

POWER SYSTEM ANALYSIS

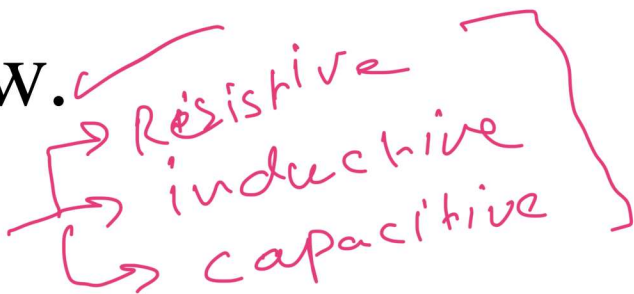
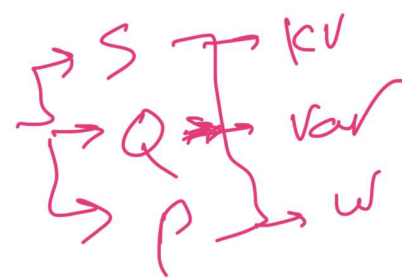
Lecture 1

REVIEW OF BASIC CONCEPTS



Dr. Emad Younis

Outline:

- Electrical power system overview.
- Types of loads in power system. 
- Analysis of voltage and current waveforms. 
- Types of power in power system. 
- Power factor correction.
- Numerical example on power factor correction.

ELECTRICAL POWER SYSTEM OVERVIEW



Electrical power system:

An electrical power system is a collection of equipment and devices. It consists of four major stages:

1. Generation →

القول

2. Transmission →

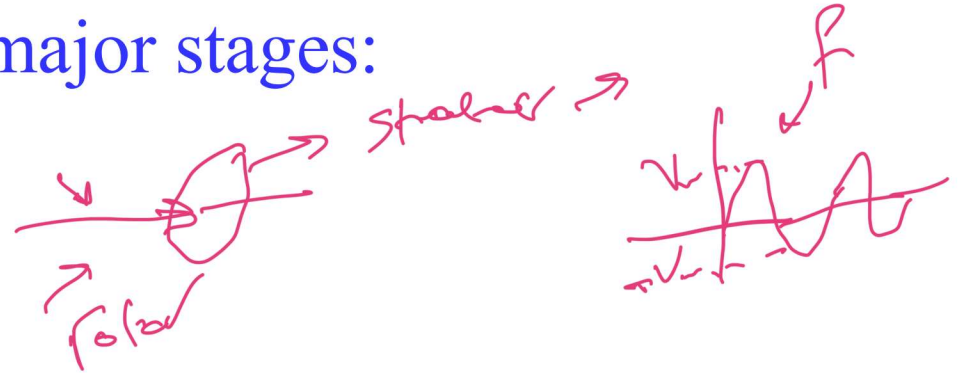
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3. Distribution →

