Introduction
Power Electronic Device

Introduction to Power Electronics Device

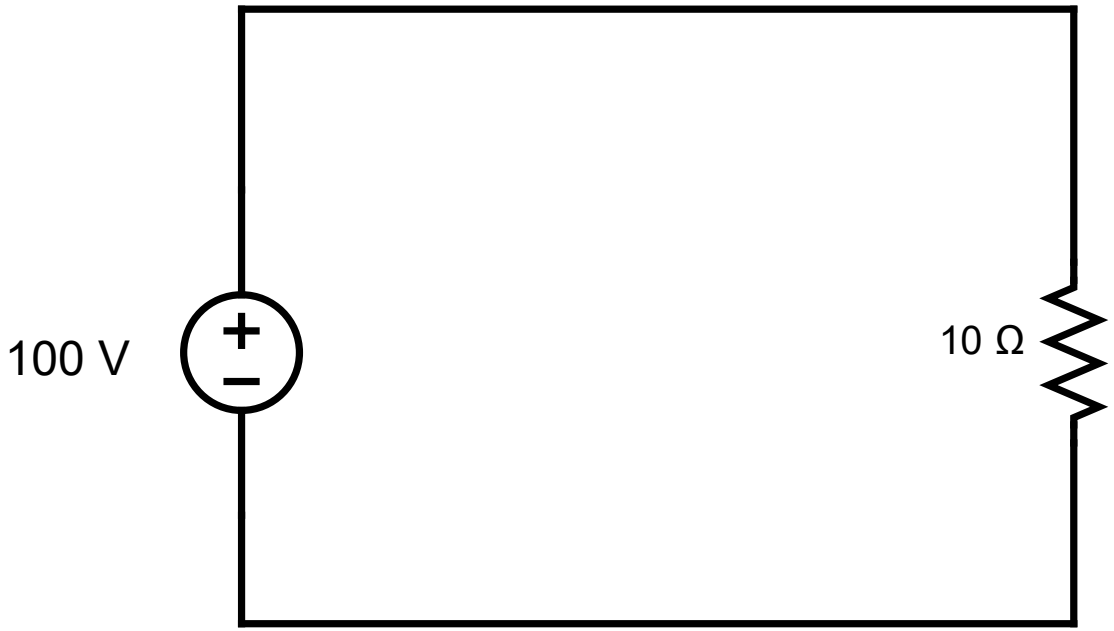
MATLAB/SIMULINK

- Design of Electric Circuit.
- Uncontrolled Device
  - Diodes
- Controlled Device
  - Thyristor
  - Mosfet
  - IGBT

Generate Pulses for AC/DC voltage

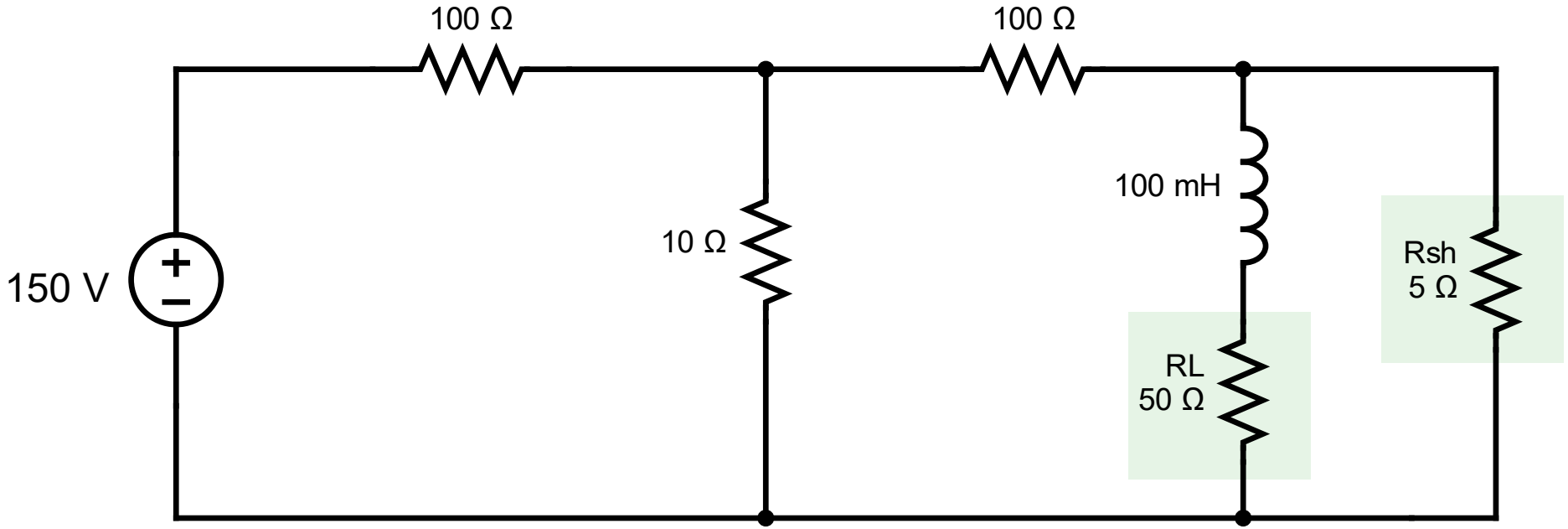
Circuit - 1

Measure Voltage and Current across R_L



Circuit - 2

Measure Voltage across R_L and current through R_{sh} in SIMULINK



Uncontrolled Devices

Diode Rectifier

Rectifier

A rectifier is a circuit that converts an AC signal into unidirectional signal.

- AC to DC converter

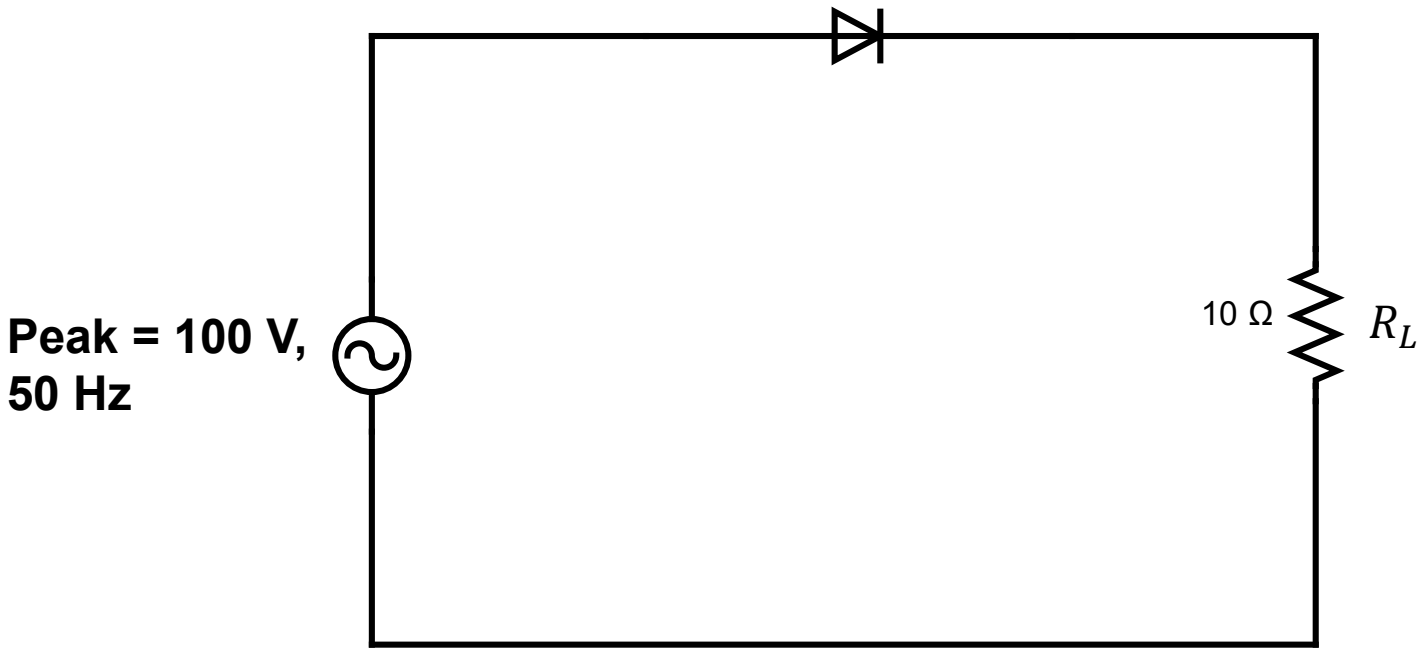
Types of Uncontrolled Rectifier:

