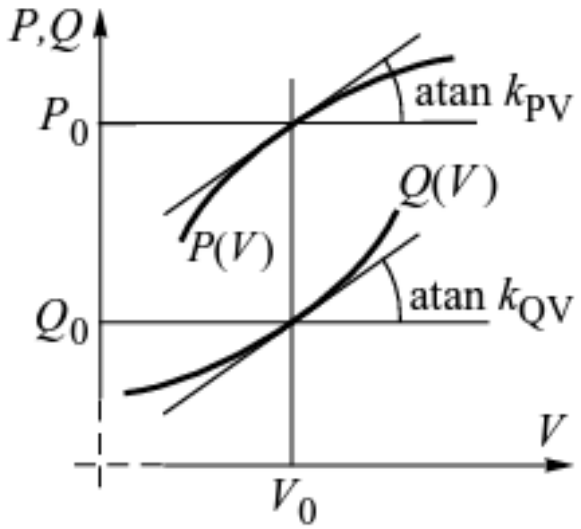
EE 740
Power System Analysis in the Steady State: Electric Loads

Spring 2013

Power System Loads

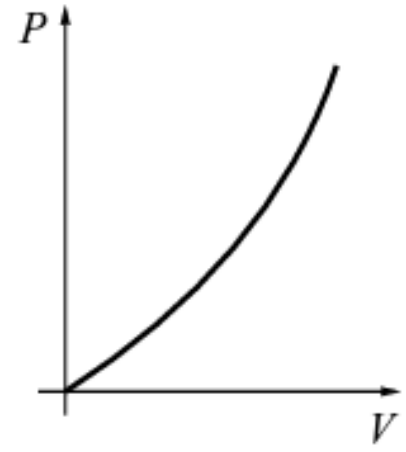
- Only static load models are described.
- The active and reactive power demand of a static composite load depends on the voltage and frequency.
- *Voltage and frequency sensitivity*: slope of load-voltage or load-frequency characteristics:

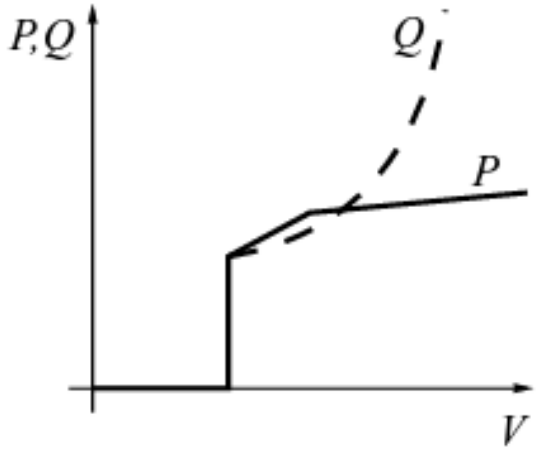
$$k_{PV} = \frac{\Delta P / P_0}{\Delta V / V_0}, \quad k_{QV} = \frac{\Delta Q / Q_0}{\Delta V / V_0}, \quad k_{Pf} = \frac{\Delta P / P_0}{\Delta f / f_0}, \quad k_{Qf} = \frac{\Delta Q / Q_0}{\Delta f / f_0},$$



Lighting and heating load characteristics

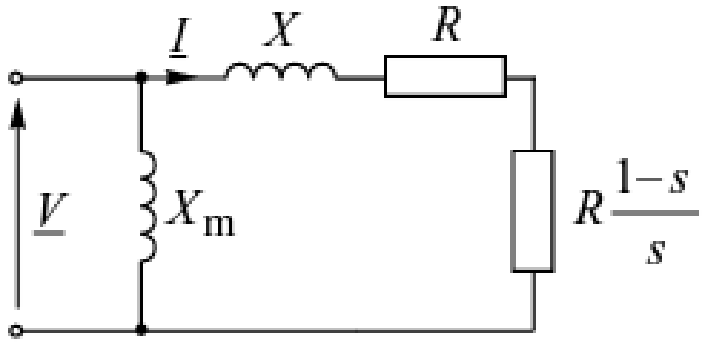
- Voltage characteristics of incandescent bulb.
- Voltage characteristics of fluorescent bulb.
- Heating load equipped with thermostat is considered a constant energy load.