التوزيع

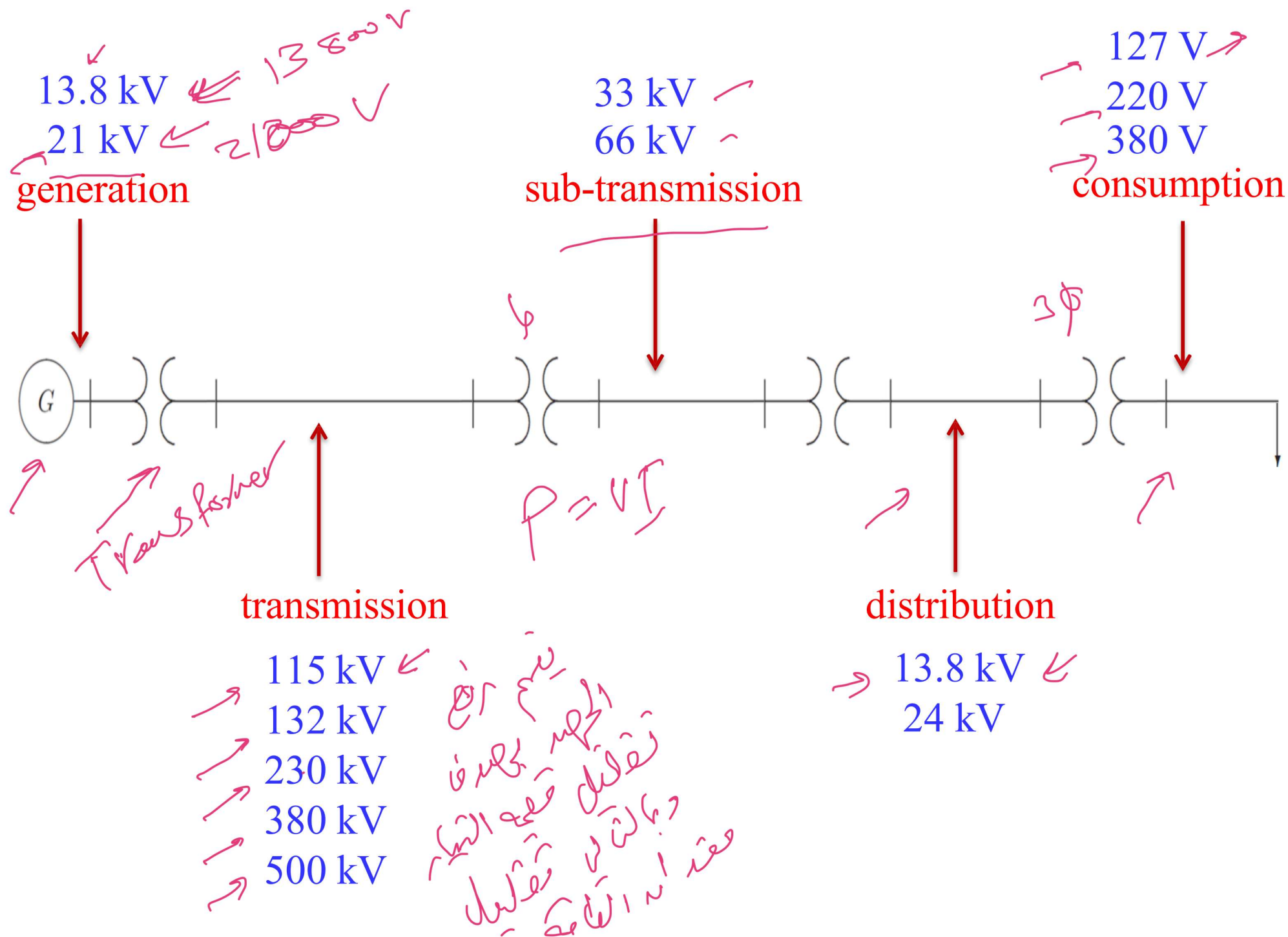
4. Consumption →

الاستهلاك



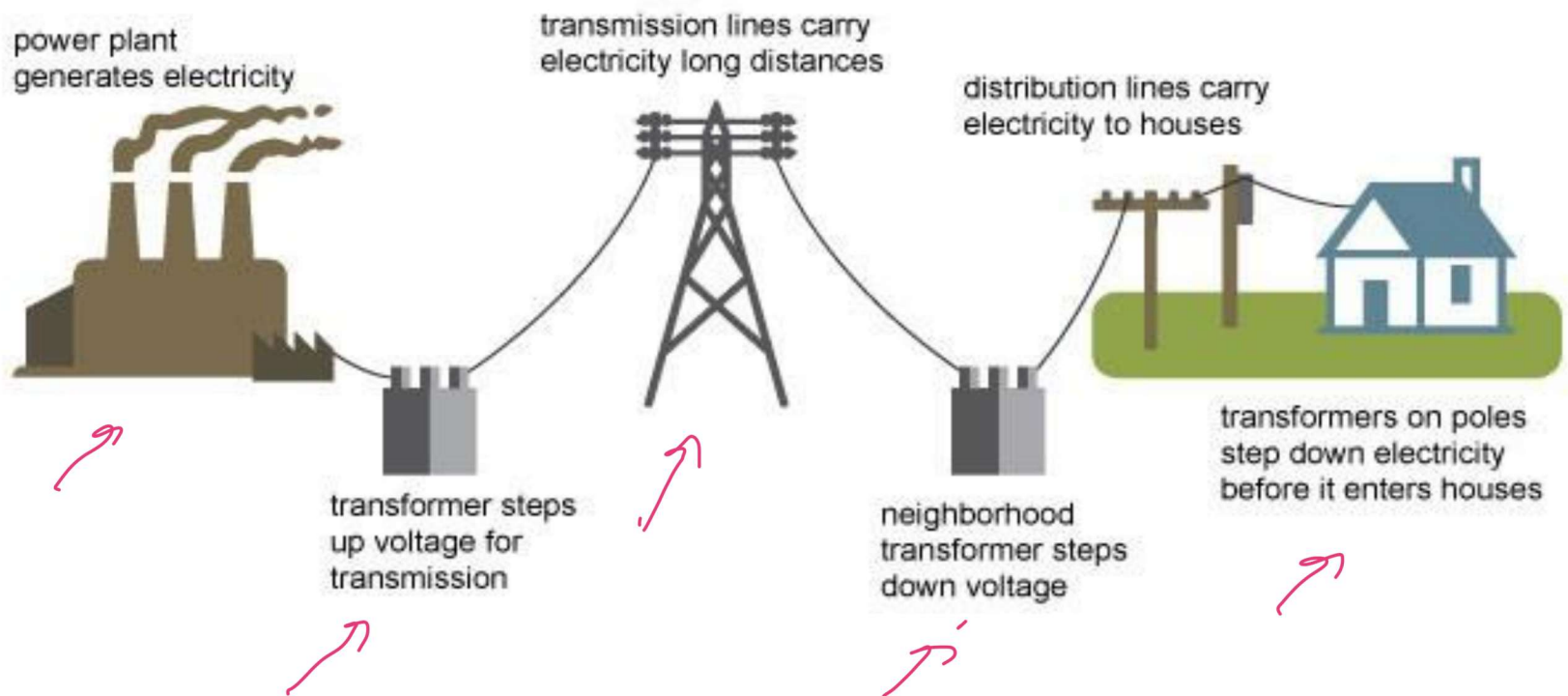
$$P = VI$$

$$P_{\text{loss}} = I^2 R$$



