capacitance of a three phase
   transmission line//
2. // Scilab Version 6.1.0; OS :Windows
3. clc ;
4. clear ;
5. d12=input('Enter the distance between the conductor 1 and
   2 meter:')
6. d23=input('Enter the distance between the conductor 2 and
   3 meter:')
7. d31=input('Enter the distance between the conductor 3 and
   1 meter:')
8. deq=(d12*d23*d31)^(1/3)
9. dia=input('Enter the diameter of the conductor in metre:')
10.r=dia /2
11.c=((2*%pi*8.854*10^(-12)*1000)/log(deq/r))
12.disp('The capacitance of the line per kilometre is:',c)
```

## Sample Output

```
Enter the distance between the conductor 1 and 2 meter:4

Enter the distance between the conductor 2 and 3 meter:4

Enter the distance between the conductor 3 and 1 meter:8

Enter the diameter of the conductor in metre:2e-2

  "The capacitance of the line per kilometre is:"

    8.940D-09
```

Q3. Calculate the capacitance of a 100 km long 3-phase, 50 Hz overhead transmission line consisting of 3 conductors, each of diameter 2 cm and spaced 2·5 m at the corners of an equilateral triangle.

**Solution.**

Equilateral spacing, $d = 2{\cdot}5 \text{ m} = 250 \text{ cm}$

Radius of conductor, $r = 2/2 = 1 \text{ cm}$

Capacitance of each conductor to netural

$$= \frac{2\pi\varepsilon_0}{\log_e d/r} \text{ F/m} = \frac{2\pi \times 8{\cdot}85 \times 10^{-12}}{\log_e 250/1} \text{ F/m}$$

$$= 10{\cdot}075 \times 10^{-12} \text{ F/m} = 10{\cdot}075 \times 10^{-9} \text{ F/km}$$

$\therefore$ Capacitance of 100 km line $= (10{\cdot}075 \times 10^{-9}) \times 100 = 1{\cdot}0075 \times 10^{-6} \text{ F} =$ **1·0075 μF/phase**

## Sample Program

```
1. //same code for all//
2. clc;
3. clear;

4. format("v",15)

5. function d=deq(a, b, c)
6. d=(a*b*c)^(1/3)
7. endfunction

8. function C=singleCap(d, r)
9. C=(%pi*8.85*10^(-12))/(log(d/r))
10. endfunction

11. function C=threeCap(d, r)
12. C=(2*%pi*8.85*10^(-12))/(log(d/r))
13. endfunction

14. function I=chargingI(v, f, c)
15. I=v*f*c*2*3.14/(3^(1/2))
16. endfunction

17. phase=input("Enter the number of phases of system(1 or
    3):")
18. dia=input("Enter diameter of the conductor in cm:")
19. r=(dia/2)*(10^-2)
20. fre=input("Enter the frequency(0 if not given): ")
21. volt=input("Enter the voltage(0 if not given): ")
22. unit=input("Enter the unit in KM(1 if perkm):")
23. lunit=unit*1000
24. if(phase==1) then
25. a=input("Enter distance between conductors in m:");
26. C=singleCap(a,r)*lunit;
```

```
27. else if (phase==3) then
28. a=input("Enter distance between conductors A and B in
    m:");
29. b=input("Enter distance between conductors B and C in
    m:");
30. c=input("Enter distance between conductors C and A in
    m:")';
31. C=threeCap(deq(a,b,c),r)*lunit;
32. end
33. end

34. i=chargingI(volt,fre,C)
35. disp("Capacitance of line per "+string(unit)+"km =
    "+string(C));
36. disp("Charging current = "+string(i));
```

## Sample Output

```
Enter the number of phases of system(1 or 3):3

Enter diameter of the conductor in cm:2

Enter the frequency(0 if not given): 50

Enter the voltage(0 if not given): 0

Enter the unit in KM(1 if perkm):100

Enter distance between conductors A and B in m:2.5

Enter distance between conductors B and C in m:2.5

Enter distance between conductors C and A in m:2.5

  "Capacitance of line per 100km = 0.000001007092"