- Half Wave Rectifier
- Full Wave Rectifier
- Full Wave Bridge Rectifier

Half Wave Rectifier

CIRCUIT – 1

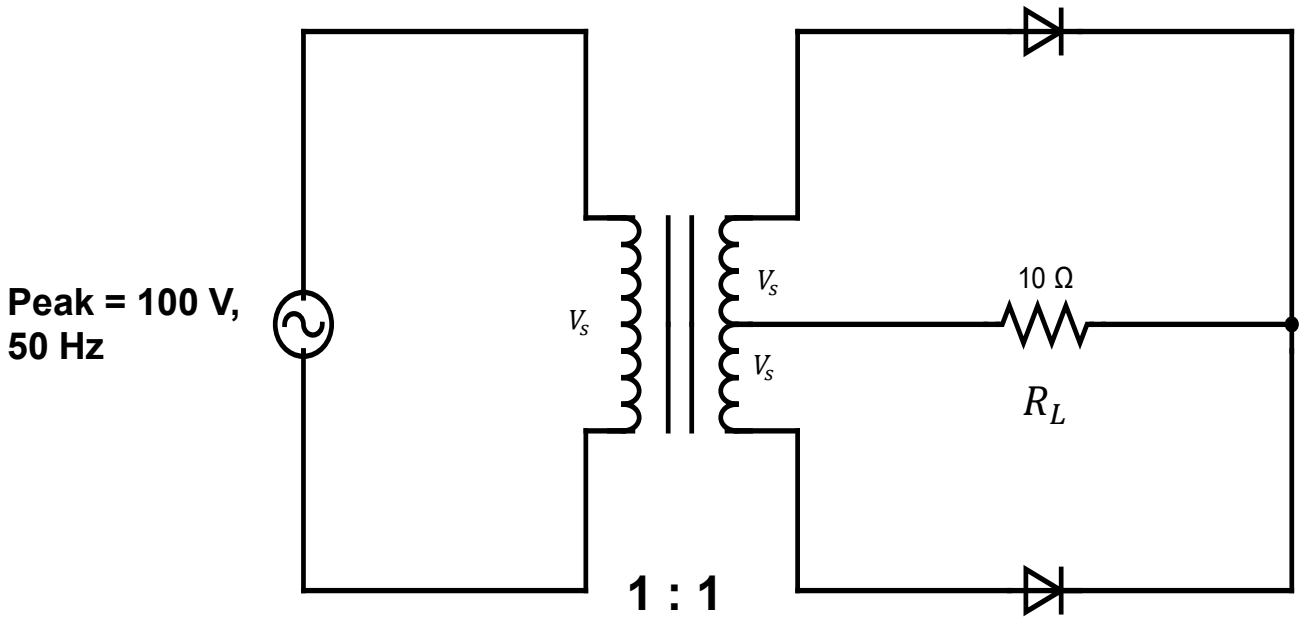
- Visualize voltage and current across R_L

