The unit vectors for the Cylindrical coordinate system shown in Fig. 12.1b are: $\boldsymbol{a}_p$, $\boldsymbol{a}_\phi$, $\boldsymbol{a}_z$ where, $\boldsymbol{a}_p$, $\boldsymbol{a}_\phi$ and $\boldsymbol{a}_z$ are constant.

The unit vectors for the spherical coordinate system shown in Fig. 12.1c are: $\boldsymbol{a}_r$, $\boldsymbol{a}_\theta$, $\boldsymbol{a}_\phi$.

2. Electric Field Intensity

The electrostatic field intensity is defined as the force on Q when $Q = 1$ C. Thus

$$E = \frac{Q_1}{4\pi\varepsilon_0 R^2}\boldsymbol{a}_R \text{ V/m}$$

and $$F = QE \text{ newton}$$

3. Coulomb's Laws

The force (F) between two charges q_1 and q_2 is

(i) directly proportional to the product of the charges q_1 and q_2;

(ii) inversely proportional to the square of distance d between them;

(iii) depends on the nature of medium surrounding the charges.

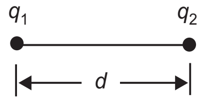

Fig. 12.2

Mathematically,

$$F \propto \frac{q_1 \cdot q_2}{d^2}$$

$$F = \frac{q_1 \cdot q_2}{4\pi\varepsilon_r\varepsilon_0 d^2}\boldsymbol{a}_R \text{ newton}$$

where ε_0 is the permittivity of air and its value is 8.854×10^{-12} F/m and ε_r is the relative permittivity of surrounding medium with respect to air and $\boldsymbol{a}_R$ the unit vector in the direction of line joining the two charges.

4. Electric Field of Many Charges

If there are several point charges q_1, q_2, q_3,..., q_n located at different points. The electric field intensity at point P is $\boldsymbol{E} = \dfrac{\boldsymbol{F}}{q}$

Under standard conditions, the value of $\delta = 1$

$$\therefore \text{ Critical disruptive voltage, } V_C = g_0 \delta r \log_e \frac{d}{r}$$

Correction must also made for the surface condition of conductor. This is accounted for by multiplying the above expression by irregularity factor m_0.

$$\therefore \text{ Critical disruptive voltage, } V_c = m_0 g_0 \delta r \log_e \frac{d}{r} \text{ kV/phase}$$

where, m_0 = 1 for polished conductors
= 0.98 to 0.92 for dirty conductors
= 0.87 to 0.8 for stranded conductors.

23. Visual Critical Voltage

It is the minimum phase-neutral voltage at which corona glow appears all along the line conductors.

It has been seen that in case of parallel conductors, the corona glow does not begin at the disruptive voltage V_C but at a higher voltage V_V, called *visual critical voltage*. The phase-neutral effective value of visual critical voltage is given by the following empirical formula:

$$V_V = m_v g_0 \delta r \left(1 + \frac{0.3}{\sqrt{\delta r}}\right) \log_e \frac{d}{r} \text{ kV/phase}$$

where m_v is another irregularity factor having a value of 1.0 for polished conductors and 0.72 to 0.82 for rough conductors.

24. Power Loss Due to Corona

Formation of corona is always accompanied by energy loss which is dissipated in the form of light, heat, sound and chemical action. When disruptive voltage is exceeded, the power loss due to corona is given by:

$$P = 244\left(\frac{f + 25}{\delta}\right)\sqrt{\frac{r}{d}}\,(V - V_c)^2 \times 10^{-5} \text{ kW/km/phase}$$

25. Caclulation of Sag

Consider a conductor suspended between two equilevel supports *A* and *B* in still air as shown in Fig. 17.5, where 0 is the lowest point on the conductor which is the middle of span.

Chapter 24

Communication Systems

1. Half-Power Bandwidth

The constancy of the magnitude $|H(j\omega)$ of a system is specified by a parameter called *bandwidth B*, and is defined as the interval of positive frequencies over which $|H(\omega)|$ remains within 3 dB (with $1/\sqrt{2}$ in voltage or $\frac{1}{2}$ in power).

Amplitude Modulation

The equation of a general sinusoidal (carrier) signal can be written as

$$y(t) = a(t) \cos [\omega_c t + \phi(t)]$$

where $a(t)$ and $\phi(t)$ vary slowly compared to $\omega_c t$. The team $a(t)$ is called the envelope of the signal, ω_c is the carrier frequency, and $\phi(t)$ is the phase modulation of $y(t)$.

The modulating signal $x(t)$ provides an amplitude modulated carrier signal as

$$x(t) = kx(t) \cos \omega_c t$$

where $x(t) = 0$ and k is a constant.

Phase and Frequency Modulation

The modulating signal $x(t)$ can be used to modulate the frequency or phase of the carrier signal as

$$y(t) = A \cos \theta(T)$$

where A is a constant.

Table B.1 Trigonometric, hyperbolic, logarithmic, and other relations (*Contd.*)

Hyperbolic relations

$$\coth x = \frac{\cosh x}{\sinh x} = \frac{1}{\tanh x}$$

$\sinh (x \pm jy) = \sinh x \cos y \pm j \cosh x \sin y$

$\cosh (x \pm jy) = \cosh x \cos y \pm j \sinh x \sin y$

$$\left.\begin{aligned}\cosh(jx) &= \frac{1}{2}\left(e^{+jx} + e^{-jx}\right) = \cos x \\ \sinh(jx) &= \frac{1}{2}\left(e^{+jx} - e^{-jx}\right) = j\sin x\end{aligned}\right\} \text{de Moivre's theorem}$$

$e^{\pm jx} = \cos x \pm j \sin x$

$$e^{\pm jx} = 1 \pm jx - \frac{x^2}{2!} \mp j\frac{x^3}{3!} + \frac{x^4}{4!} \pm j\frac{x^5}{5} - \ldots$$

$e^x = \cosh x + \sinh x$

$e^{-x} = \cosh x - \sinh x$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots$$

$\cosh x = \cos jx$

$j \sinh x = \sin jx$

$$\tanh(x \pm jy) = \frac{\sinh 2x}{\cosh 2x + \cos 2y} \pm j\frac{\sin 2y}{\cosh 2x + \cos 2y}$$

$$\coth(x \pm jy) = \frac{\sinh 2x}{\cosh 2x - \cos 2y} \pm j\frac{\sin 2y}{\cosh 2x - \cos 2y}$$

Logarithmic relations

$\log_{10} x = \log x$ — common logarithm

$\log_e x = \ln x$ — natural logarithm

$\log_{10} x = 0.4343 \log_e x = 0.4343 \ln x$

$\ln x = \log_e x = 2.3026 \log_{10} x$

$e = 2.71828$

$\text{dB} = 10 \log (\text{power ratio}) = 20 \log (\text{voltage ratio})$

$$1\ \text{Np}(\text{voltage attenuation}) = \frac{1}{e} = 0.368(\text{voltage}) = -8.68\ \text{dB}$$