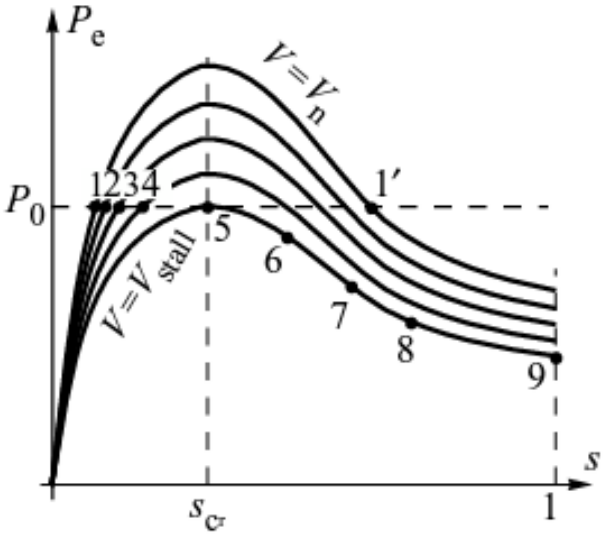


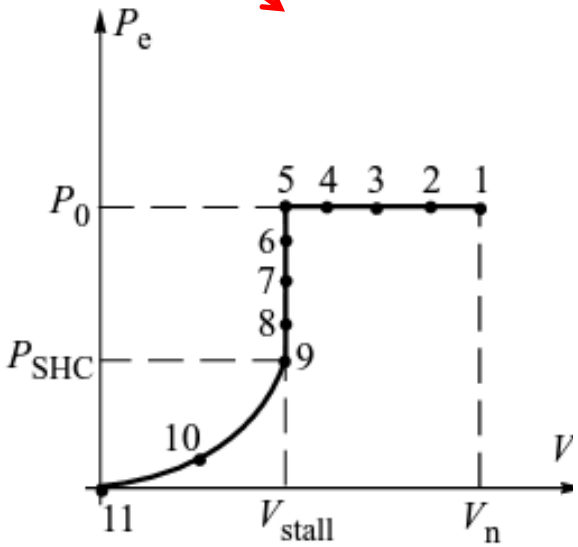
Induction Motors

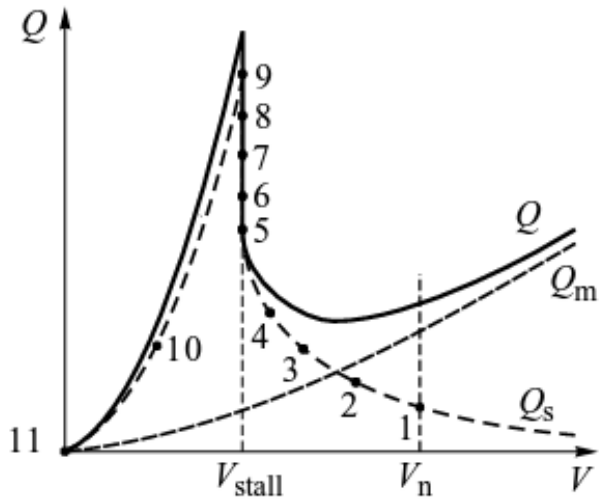
- Equivalent circuit with stator impedance neglected.