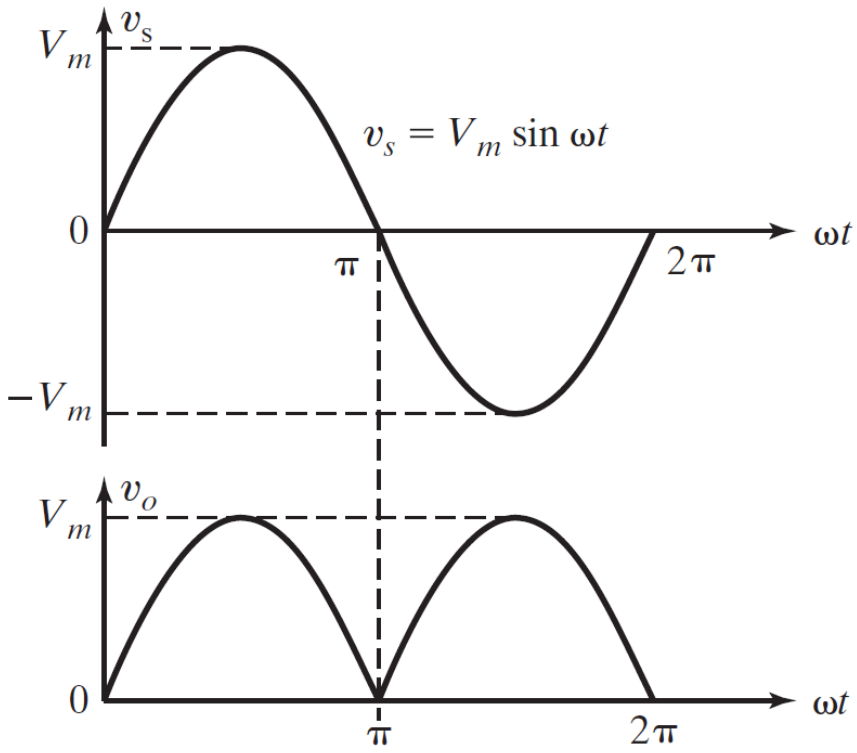


Full Wave Rectifier

CIRCUIT – 2

- Visualize voltage and current across R_L

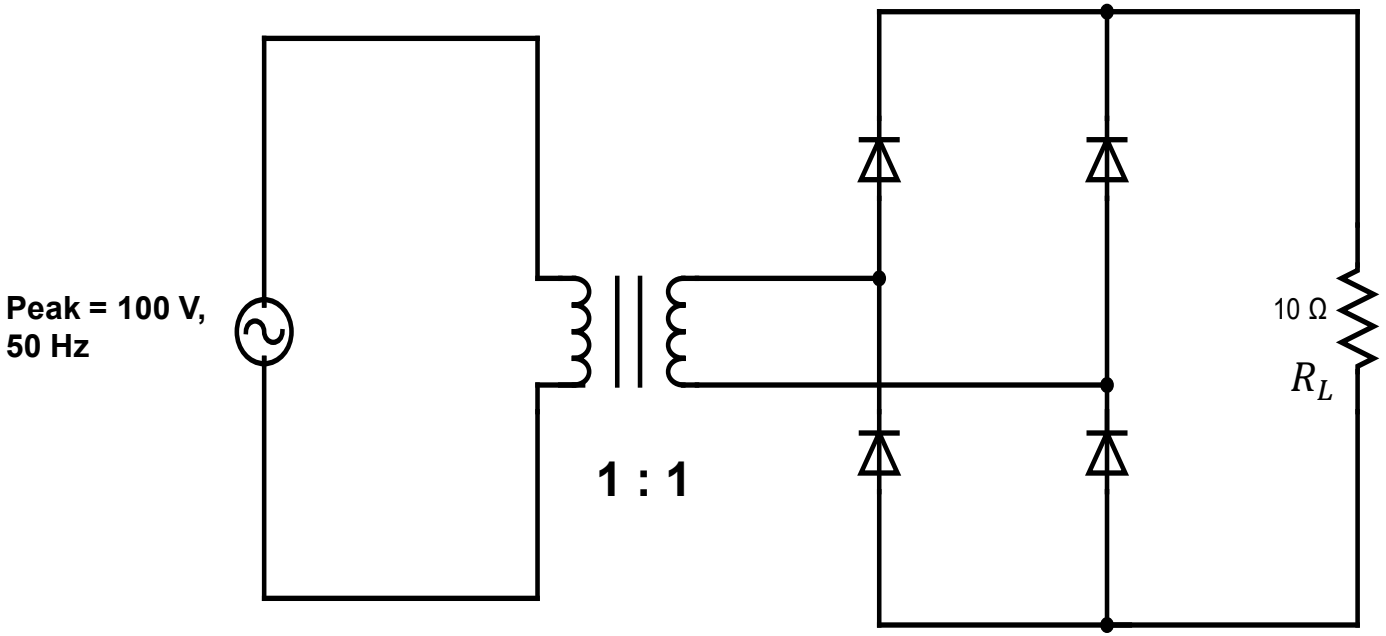


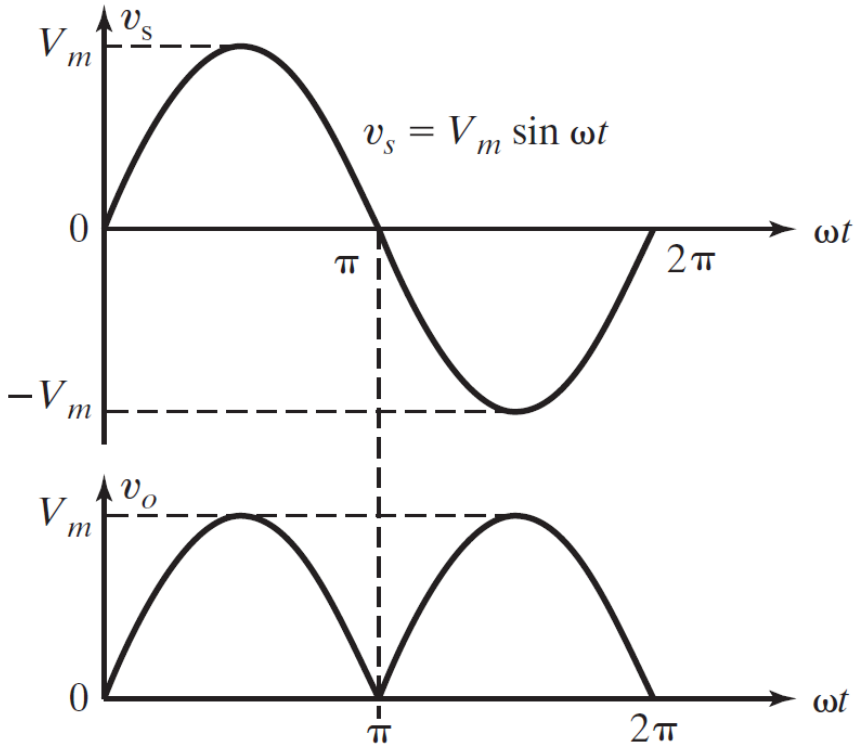


Full Wave Bridge Rectifier

CIRCUIT – 3

- Visualize voltage and current across R_L

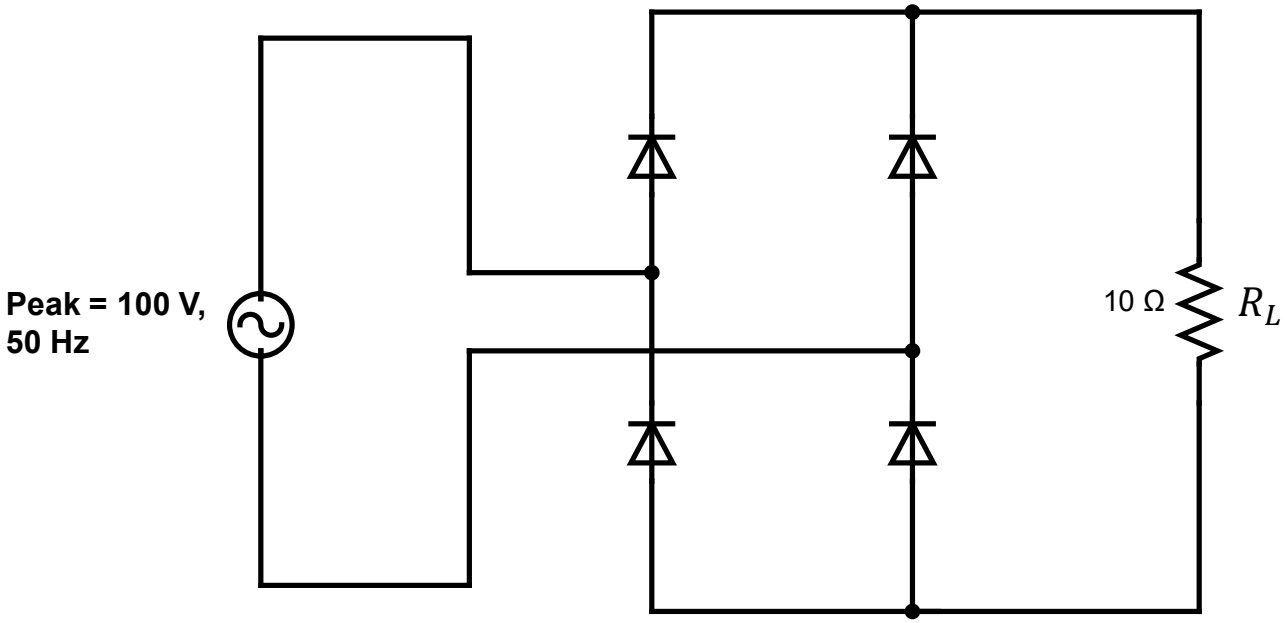


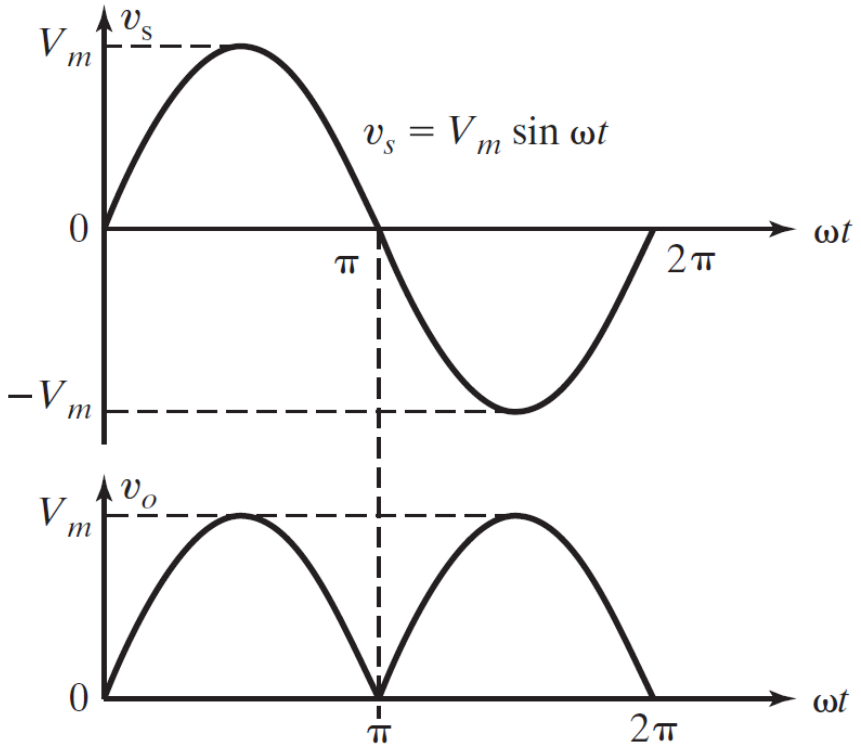


Full Wave Bridge Rectifier

CIRCUIT – 4

- Visualize voltage and current across R_L



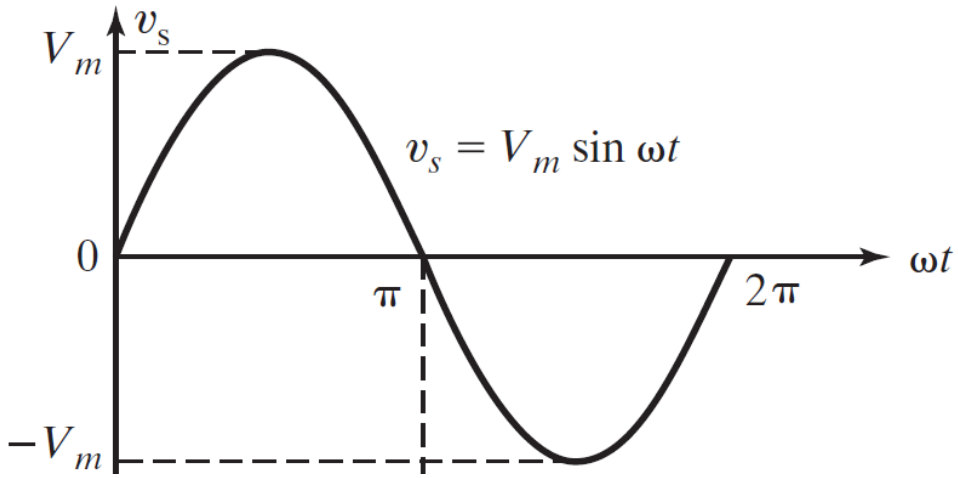


VEDIC SKILL.

