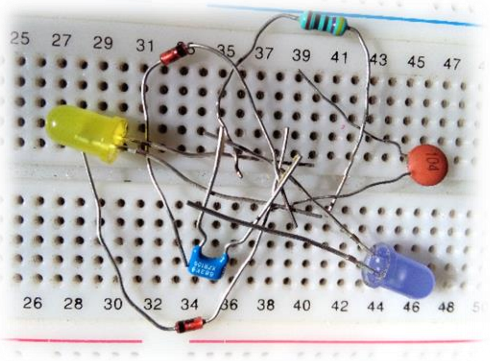
ELECTRONIC DEVICES

Assist. prof. Laura-Nicoleta IVANCIU, Ph.D.

C4 – DR rectifiers. DRC rectifiers. LEDs. Photodiodes.

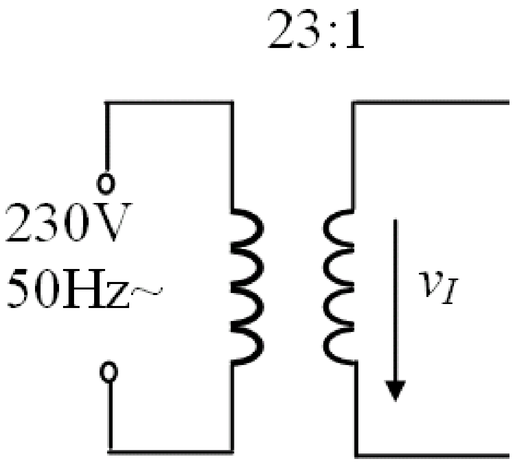


Contents

- DR rectifiers – half-wave and full-wave
- DRC rectifiers (power supply filtering)
- LEDs and photodiodes

