Budapest University of Technology and Economics
Faculty of Transportation Engineering and Vehicle Engineering
Department of Control for Transportation and Vehicle Systems

# Electronics - electronic measuring systems

## Transient responses, 3 phase circuits

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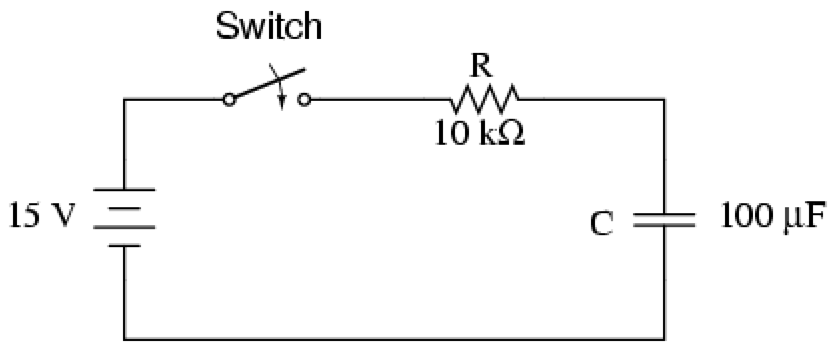
# Transient responses(1)



## Sudden change in DC voltage when wired in series with a resistor

## Capacitor response

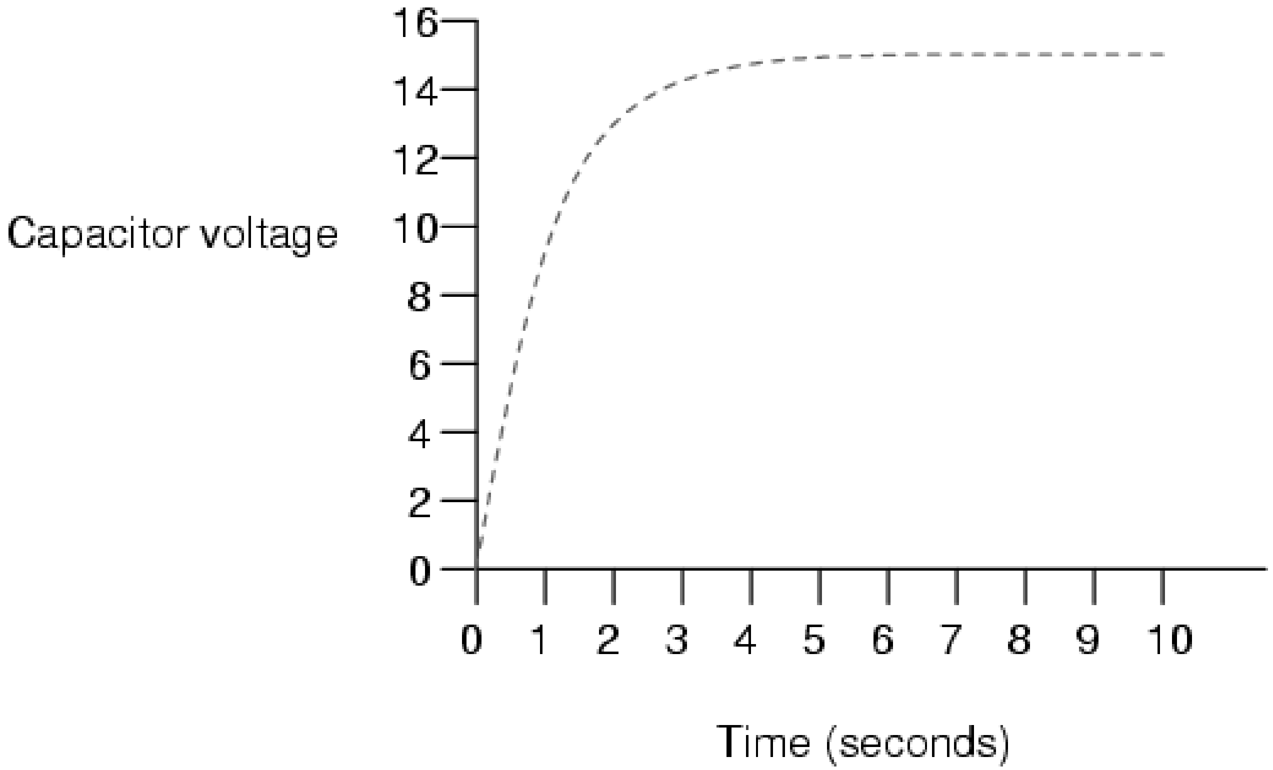
- Capacitors store energy in the form of charges (electric field) – small batteries
- Fully discharged – zero volts on terminals
- Fully charged – voltage of the applied voltage source on terminals
- Current acts in reverse compared to voltage