Measurement

Measurement - AC

AC Voltage or Current always measure in **RMS** (root mean square) value



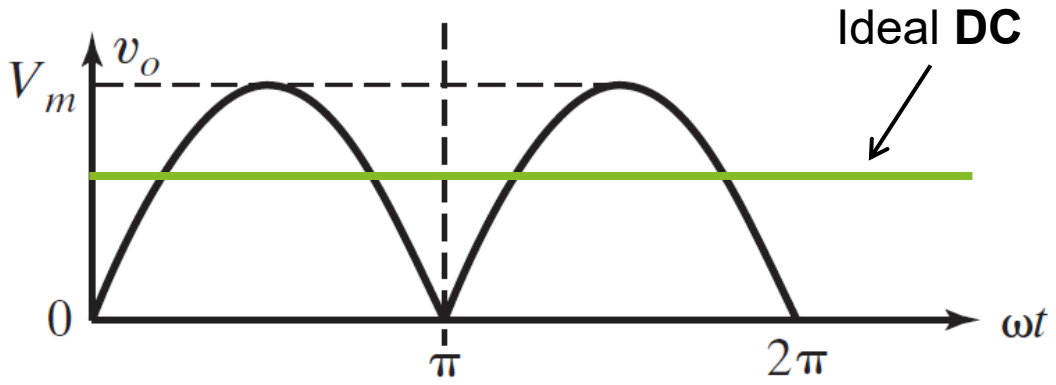
$$V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707\ V_m$$

$$I_{rms} = \frac{V_{rms}}{R}$$

Average value of AC Signal is always **ZERO**

Measurement - DC

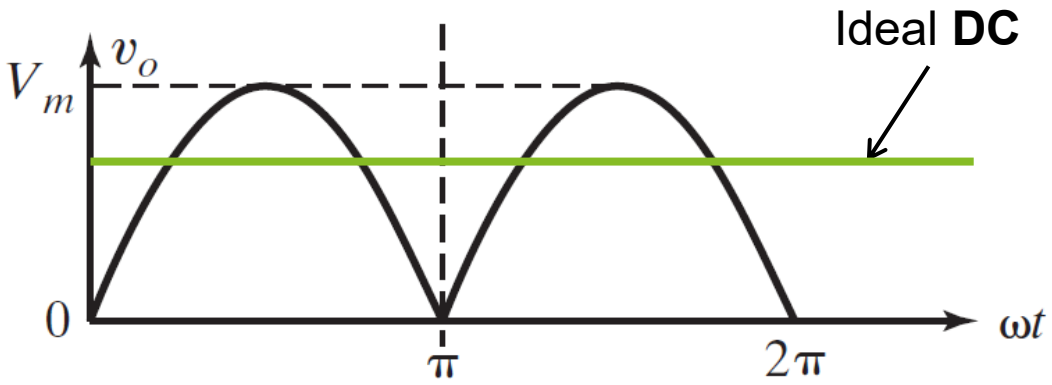
DC Voltage or Current always measure in **Average** value



$$V_{avg} \; or \; V_{dc} = \frac{2V_m}{\pi} = 0.6366 \; V_m$$

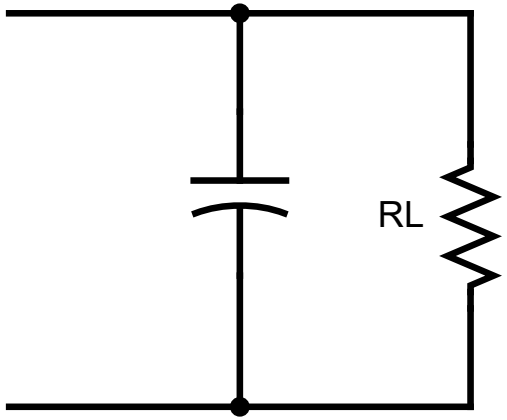
$$I_{avg} \; or \; I_{dc} = \frac{V_{avg}}{R}$$

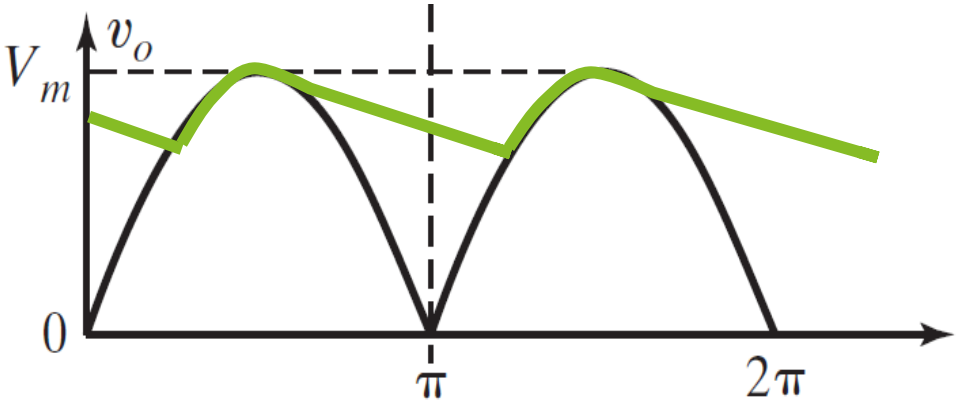
RMS value of DC Signal is **EQUAL** to AC Signal



Filters

C Filter





A single shunt capacitor across the load is the simplest smoothing element. It smoothens both Voltage and Current across Load

When a **capacitor C** is connected across the load:

- During each cycle of the input, the capacitor **charges to the peak voltage** V_m.
- Between peaks, the source voltage falls, but the capacitor **discharges through the load** R_L.
- This discharge causes a small drop in capacitor voltage = **ripple** ΔV.

Discharge Equations

The current through the load is:

$$I_L = \frac{V}{R_L}$$

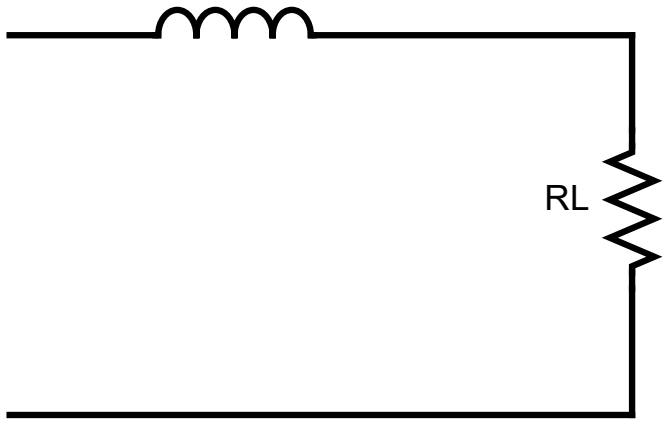
The capacitor current during discharge is:

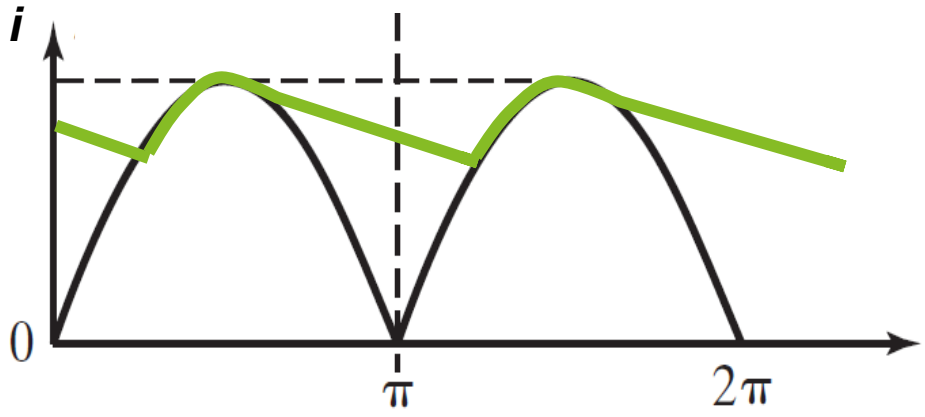
$$I_C = C\frac{dV}{dt}$$

Since the capacitor is supplying the load during the discharge interval:

$$I_L = -I_C$$

L Filter





Here the inductor filters the pulsating current before it reaches the load.