  "Charging current = 0"
```

Q4. A 3-phase, 50 Hz, 66 kV overhead line conductors are placed in a horizontal plane as shown in Figure 9.26. The conductor diameter is 1·25 cm. If the line length is 100 km, calculate (i) capacitance per phase, (ii) charging current per phase, assuming complete transposition of the line.

**Solution.** Fig 9.26 shows the arrangement of conductors of the 3-phase line. The equivalent equilateral spacing is

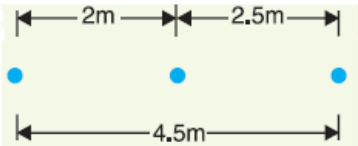


Fig. 9.26

$$d = \sqrt[3]{d_1 d_2 d_3} = \sqrt[3]{2 \times 2 \cdot 5 \times 4 \cdot 5} = 2 \cdot 82 \text{ m}$$

Conductor radius, $r = 1 \cdot 25/2 = 0 \cdot 625$ cm

Conductor spacing , $d = 2 \cdot 82$ m $= 282$ cm

(*i*) Line to neutral capacitance $= \dfrac{2\pi\varepsilon_0}{\log_e d/r}$ F/m $= \dfrac{2\pi \times 8 \cdot 854 \times 10^{-12}}{\log_e 282/0 \cdot 625}$ F/m

$= 0 \cdot 0091 \times 10^{-9}$ F/m $= 0 \cdot 0091 \times 10^{-6}$ F/km $= 0 \cdot 0091$ μF/km

$\therefore$ Line to neutral capacitance for 100 km line is

$$C = 0 \cdot 0091 \times 100 = \mathbf{0 \cdot 91\ \mu F}$$

(*ii*) Charging current per phase is

$$I_C = \frac{V_{ph}}{X_C} = \frac{66{,}000}{\sqrt{3}} \times 2\pi f C$$

$$= \frac{66{,}000}{\sqrt{3}} \times 2\pi \times 50 \times 0 \cdot 91 \times 10^{-6} = \mathbf{10 \cdot 9\ A}$$

## Sample Program

```
1. //same code for all//
2. clc;
3. clear;

4. format("v",15)

5. function d=deq(a, b, c)
6. d=(a*b*c)^(1/3)
7. endfunction

8. function C=singleCap(d, r)
9. C=(%pi*8.85*10^(-12))/(log(d/r))
10. endfunction

11. function C=threeCap(d, r)
12. C=(2*%pi*8.85*10^(-12))/(log(d/r))
13. endfunction

14. function I=chargingI(v, f, c)
15. I=v*f*c*2*3.14/(3^(1/2))
16. endfunction

17. phase=input("Enter the number of phases of system(1 or
    3):")
18. dia=input("Enter diameter of the conductor in cm:")
19. r=(dia/2)*(10^-2)
20. fre=input("Enter the frequency(0 if not given): ")
21. volt=input("Enter the voltage(0 if not given): ")
```

```
22. unit=input("Enter the unit in KM(1 if perkm):")
23. lunit=unit*1000
24. if(phase==1) then
25. a=input("Enter distance between conductors in m:");
26. C=singleCap(a,r)*lunit;
27. else if (phase==3) then
28. a=input("Enter distance between conductors A and B in
    m:");
29. b=input("Enter distance between conductors B and C in
    m:");
30. c=input("Enter distance between conductors C and A in
    m:")';
31. C=threeCap(deq(a,b,c),r)*lunit;
32. end
33. end

34. i=chargingI(volt,fre,C)
35. disp("Capacitance of line per "+string(unit)+"km =
    "+string(C));
36. disp("Charging current = "+string(i));
```

## Sample Output

```
Enter the number of phases of system(1 or 3):3

Enter diameter of the conductor in cm:1.25

Enter the frequency(0 if not given): 50

Enter the voltage(0 if not given): 66000

Enter the unit in KM(1 if perkm):100

Enter distance between conductors A and B in m:2

Enter distance between conductors B and C in m:2.5

Enter distance between conductors C and A in m:2+2.5

  "Capacitance of line per 100km = 0.000000909636"

  "Charging current = 10.88380692928"
```

## Result

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