Utilization of Electrical Energy 3340903

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Unit – 4
Electric Traction

UTILIZATION OF ELECTRICAL ENERGY

Topics

- Requirements of ideal Traction System
- Traction Mechanics: Types of Services, Speed Time Curve
- Supply system: DC System, Composite System, Single Phase ac system with low and normal frequency and 3 phase system

Requirement of Ideal Traction System

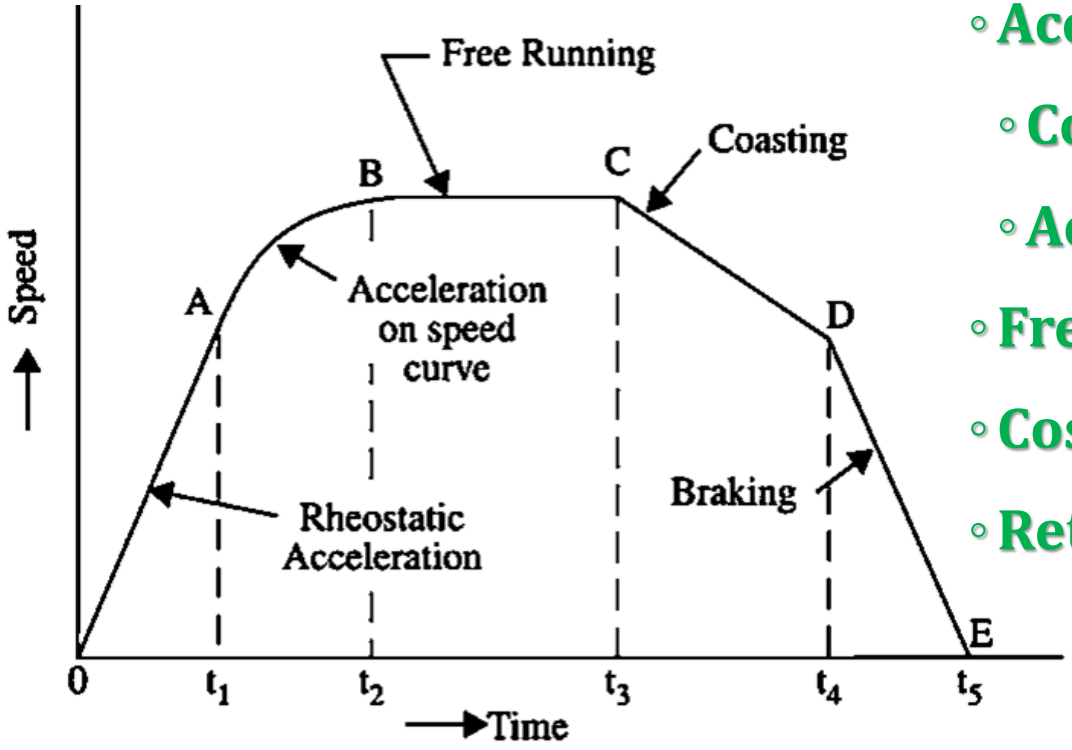
- High Starting Torque
- Self Contained
- Simple Speed Control
- Smooth Acceleration & Retardation
- High Overload Capacity
- Compact In Size
- Low Maintenance
- High Efficiency
- No Interference to Communication Lines
- Long Life
- Low Cost
- Pollution Free

Traction Mechanics

- Speed Time Curve
- Types of Services

Speed – Time Curve

- The curve drawn between Speed v/s Time, taking Speed (km/hr) on Y-axis and Time (second or Minute) on X-axis, is known as Speed-Time Curve.