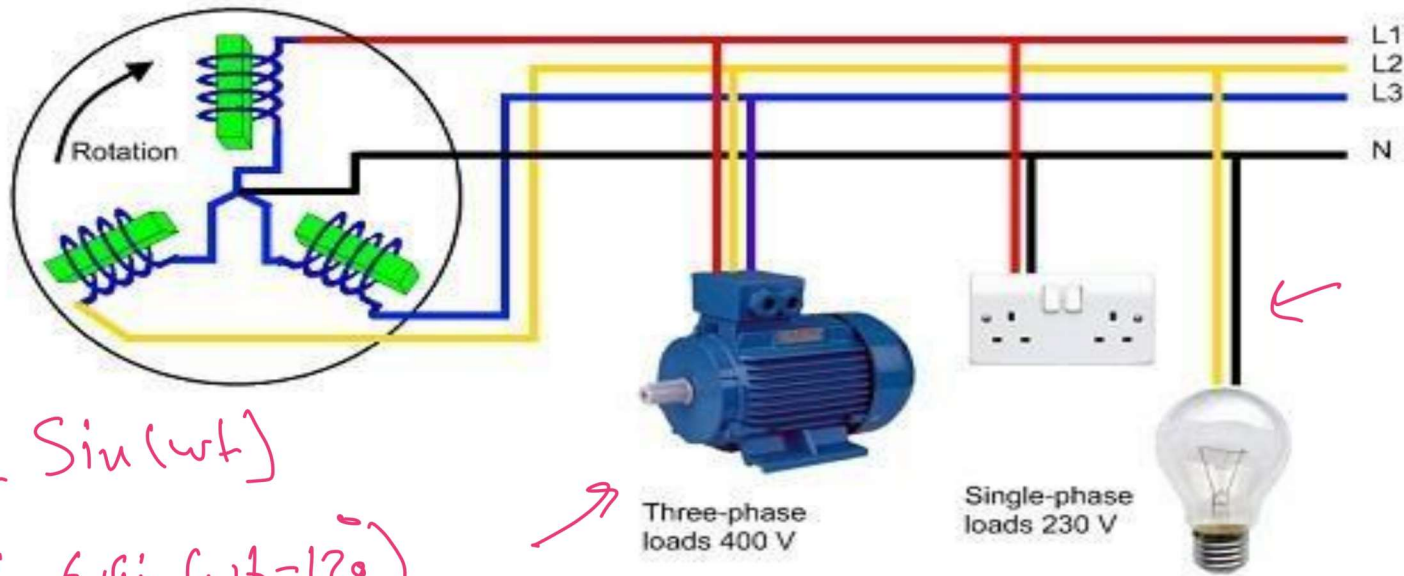
From generation to consumption:

Electricity generation, transmission, and distribution



Three phase system:

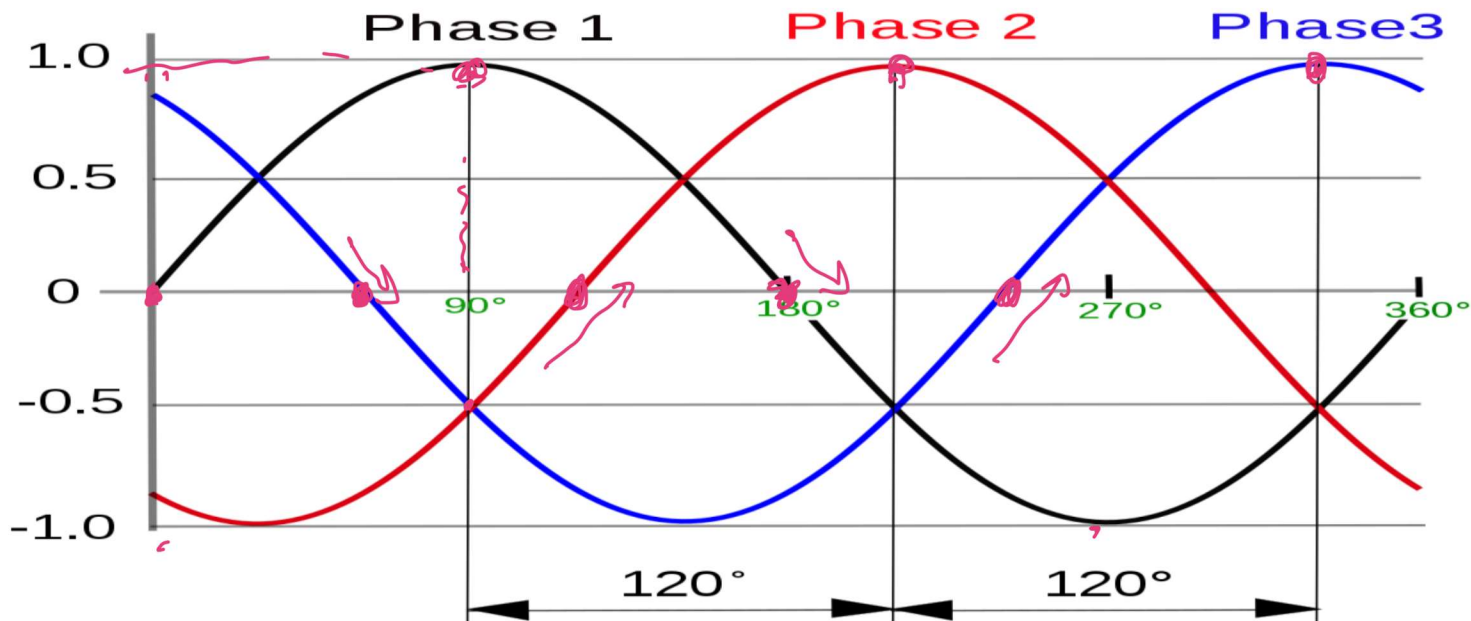


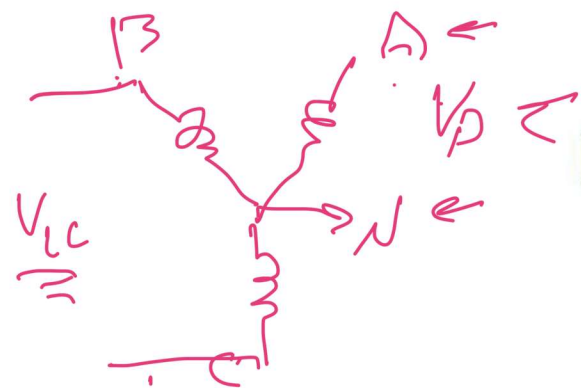


$$V_1 = V_m \sin(\omega t)$$

$$V_2 = V_m \sin(\omega t - 120^\circ)$$

$$V_3 = V_m \sin(\omega t - 240^\circ)$$

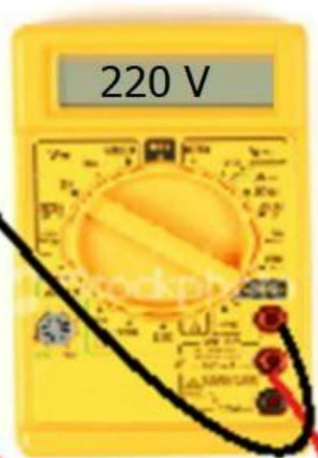




line to neutral voltage, V_{L-N}



$$V_{LL} = \sqrt{3} V_{LN}$$

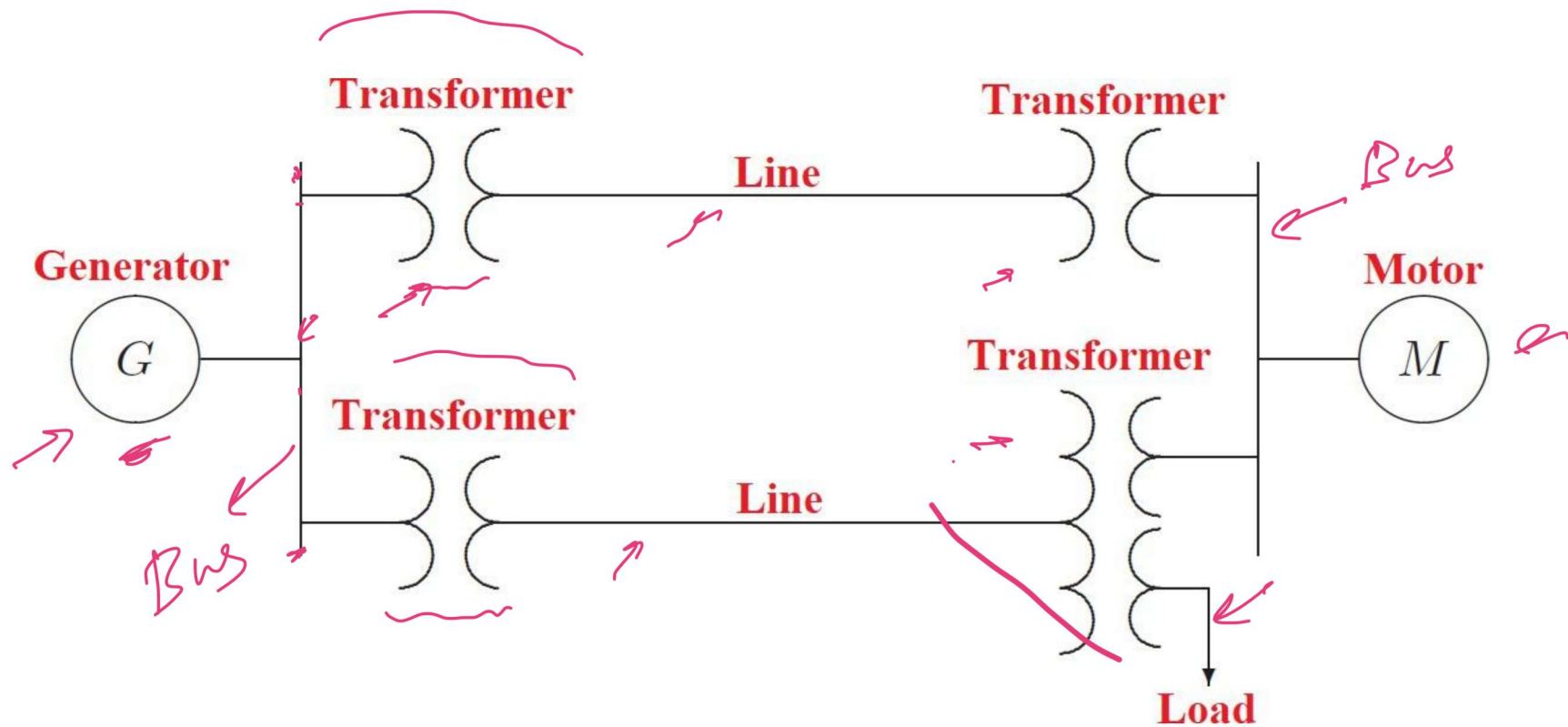


line to line voltage, V_{L-L}

$$V_{L-L} = \sqrt{3} V_{L-N}$$

Single line diagram (SLD): (one line diagram)