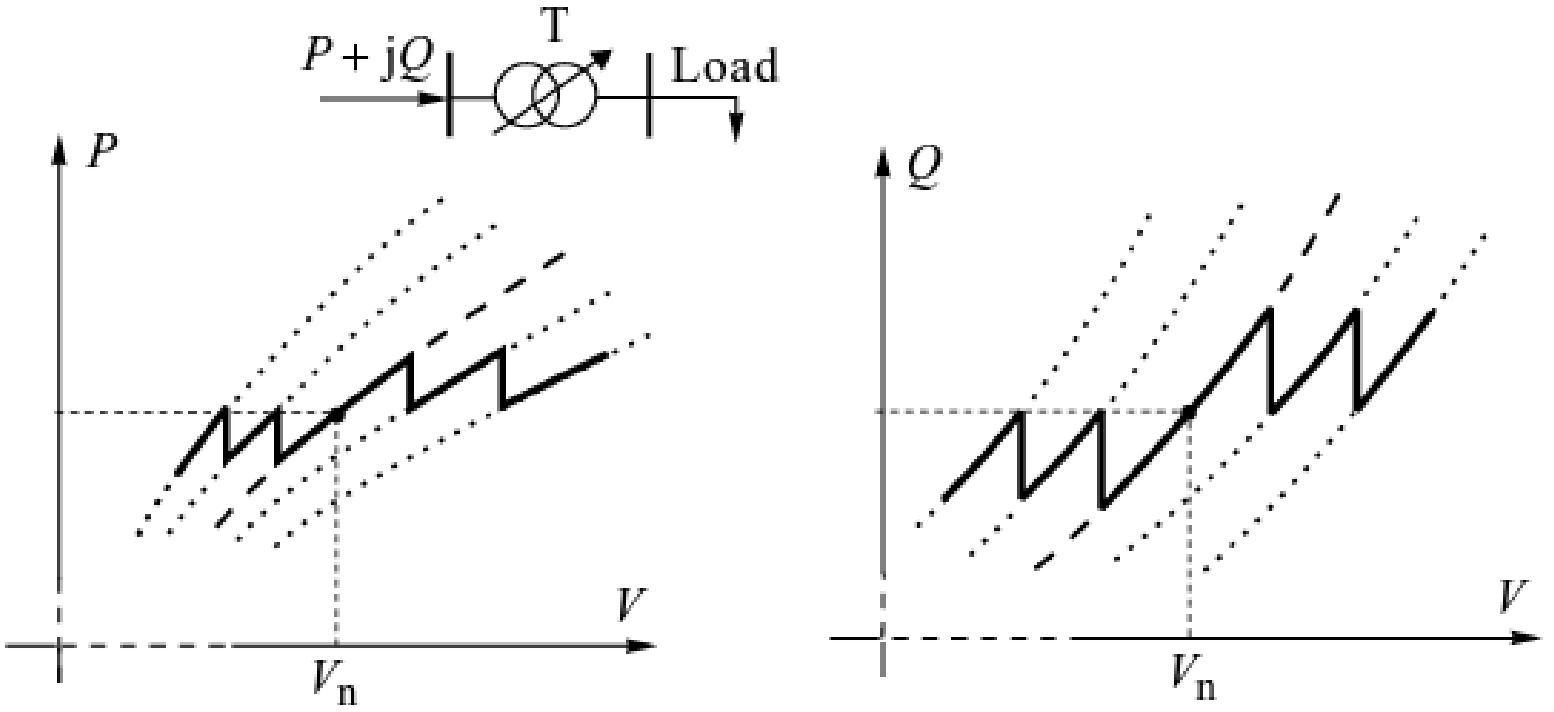
- Voltage characteristic under constant load torque.







Influence of tap-changing transformer on composite load voltage characteristics



ZIP and Exponential and Frequency-Dependent Load Models

- ZIP model:

$$P = P_0 \left[a_1 \left(\frac{V}{V_0} \right)^2 + a_2 \left(\frac{V}{V_0} \right) + a_3 \right]$$

$$Q = Q_0 \left[a_4 \left(\frac{V}{V_0} \right)^2 + a_5 \left(\frac{V}{V_0} \right) + a_6 \right],$$

- Exponential model:

$$P = P_0 \left(\frac{V}{V_0} \right)^{n_p} \quad \text{and} \quad Q = Q_0 \left(\frac{V}{V_0} \right)^{n_q},$$

- Frequency dependent model:

$$P = P(V) \left[1 + k_{Pf} \frac{\Delta f}{f_0} \right]$$

$$Q = Q(V) \left[1 + k_{Qf} \frac{\Delta f}{f_0}) \right],$$

DETERMINATION OF STATIC LOAD MODELS FROM LTC AND CAPACITOR SWITCHING TESTS

- Refer to article