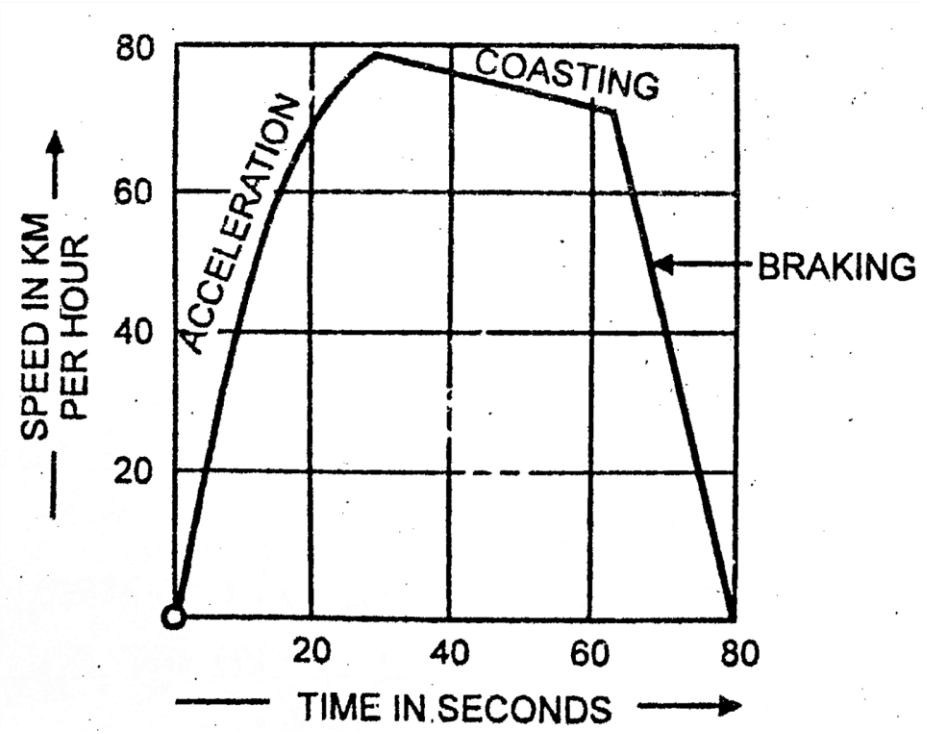


- Acceleration
  - Constant Acceleration
  - Acceleration on speed curve
- Free Running
- Costing
- Retardation(Braking)

Speed – Time Curve

- Typical Speed – Time Curves

Urban/City Service

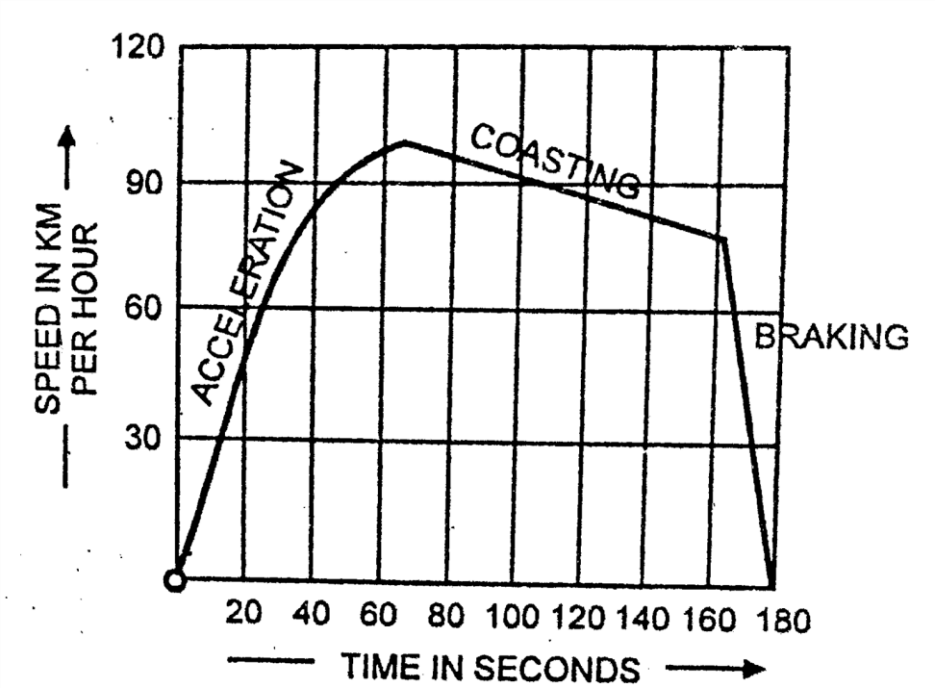


- **Distance between two stops:**
  Short (about 1km)
- **Acceleration:**
  1.5 – 4 km/h/sec
- **Retardation:**
  3 – 4 km/h/sec
- **Coasting Period:**
  Short
- **Free Running:**
  NA