DR rectifiers

The input voltage is obtained from the secondary winding of a transformer

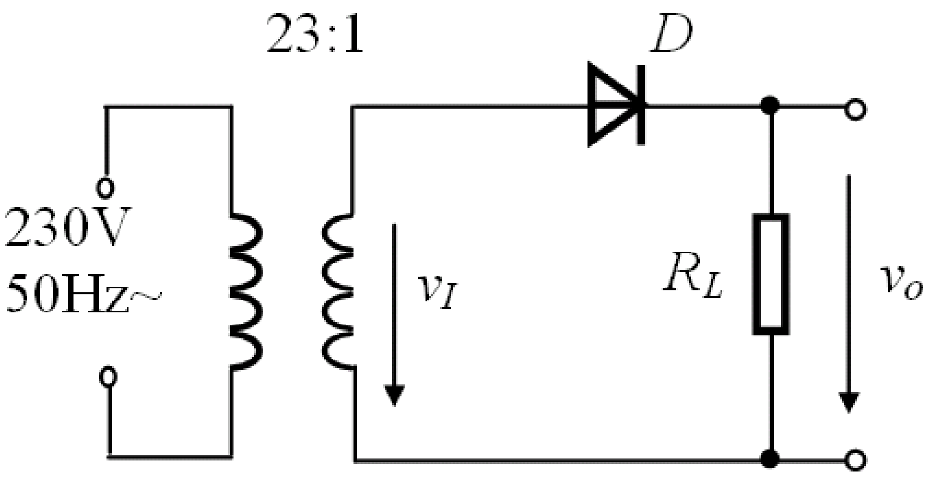


$$\widehat{V_I} = \frac{\widehat{V_S}}{n}$$, n–transformer ratio

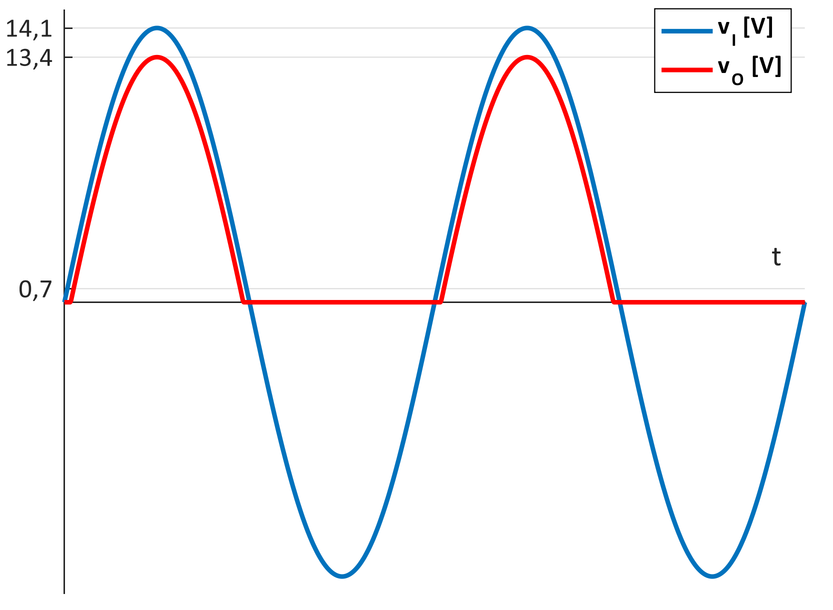
$$\widehat{V_I} = \frac{230\sqrt{2}}{23} = 14.1V$$

Shape of v_I?