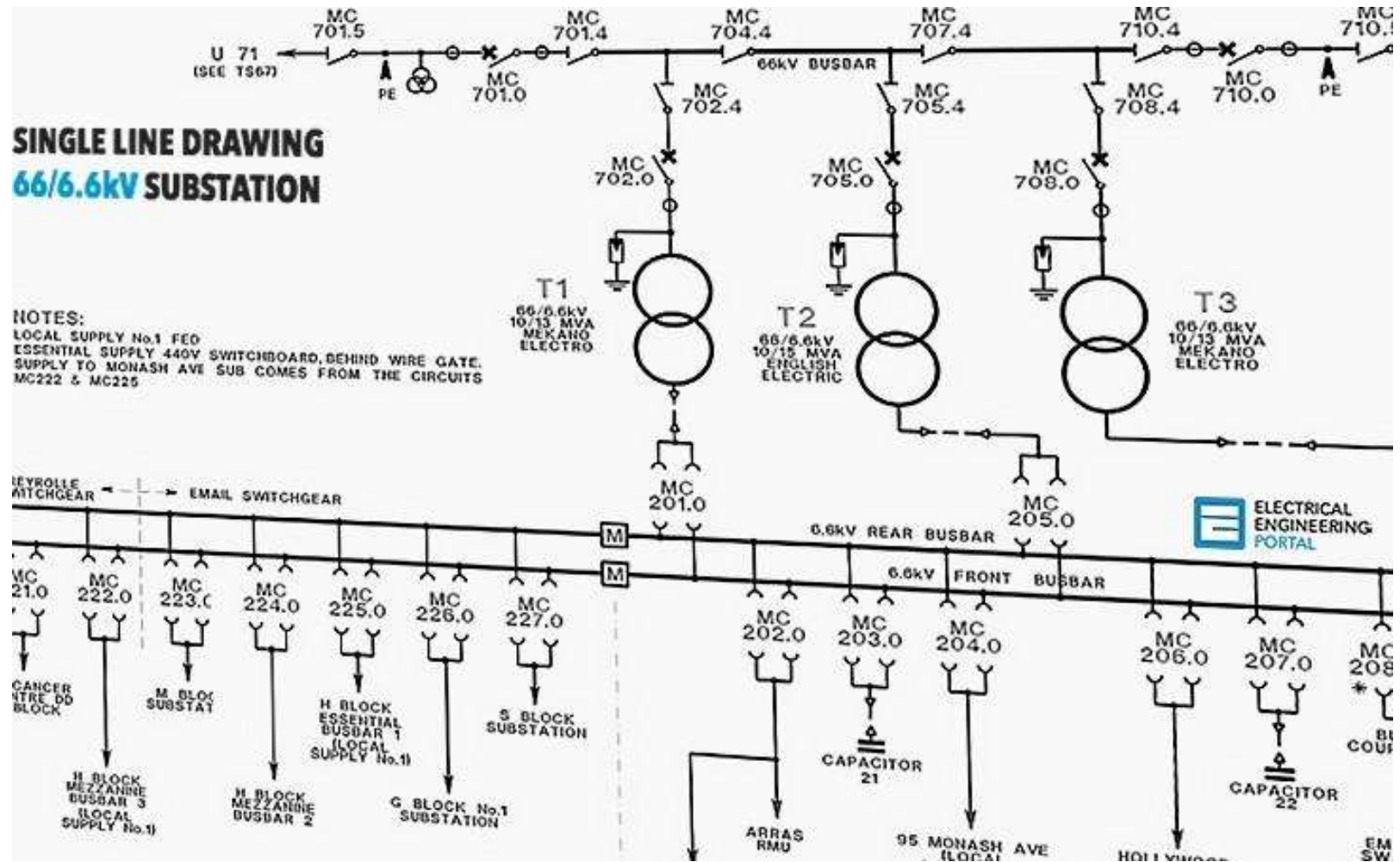
SLD is a simplified notation for representing a three phase power system using a symbol for each component. It is a graphical representation of the power system.



SINGLE LINE DRAWING 66/6.6kV SUBSTATION

NOTES:

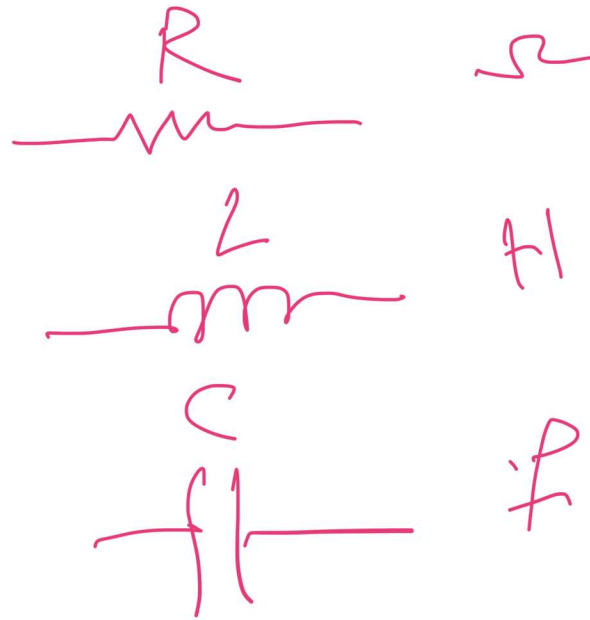
LOCAL SUPPLY No.1 FED
ESSENTIAL SUPPLY 440V SWITCHBOARD, BEHIND WIRE GATE.
SUPPLY TO MONASH AVE SUB COMES FROM THE CIRCUITS
MC222 & MC225



TYPES OF LOADS IN POWER SYSTEM

Types of loads in power system:

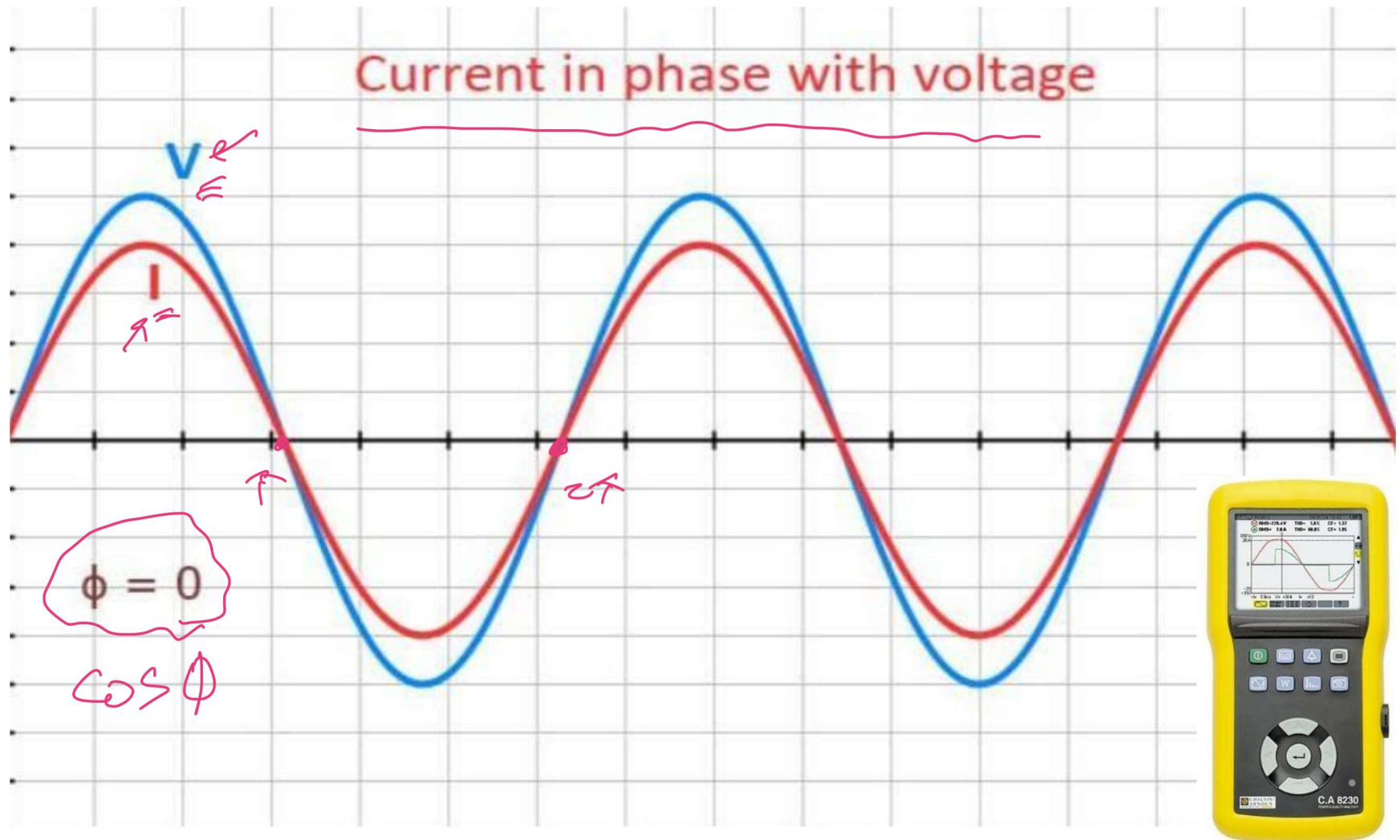
- **Resistive loads**
- **Inductive loads**
- **Capacitive loads**