Speed – Time Curve

- Typical Speed – Time Curves

Suburban Service

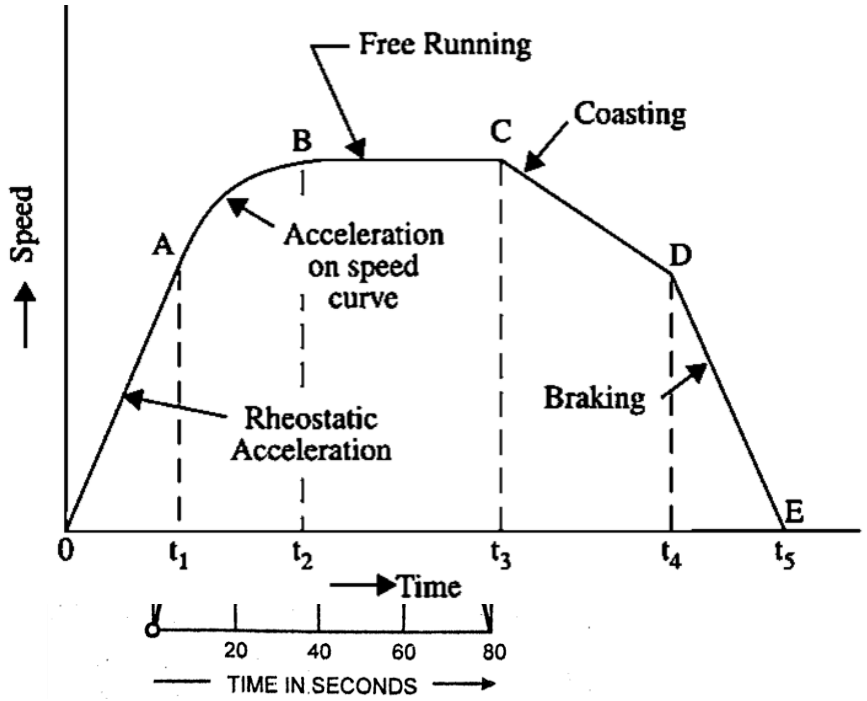


- **Distance between two stops:**
  1 – 8 km
- **Acceleration:**
  1.5 – 4 km/h/sec
- **Retardation:**
  3 – 4 km/h/sec
- **Coasting Period:**
  Comparatively long
- **Free Running:**
  NA

Speed – Time Curve

- Typical Speed – Time Curves

Main Line Service



- **Distance between two stops:**

  More than 10 km

- **Acceleration:**

  0.6 – 0.8 km/h/sec

- **Retardation:**

  1.5 km/h/sec

- **Coasting Period:**

- **Long**

- **Free Running:**

  Long

Terms related to Speed – Time Curve

- **Crest Speed:**

  The maximum speed attained by the vehicle during the run is known as Crest Speed.

- **Average Speed:**

$$\text{Average Speed} = \frac{\text{Distance between stops}}{\text{Actual time of run}}$$