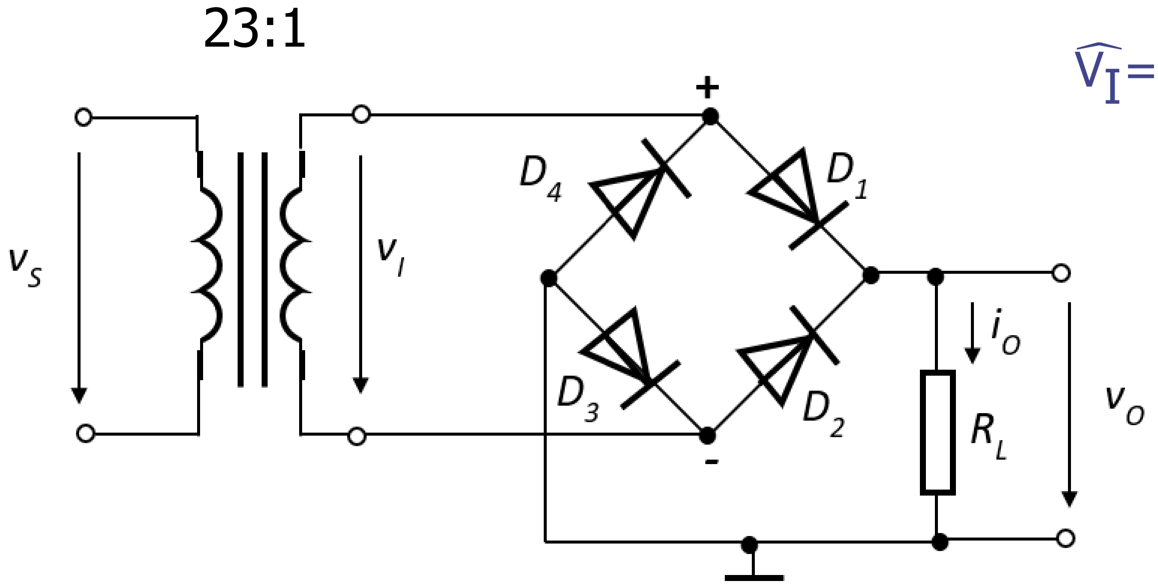
➢ Half-wave DR rectifier



$$\widehat{V_I} = \frac{230\sqrt{2}}{23} = 14.1\text{V}$$

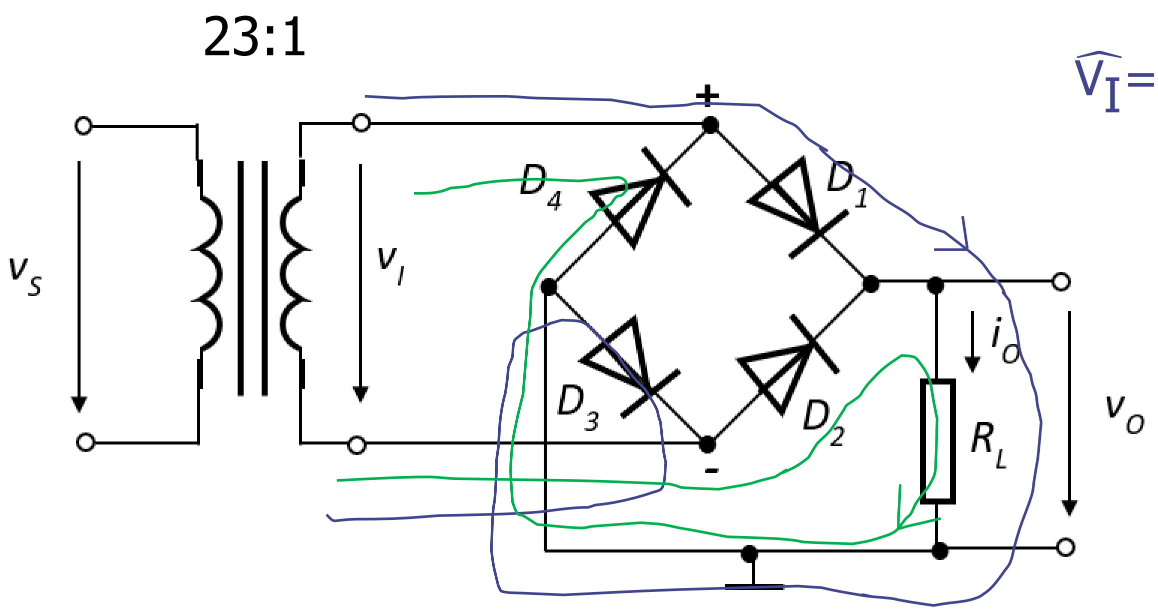


➢ Full-wave DR rectifier – diode bridge



$$\widehat{V_I} = \frac{230\sqrt{2}}{23} = 14.1\text{V}$$

Full-wave DR rectifier – diode bridge



$\widehat{V_I} = \frac{230\sqrt{2}}{23} = 14.1V$

- positive half, $v_I > 1.4$ V

D_1, D_3 – (on)

D_2, D_4 – (off)