Inductor L is connected in series to the load:

$$V_L = L\frac{di}{dt}$$

This means the inductor opposes sudden changes in current

- If the input is a pulsating waveform, the inductor slows down the rate of change of current, so the current delivered to the load becomes smoother.
- Since the load voltage is proportional to load current, the load voltage also become smoother.

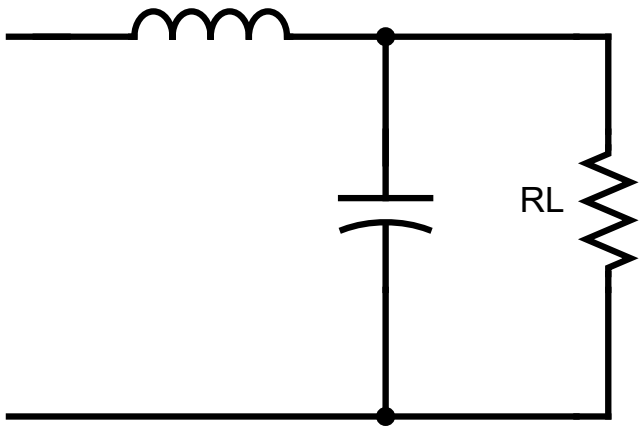
Advantage:

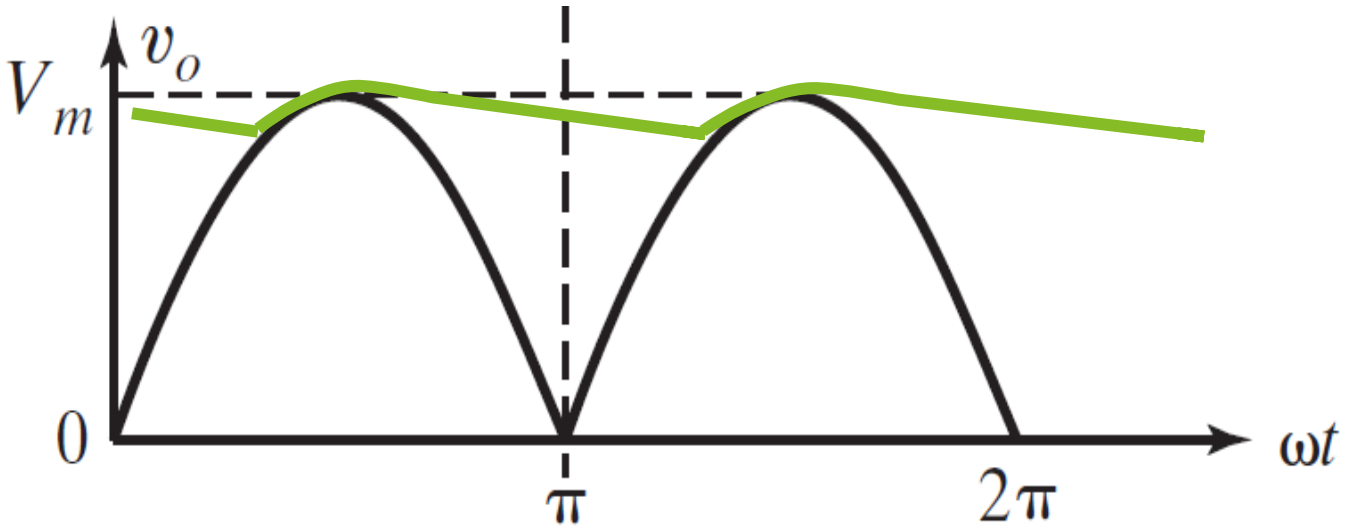
- Good current smoothing (better than simple capacitor)
- No large inrush current
- Provides continuous current

LC Filter

LC filter is combination of both inductor and capacitor. This configuration reduces the pulses and make smoother.

- **Inductor (L):** opposes rapid changes in current, delivering a smoother current to the load.
- **Capacitor (C):** bypasses high-frequency AC ripple to ground, keeping the load voltage steady.

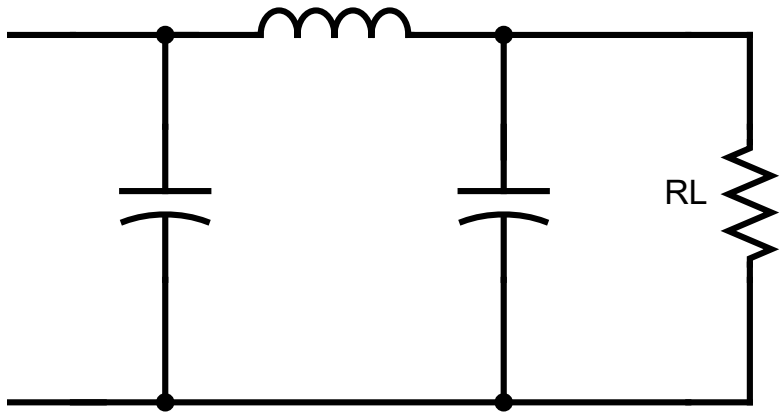


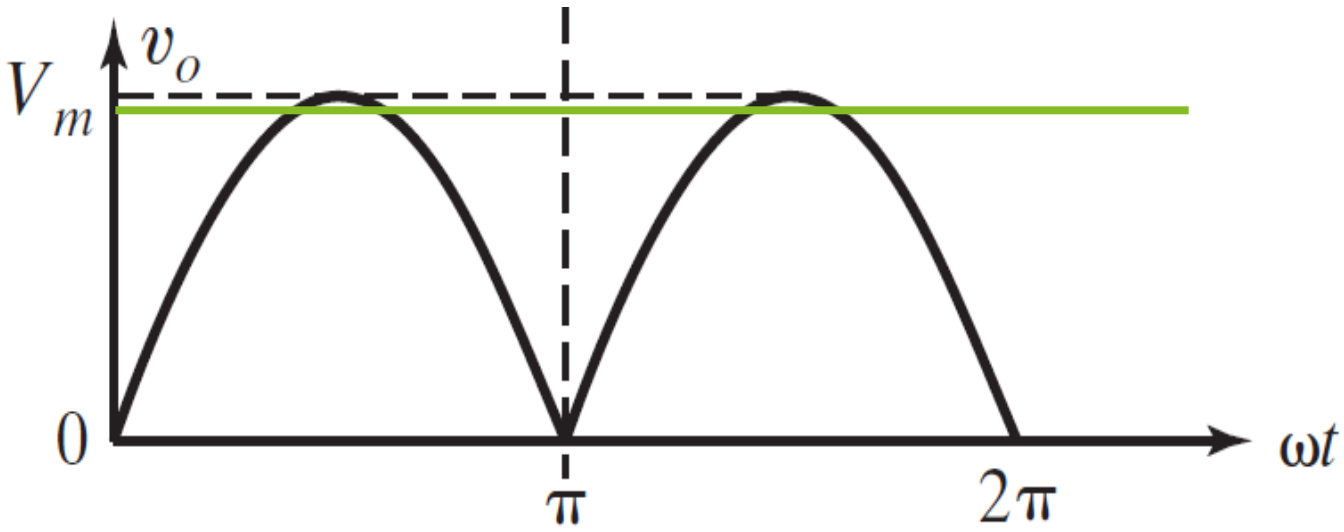


π Filter

This circuit uses capacitor, inductor and another capacitor

- **C1 (input capacitor):** immediately smooths the high-frequency ripple and charges to peak voltage.
- **L (inductor):** opposes current ripple and further smooths variations.
- **C2 (output capacitor):** provides final filtering, bypassing any remaining ripple to ground