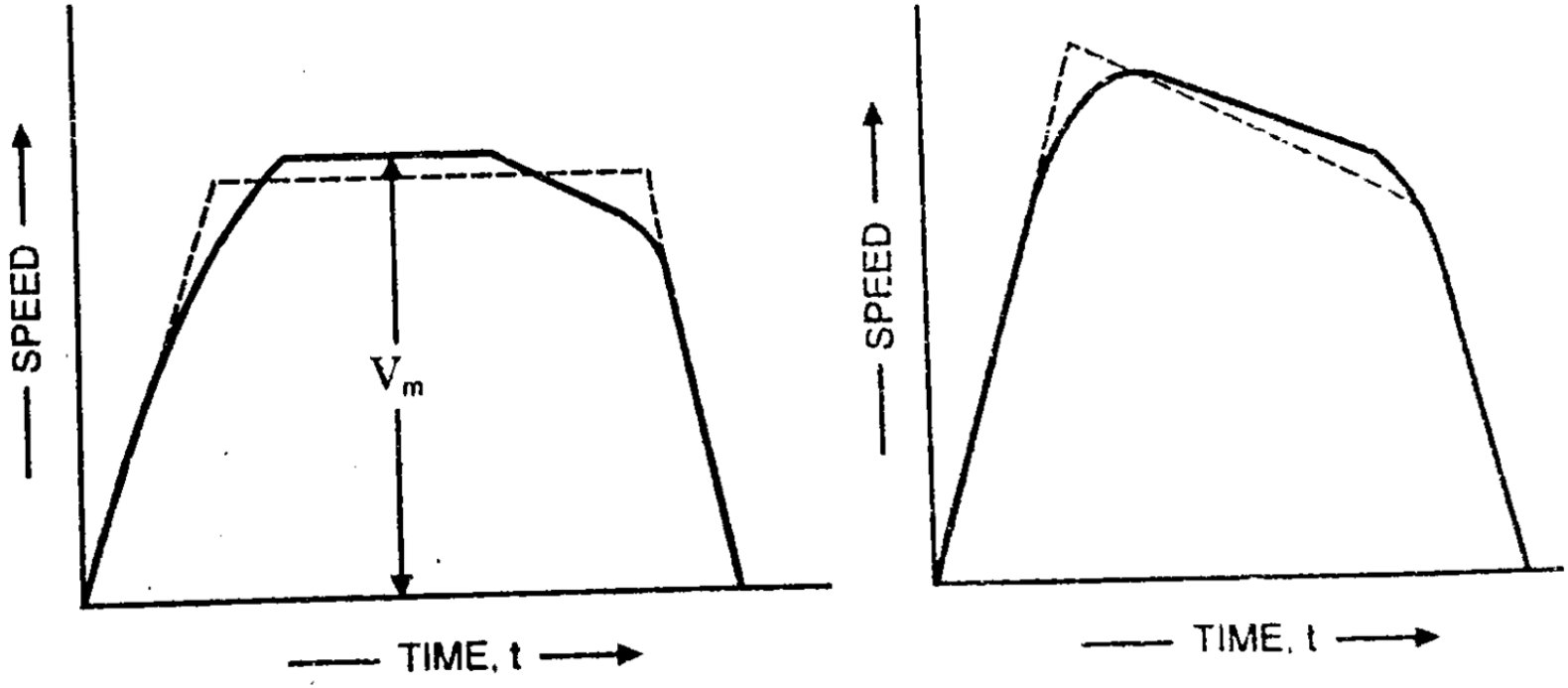
  The mean of the speeds from start to stop, the distance covered between two stops divided by the actual time of run is known as Average Speed.

- **Schedule Speed:**

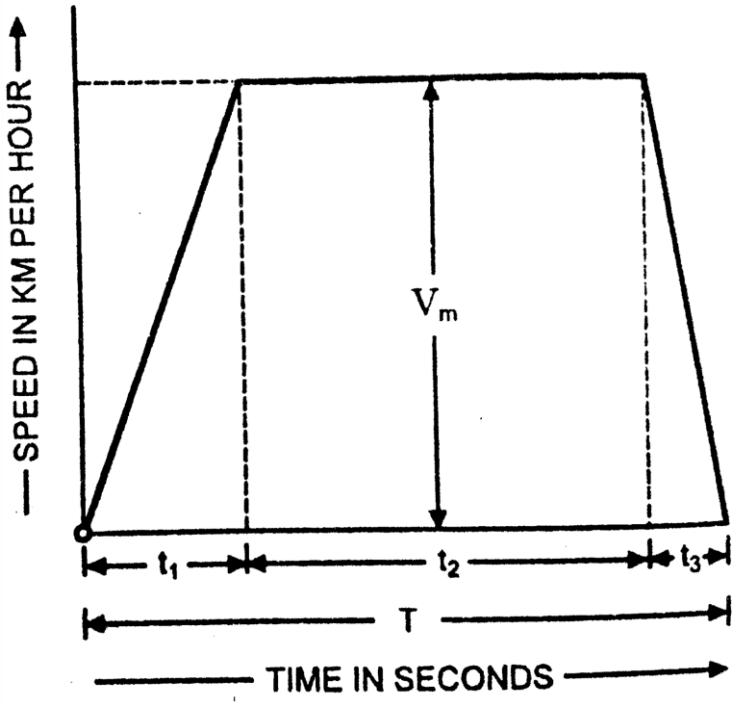
$$\text{Schedule Speed} = \frac{\text{Distance between stops}}{\text{Actual time of run} + \text{Stop time}}$$

  The ratio of distance covered between two stops divided by the actual time of run including time of stop is known as Schedule Speed.

Simplified Speed – Time Curve



Trapezoidal Speed – Time Curve



Let α = Acceleration in kmphps

β = Retardation in kmphps

V_m = Crest speed in kmph

T = Total time of run in seconds.