# Capacitor response



- Voltage goes from 0 to maximum
- Current goes from peak to 0



# Capacitor response



| Time (seconds) | Battery voltage | Capacitor voltage | Current |
|---|---|---|---|
| 0 | 15 V | 0 V | 1500 uA |
| 0.5 | 15 V | 5.902 V | 909.8 uA |
| 1 | 15 V | 9.482 V | 551.8 uA |
| 2 | 15 V | 12.970 V | 203.0 uA |
| 3 | 15 V | 14.253 V | 74.68 uA |
| 4 | 15 V | 14.725 V | 27.47 uA |
| 5 | 15 V | 14.899 V | 10.11 uA |
| 6 | 15 V | 14.963 V | 3.718 uA |
| 10 | 15 V | 14.999 V | 0.068 uA |

# Capacitor response



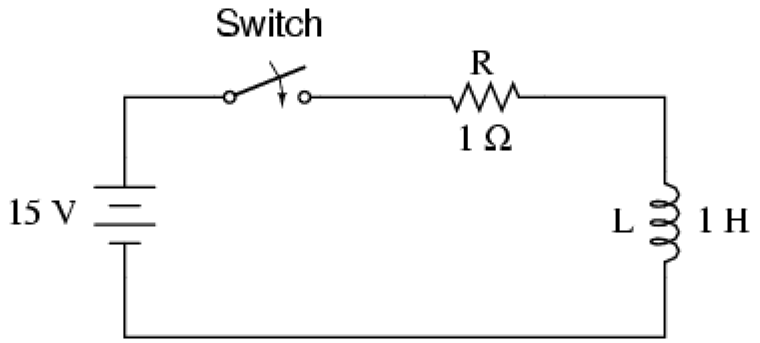
- Capacitors act somewhat like batteries when faced with a sudden change in applied voltage: they initially react by producing a high current which tapers off over time.
- A fully discharged capacitor initially acts as a short circuit. After charging fully to the supplied voltage, it acts as an open circuit.
- In a resistor-capacitor charging circuit, capacitor voltage goes from nothing to full source voltage, current goes from maximum to zero, both variables changing rapidly at first, approaching their final values slower and slower as time goes on.

# Transient responses(2)



## Inductor response

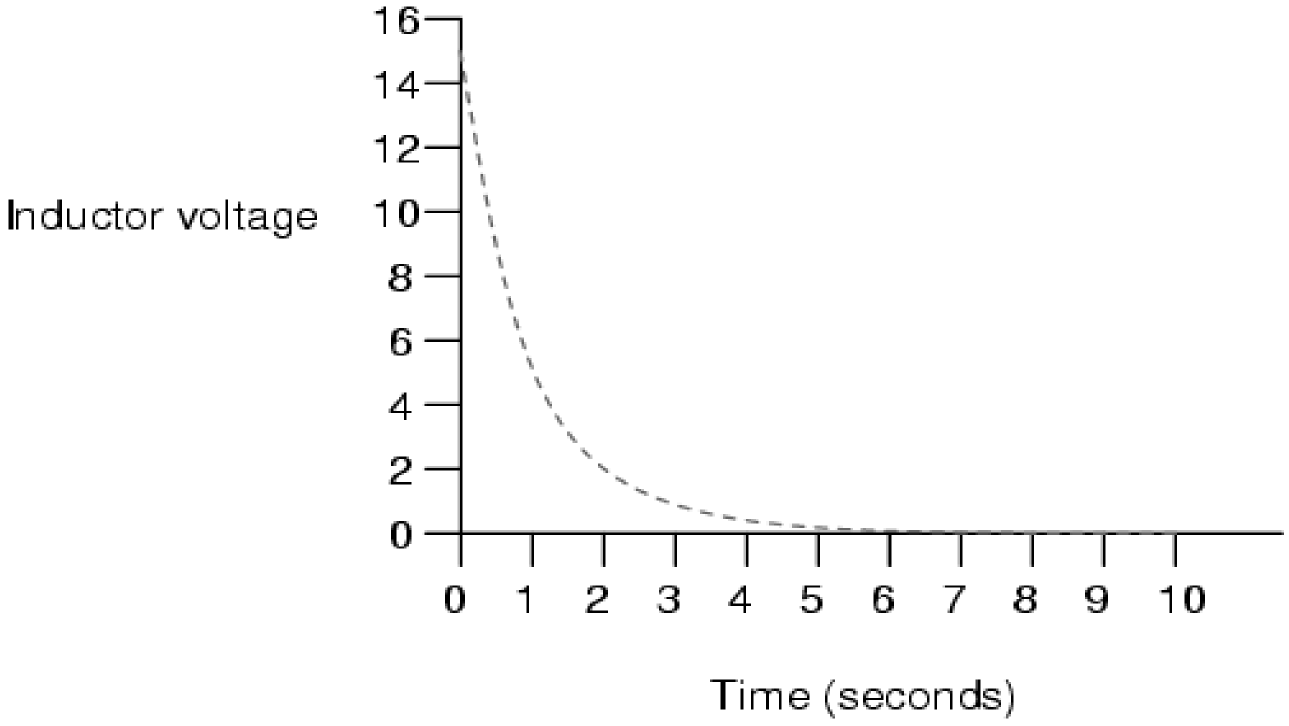
- Inductors store energy in the form of a magnetic field – small batteries
- Fully discharged (no magnetic field) – zero current
- Fully charged – current rises to maximum
- Voltage acts in reverse compared to current