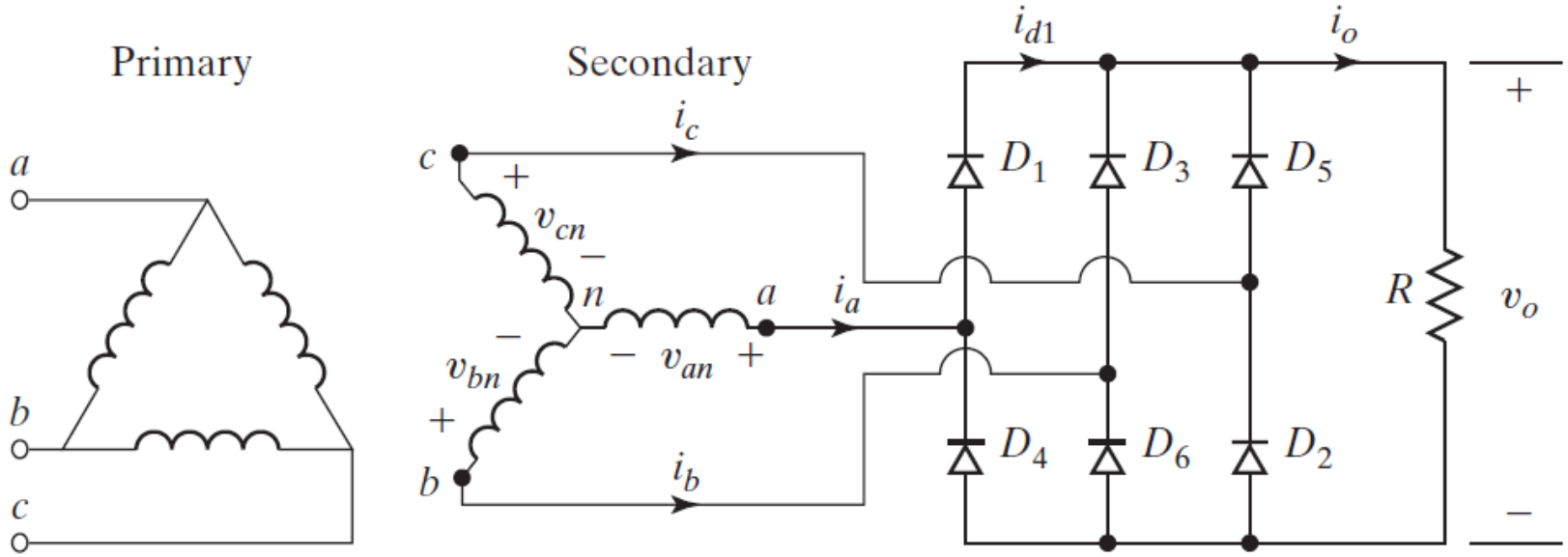


Three Phase Rectifier

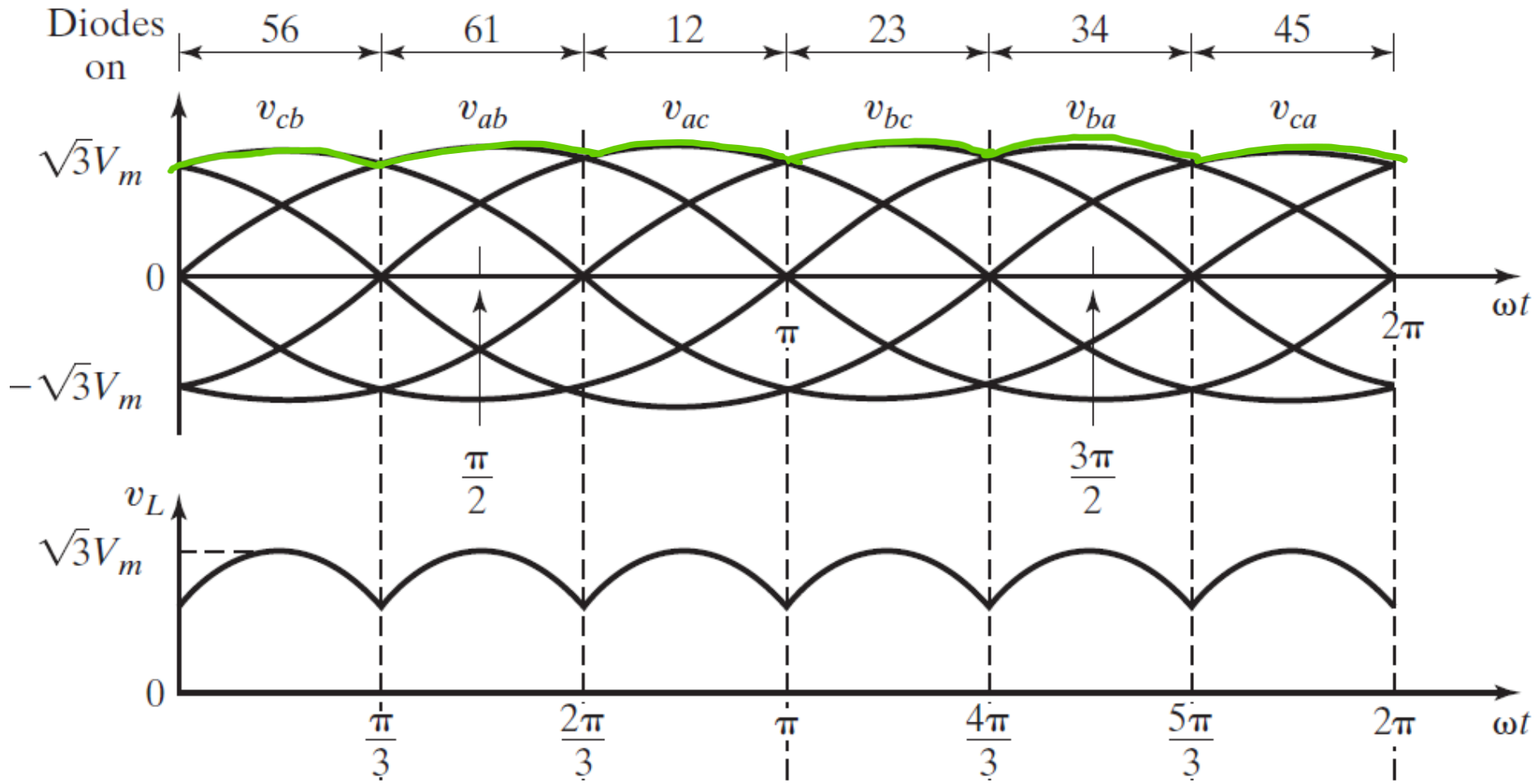
3 Phase Bridge Rectifier

- Full-wave rectifier, can operate with or without a transformer and gives six-pulses ripples on the output voltage.
- The conduction sequence for diodes is

  *D*1 - *D*2, *D*3 - *D*2, *D*3 - *D*4, *D*5 - *D*4, *D*5 - *D*6, and *D*1 - *D*6.