1. Resistive loads: heating loads

unity power factor

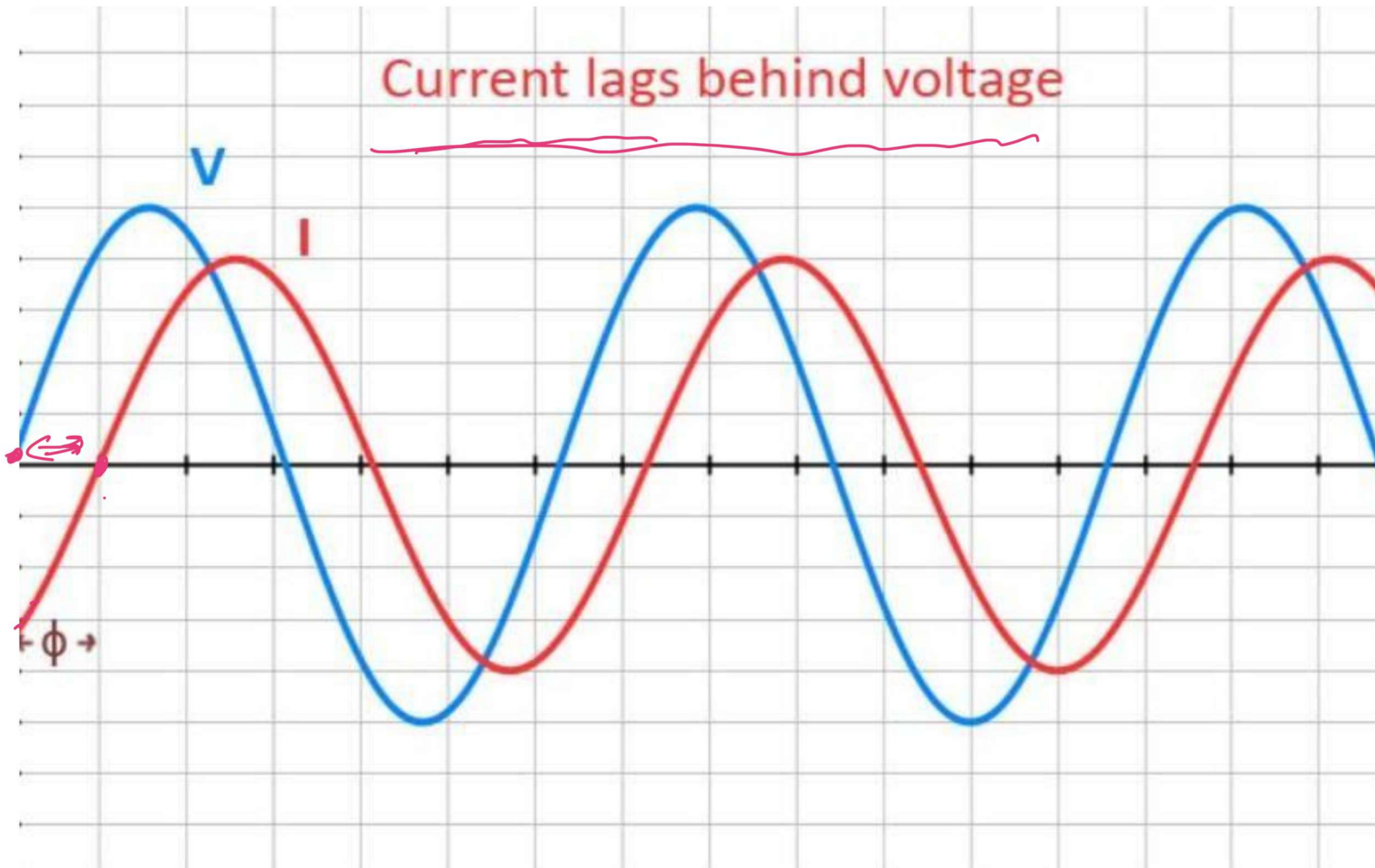
Power factor = $\cos(\Phi) = 1$



2. Inductive loads: any load having coils

lagging power factor

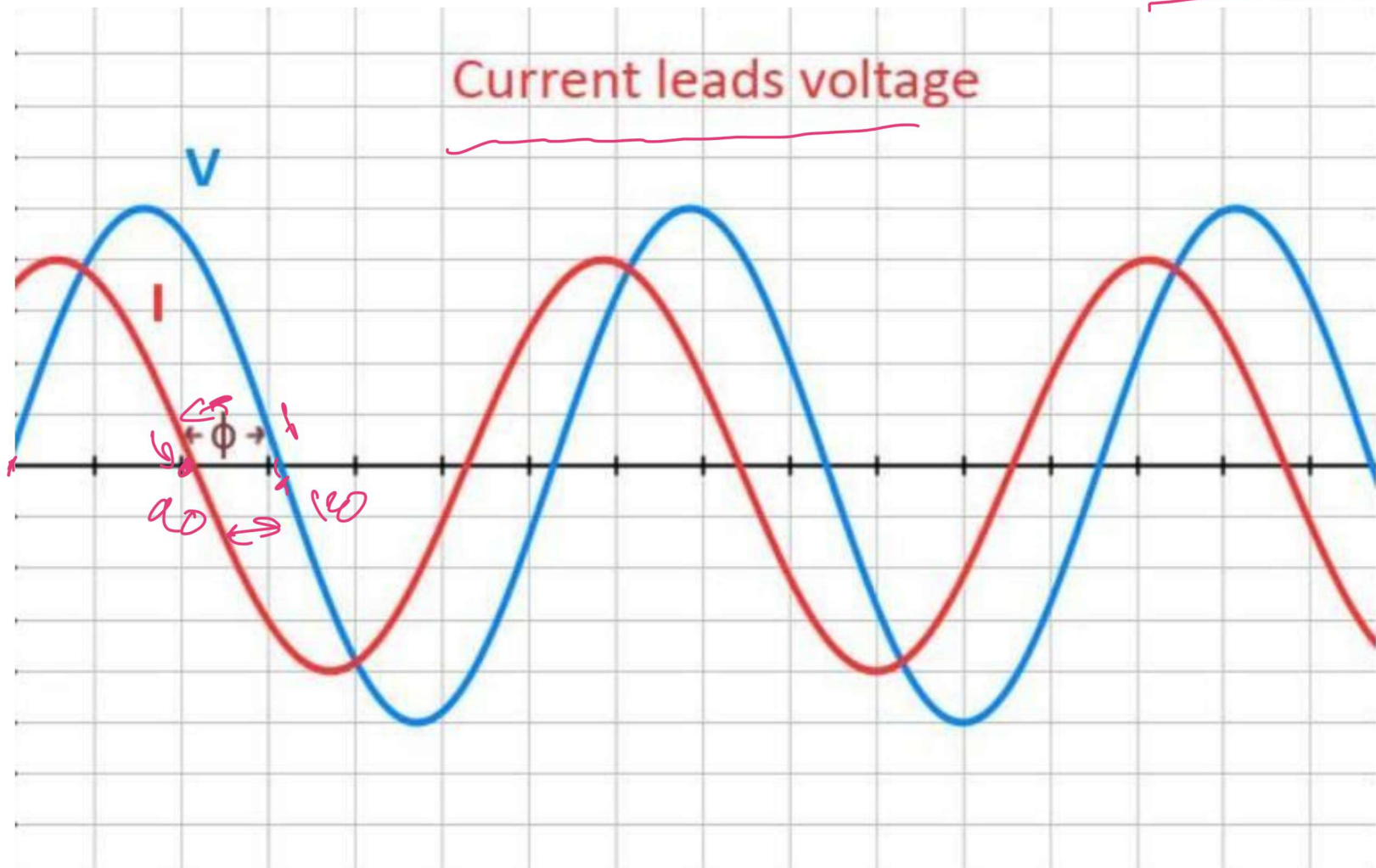
$$\text{Power factor} = \cos(\Phi) < 1$$