Time for acceleration in seconds, $t_1 = \frac{V_m}{\alpha}$

Time for retardation in seconds, $t_3 = \frac{V_m}{\beta}$

Trapezoidal Speed – Time Curve

Time for free running in seconds, $t_2 = T - (t_1 + t_3) = T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)$

Total distance of run in km, S = Distance travelled during acceleration + distance travelled during free run + distance travelled during braking

$$= \frac{1}{2} V_m \frac{t_1}{3,600} + V_m \frac{t_2}{3,600} + \frac{1}{2} V_m \frac{t_3}{3,600}$$

Substituting $t_1 = \frac{V_m}{\alpha}$, $t_3 = \frac{V_m}{\beta}$ and $t_2 = T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)$ we get

$$S = \frac{V_m^2}{7,200\alpha} + \frac{V_m}{3,600}\left[T - \left(\frac{V_m}{\alpha} + \frac{V_m}{\beta}\right)\right] + \frac{V_m^2}{7,200\beta}$$

$$\text{or } S = \frac{V_m^2}{7,200\alpha} + \frac{V_m}{3,600} T - \frac{V_m^2}{3,600\alpha} - \frac{V_m^2}{3,600\beta} + \frac{V_m^2}{7,200\beta}$$

$$= \frac{V_m T}{3,600} - \frac{V_m^2}{7,200\alpha} - \frac{V_m^2}{7,200\beta} \qquad \ldots(11.1)$$

Trapezoidal Speed – Time Curve

$$\text{or} \quad \frac{V_m^2}{3,600}\left(\frac{1}{2\alpha}+\frac{1}{2\beta}\right)-\frac{V_m T}{3,600}+S=0$$

$$\text{or} \quad V_m^2\left(\frac{1}{2\alpha}+\frac{1}{2\beta}\right)-V_m T+3,600S=0$$

This is a quadratic equation for V_m. Substituting $\frac{1}{2\alpha}+\frac{1}{2\beta}=K$, we get

$$KV_m^2 - V_m T + 3,600\,S = 0$$

$$\text{or} \quad V_m = \frac{T \pm \sqrt{T^2 - 4K \times 3,600\,S}}{2K} = \frac{T}{2K} \pm \sqrt{\frac{T^2}{4K^2} - \frac{3,600\,S}{K}}$$

The + ve sign cannot be adopted, as value of V_m obtained by using + ve sign will be much higher than that is possible in practice. Hence – ve sign will be used and, therefore, we have

$$V_m = \frac{T}{2K} - \sqrt{\frac{T^2}{4K^2} - \frac{3,600\,S}{K}} \qquad \ldots(11.2)$$

From the above equation unknown quantity can be determined by substituting the value of known quantities.

Different Traction System

Non Electric

- Direct Steam Engine Drive
- Direct IC Engine Drive

Electric

- Steam Electric Drive
- IC Engine Electric Drive
- Petrol Electric Traction
- Battery Electric Drive
- Electric Drive

Classification of Locomotives

Self Contained Locomotive

- Diesel
- Steam
- Battery
- Diesel Electric

Locomotive obtaining energy from external source

- DC
- AC
- Dual (AC&DC)

System of Track Electrification

DC System

- 600V – 750V Suburban (SS : 3 – 5 km)
- 1500V – 3000V Main Line Service (SS : 15 – 40 km)

Single Phase AC System

- 15kV – 25kV, 25Hz (SS : 50 – 80 km)