# Inductor response



- Voltage goes from peak to 0
- Current goes 0 peak to peak



# Inductor response

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| Time (seconds) | Battery voltage | Inductor voltage | Current |
|---|---|---|---|
| 0 | 15 V | 15 V | 0 |
| 0.5 | 15 V | 9.098 V | 5.902 A |
| 1 | 15 V | 5.518 V | 9.482 A |
| 2 | 15 V | 2.030 V | 12.97 A |
| 3 | 15 V | 0.747 V | 14.25 A |
| 4 | 15 V | 0.275 V | 14.73 A |
| 5 | 15 V | 0.101 V | 14.90 A |
| 6 | 15 V | 37.181 mV | 14.96 A |
| 10 | 15 V | 0.681 mV | 14.99 A |

# Inductor response



- A fully discharged inductor (no current through it) initially acts as an open circuit with the sudden application of voltage. After charging fully, it acts as a short circuit.
- In a resistor-inductor "charging" circuit, inductor current goes from nothing to full value while voltage goes from maximum to zero, both variables changing rapidly at first, approaching their final values slower and slower as time goes on.

# Transient responses(3)



- *time constant* of the circuit: the amount of time it takes for voltage or current values to change approximately 63 percent from their starting values to their final values in a transient situation.

*For resistor-capacitor circuits:*

$$\tau = RC$$

*For resistor-inductor circuits:*

$$\tau = \frac{L}{R}$$

# Transient responses(3)

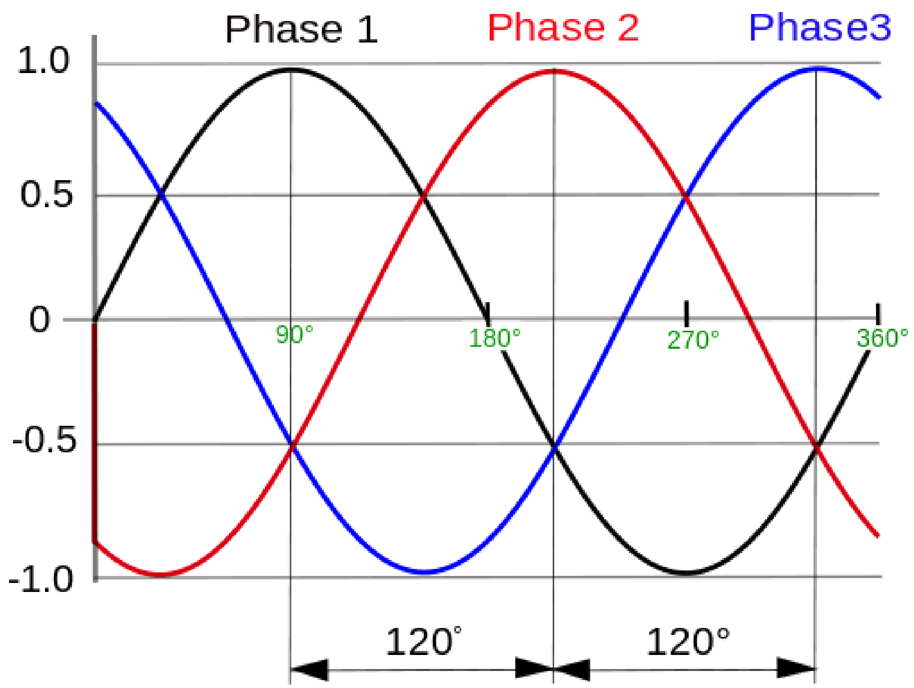


- Charging functions: $V(t) = V_0(1 - e^{-t/\tau})$
- Discharging functions: $V(t) = V_0(e^{-t/\tau})$
  - $V_0$ - peak voltage
  - Same for current

# Three-phase circuits



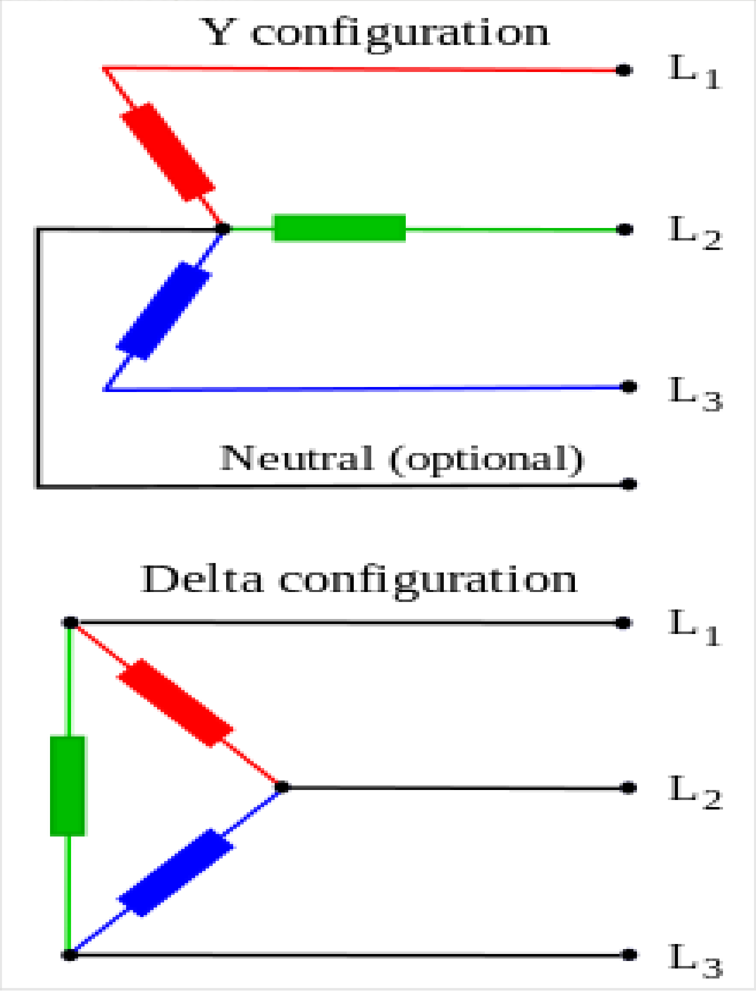
- **3 separate AC phases with same volume a 120° phase difference**
  - Assymetric systems lack the advantagees of a symmetric one
- Common reference connected to ground
- Load can be symmetric or asymmetric
- Phase currents can cancel out each other
- Power transfer on linear loads is constant
- Can produce a rotating magnetic field



# Three-phase circuits



- 2 separate configurations
  - Line and phase voltages/currents
- Phase – between a phase and neutral
- Line – between 2 lines
- Y configuration
  - $U_{LL} = \sqrt{3}U_{LN}$
  - $I_{LL} = I_{LN}$
- Delta configuration
  - $I_{LL} = \sqrt{3}I_{LN}$
  - $U_{LL} = U_{LN}$



# Three-phase circuits



- Both configurations
  - $P = 3U_{LN}I_{LN}\cos\varphi$
  - $P = \sqrt{3}U_{LL}I_{LL}\cos\varphi$