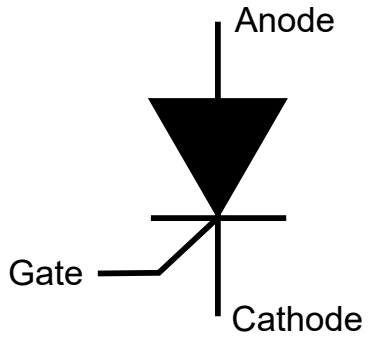
Output Waveform

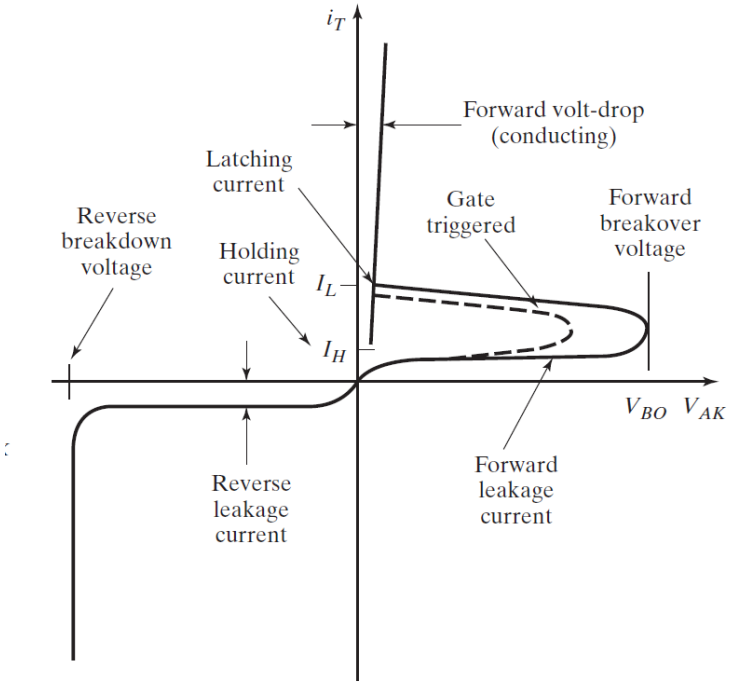


Controlled Rectifier

Thyristor

SCR – Silicon Controlled Rectifier





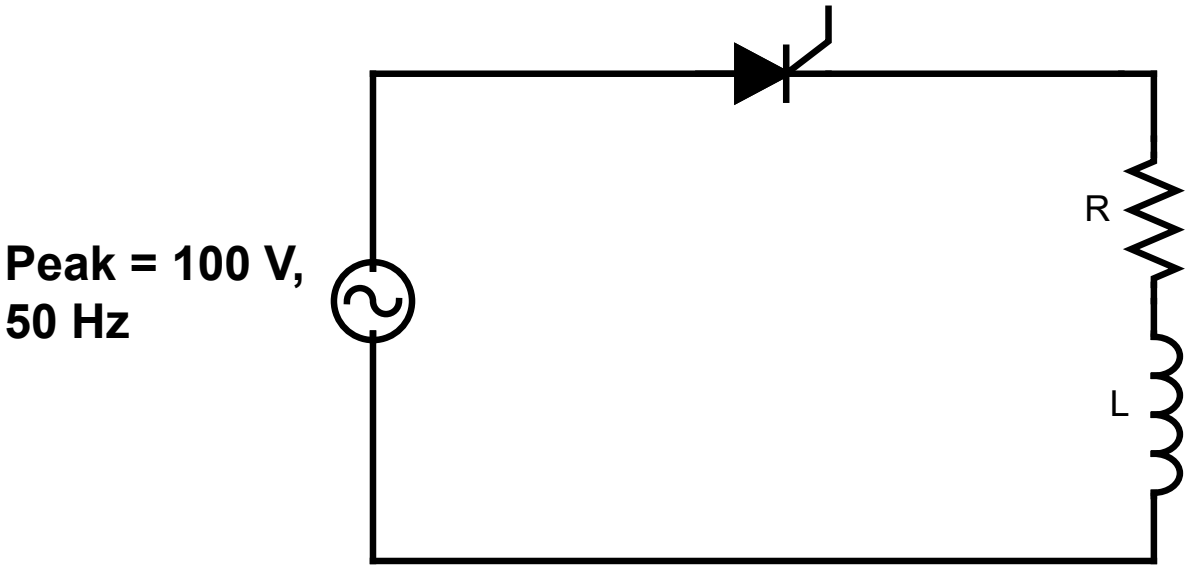
Characteristics

Properties

- A thyristor is a four-layer semiconductor device of PNPN structure
- Can be turned **ON** by a gate signal
- **Cannot** be turned **OFF** by gate signal
- Once triggered ON, it remains ON even if gate signal is removed
- Turns OFF only when current falls below holding current
- Conducts current only in one direction
- Works as a controlled rectifier
- Can handle high voltage and large currents.