Three Phase AC System

- 3000V – 3600V, 25Hz

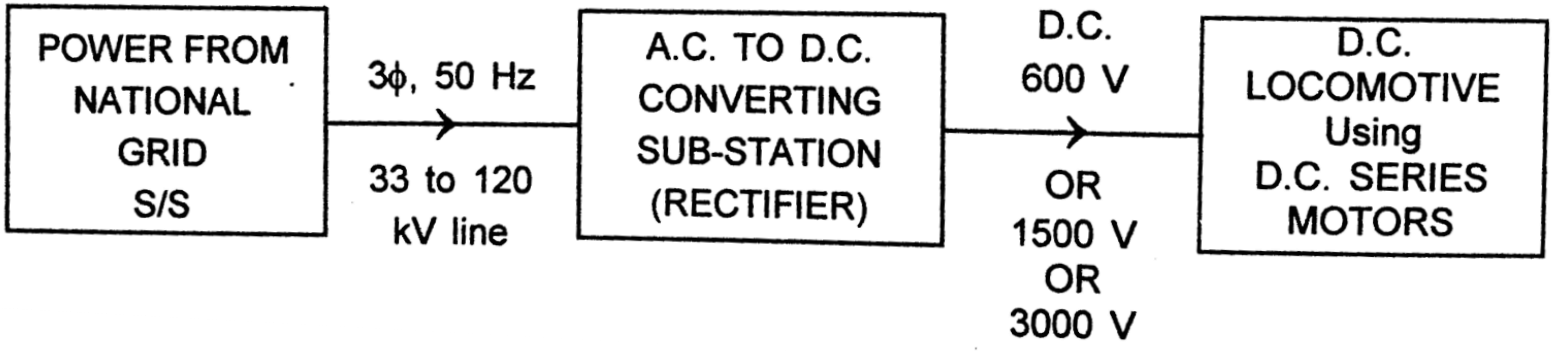
Composite System

- KANDO (1Φ - 3Φ) System
- 1Φ - DC System

System of Track Electrification

DC System

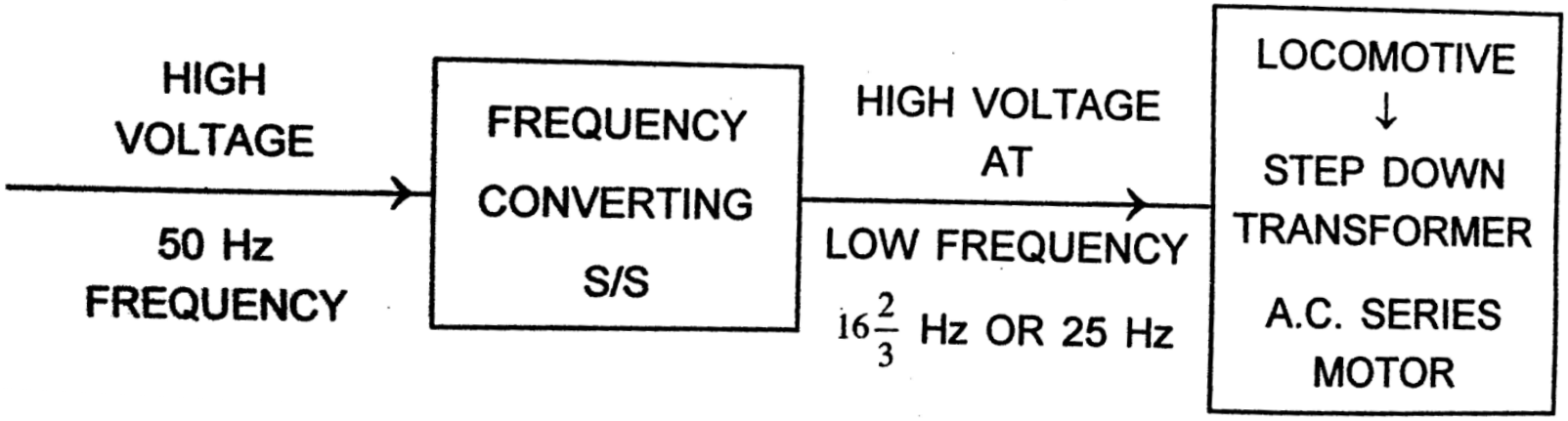
- 600V – 750V Suburban (SS : 3 – 5 km)
- 1500V – 3000V Main Line Service (SS : 15 – 40 km)