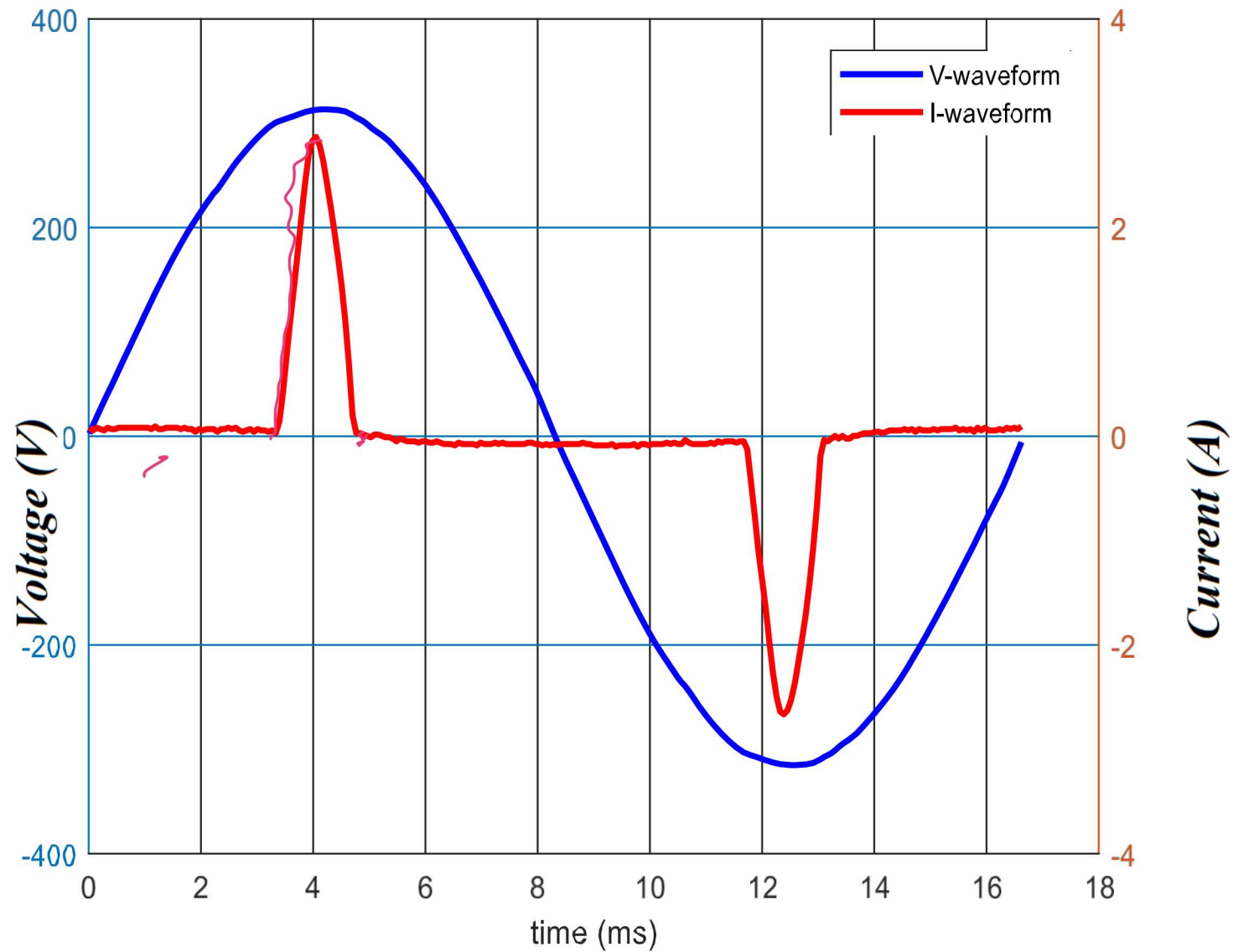
3. Capacitive loads:

➤ Leading power factor

Power factor = $\cos(\Phi) < 1$



4. Electronic loads: TV, charger



How do we evaluate the impedance of R, L and C ?



$$Z_R = R$$



Inductive reactance



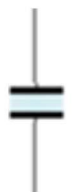
$$Z_L = jX_L$$

Where,

$$X_L = 2\pi fL$$

$$\omega = 2\pi f$$

$$f = \frac{1}{T}$$



$$Z_C = -jX_C$$

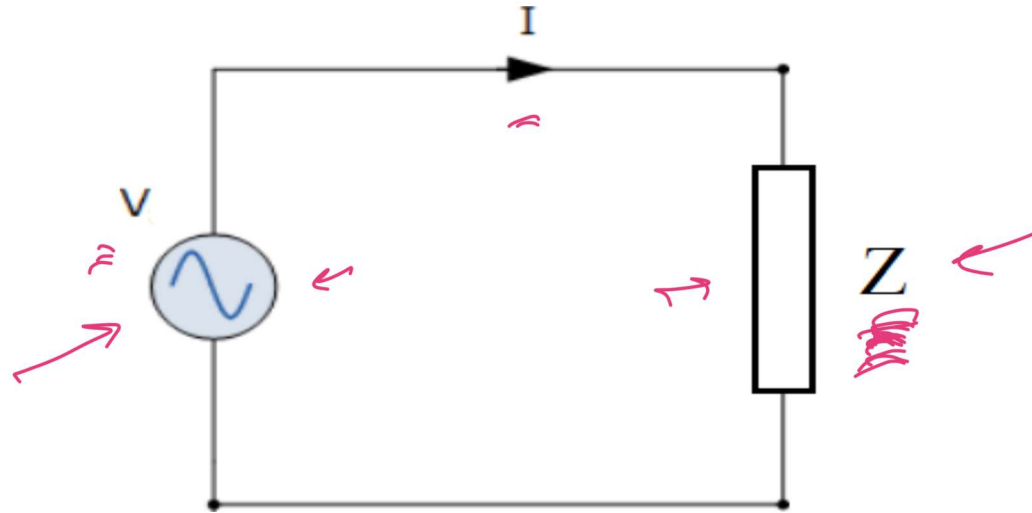
Where,

$$X_C = \frac{1}{2\pi fC}$$

$$\frac{1}{\omega C}$$

Capacitive reactance

This is the final equivalent circuit of the circuits with R, L and C combinations:



Ohm's Law: $V = I \times Z$

Impedance

The equivalent impedance is formed in complex form as:

Impedance

$$Z = R + jX$$

Real part

Imag. part

Resistance = $|Z| \cos \theta$

Reactance

Its magnitude is:

$$|Z| = \sqrt{R^2 + X^2}$$

$\theta = \tan^{-1} \left(\frac{X}{R} \right)$

$$\vec{Y} = \frac{1}{Z}$$

Admittance

$$\vec{Y} = G + jB$$

Conductance

At steady state, it is usually very small so it is neglected.

Susceptance

ANALYSIS OF VOLTAGE AND CURRENT WAVEFORMS