Half wave-controlled rectifier

Below circuit diagram defines the half wave-controlled rectifier

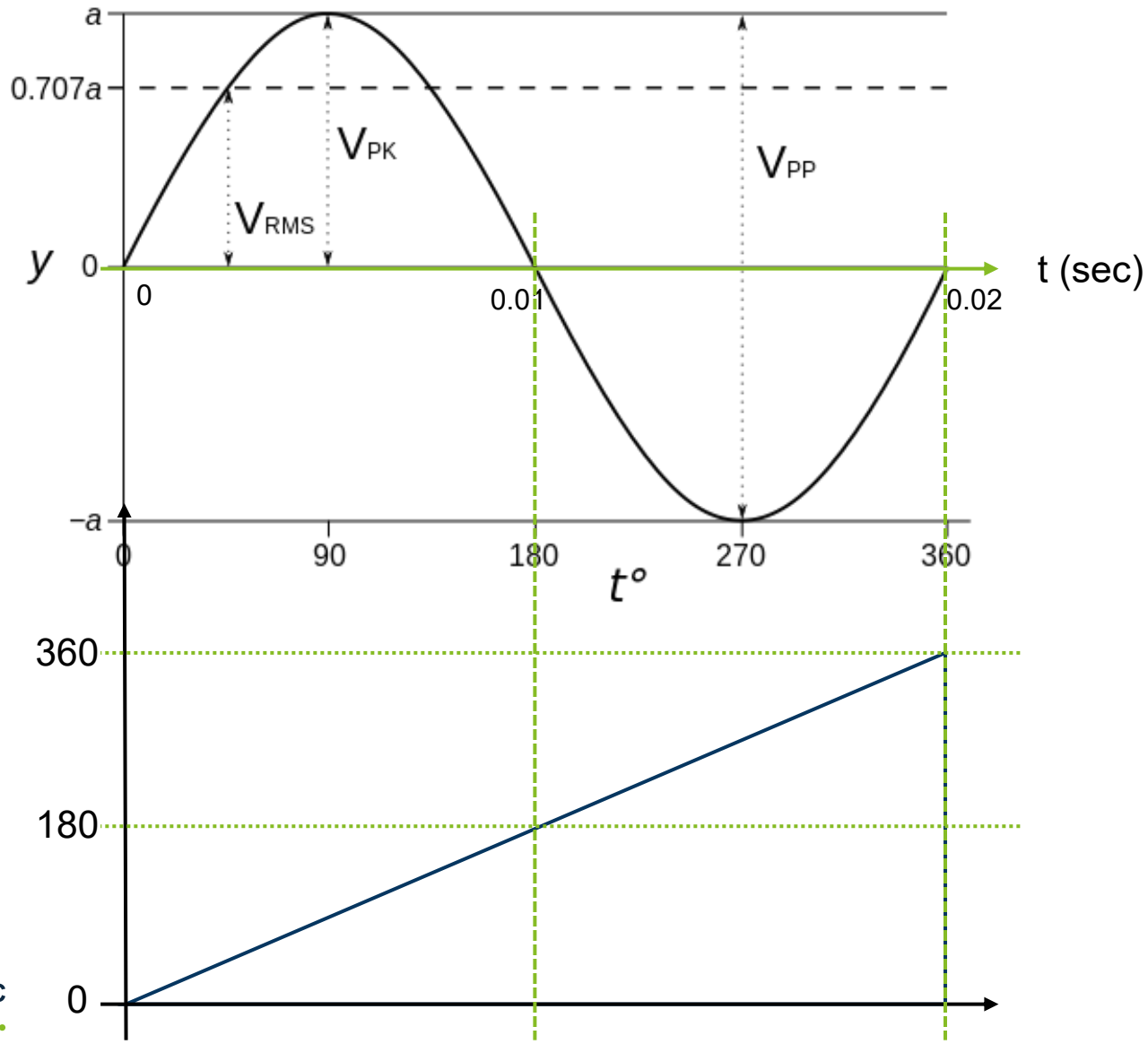


Explore

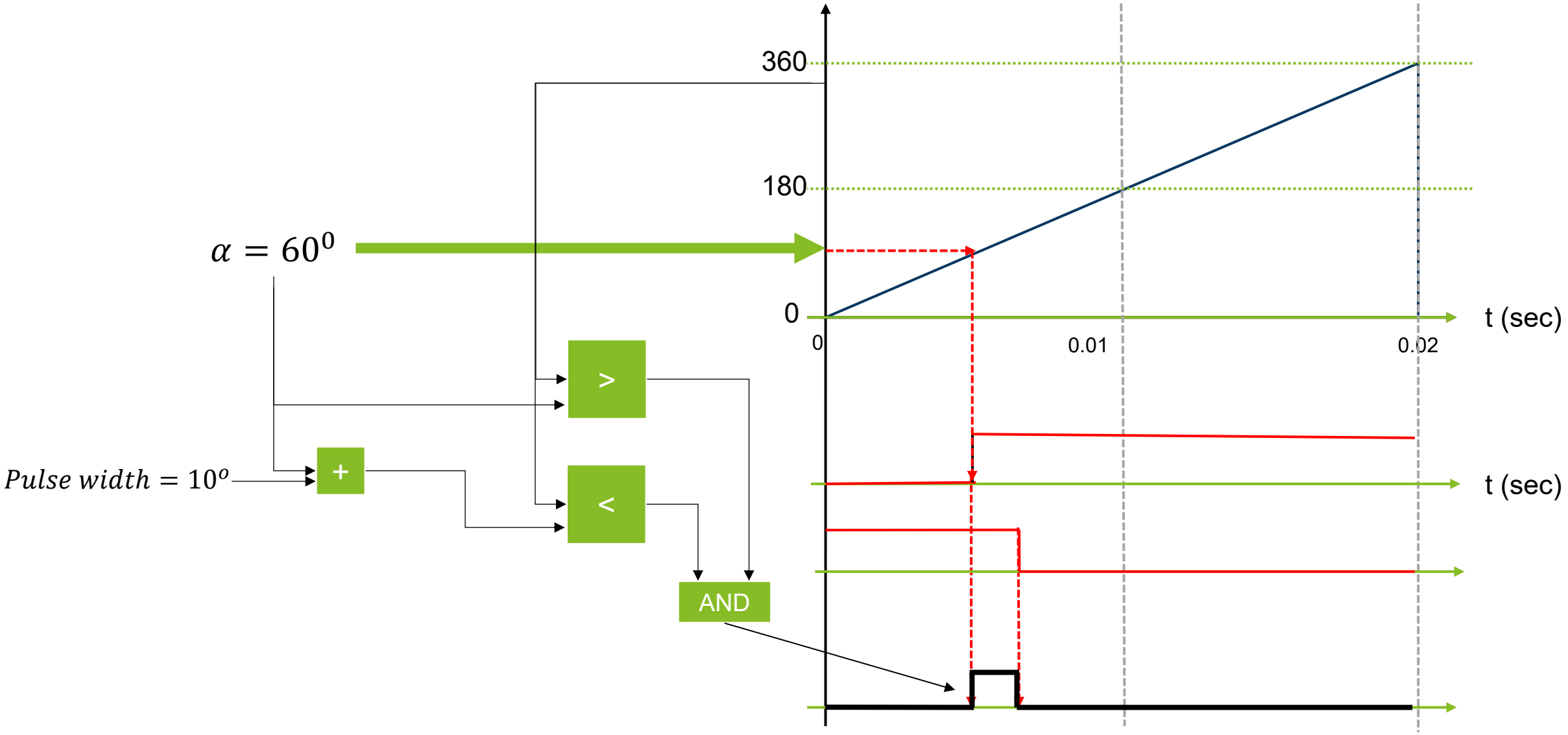
- **R – Load**
  - Firing angle: 0, 30, 60, 90
- **RL – Load**
  - Firing angle: 0, 30, 60, 90

Thyristor Pulse Generator

Pulse Generator



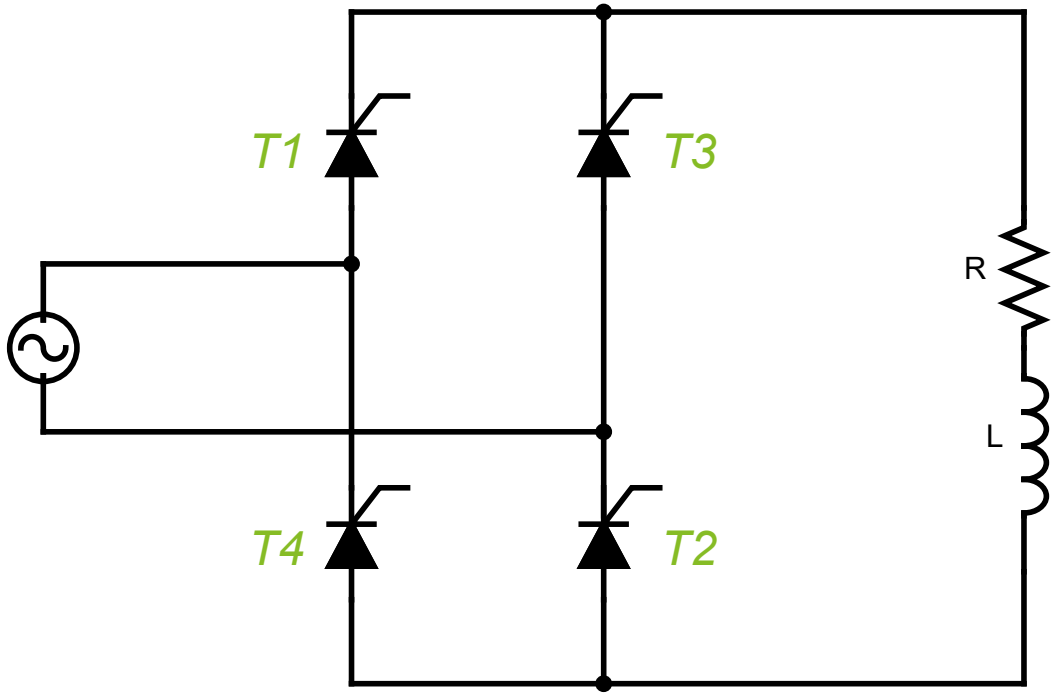
Pulse Generator

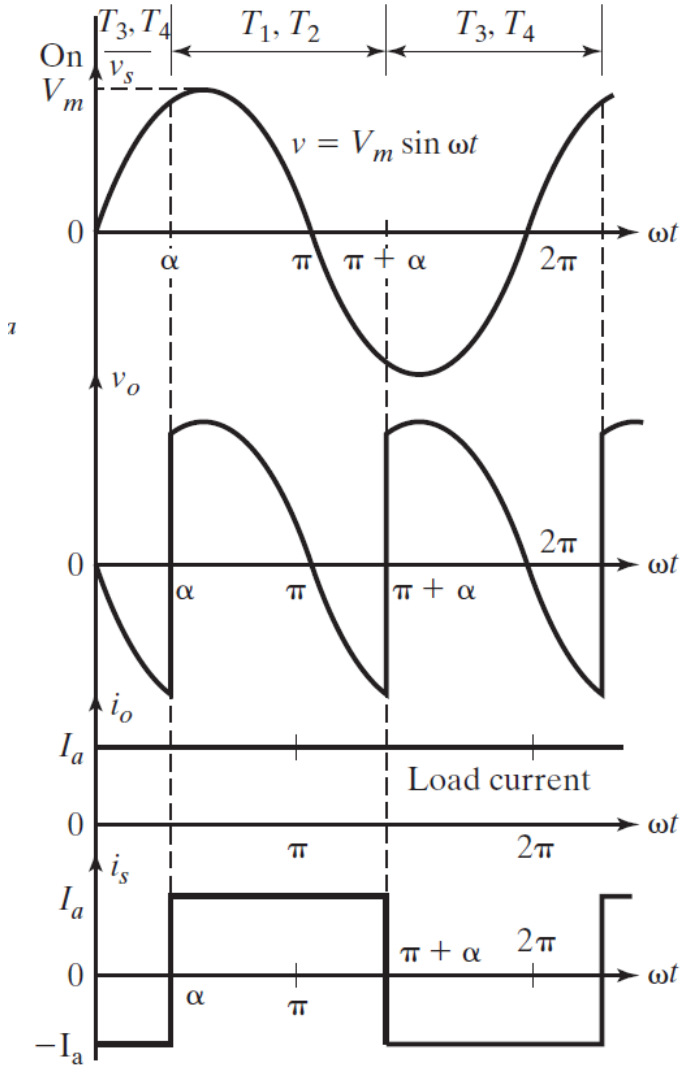


Full wave-controlled rectifier

Condition angle: 180^0

Sequence of conduction: *T1-T2*, *T3,T4*





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