System of Track Electrification

Single Phase Low Frequency AC System

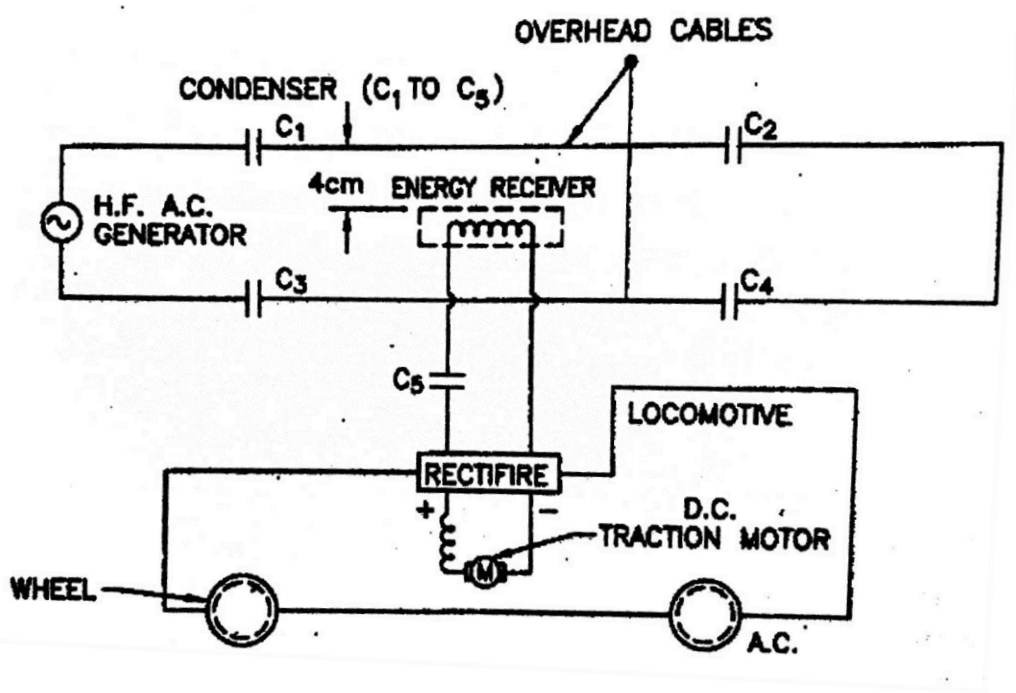
- **15kV – 25kV, 25Hz (SS : 50 – 80 km)**



System of Track Electrification

Single Phase High Frequency AC System

- Several Volt, 2.5kHz – 3kHz (Coal Mines)



System of Track Electrification

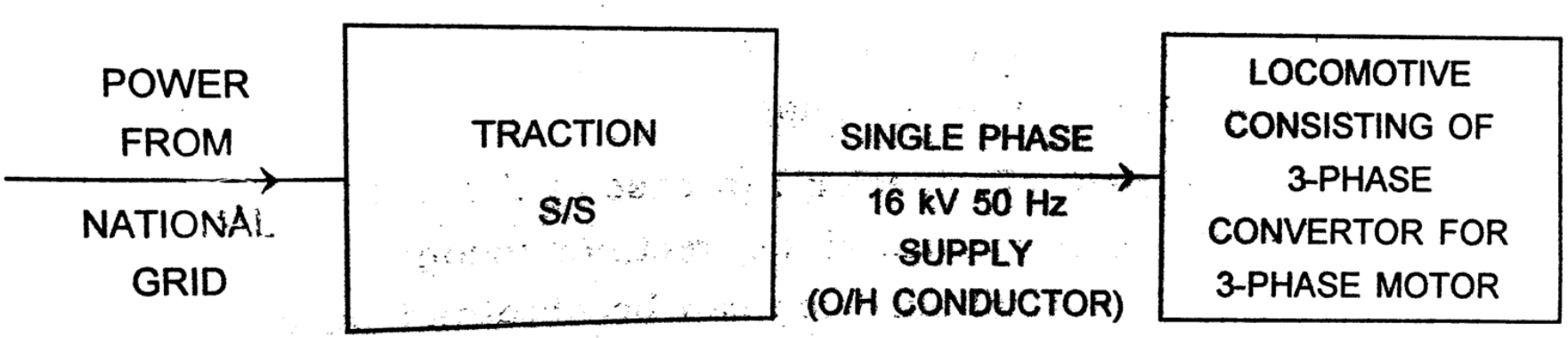
Three Phase AC System

- 3000V – 3600V, 25Hz

System of Track Electrification

Composite System

- KANDO (1Φ - 3Φ) System
- 1Φ - DC System



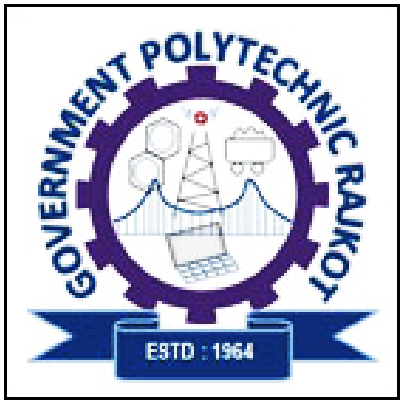
Reference

Utilization of Electrical Power &

Electric Traction – J B Gupta

Publication : S K Kataria & Sons

Thank You



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