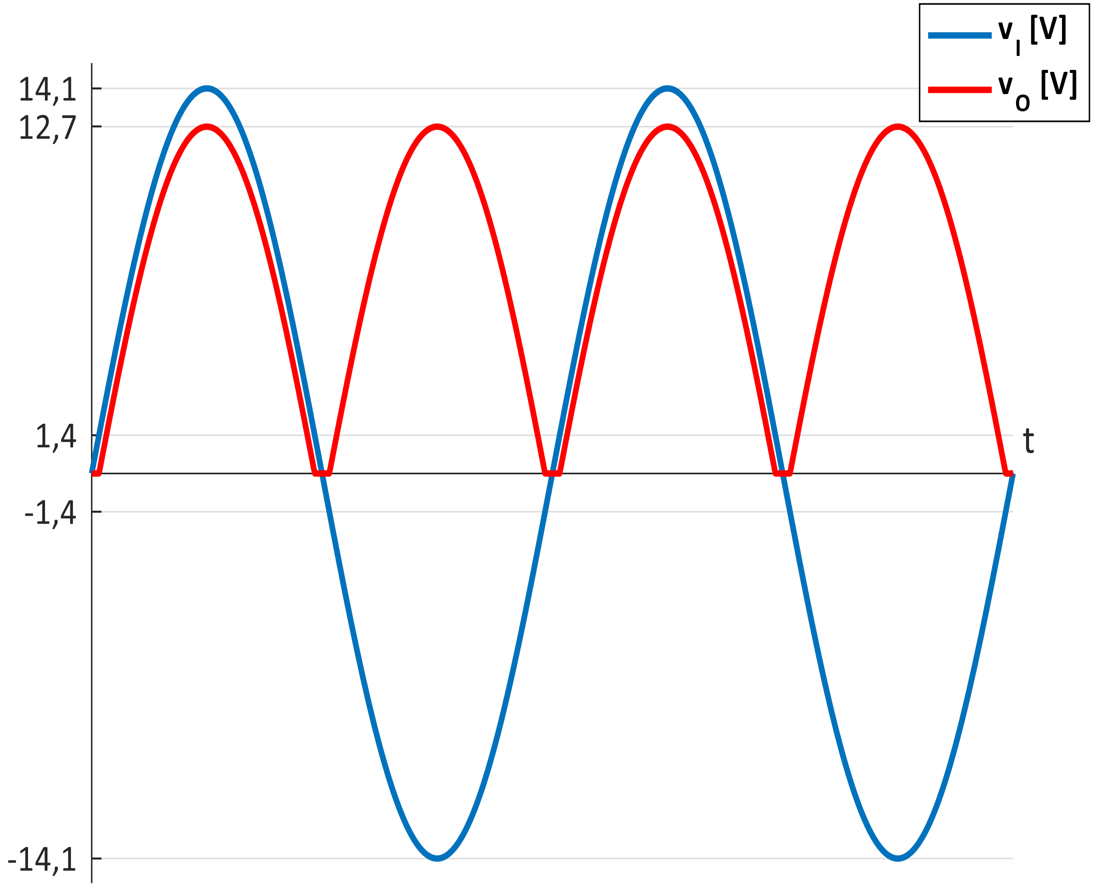
- negative half, $v_I < -1.4$ V

D_1, D_3 – (off)

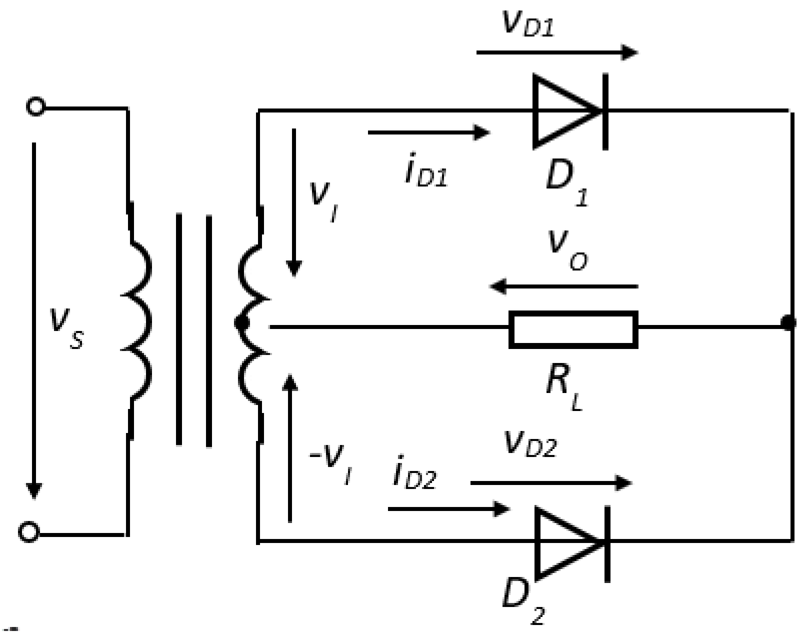
D_2, D_4 – (on)

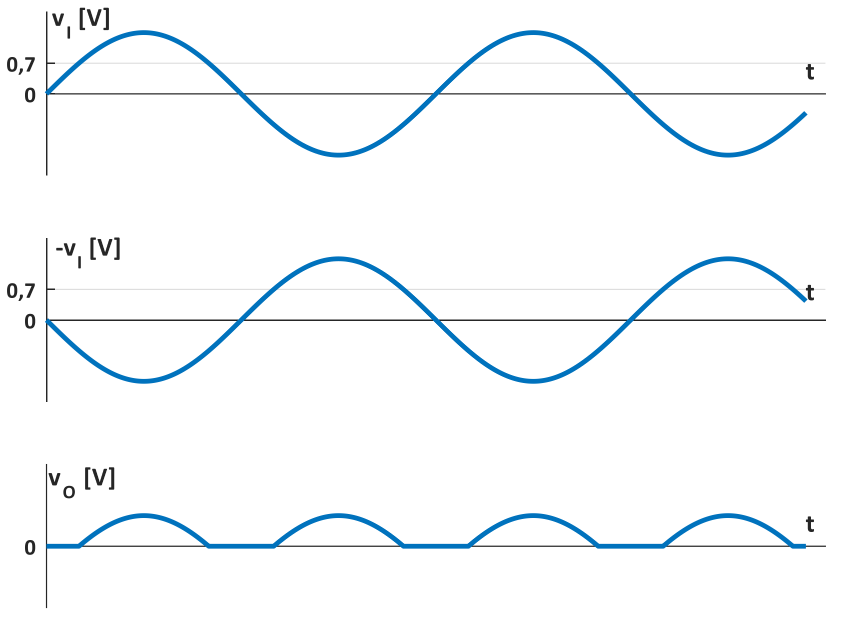
➢ Full-wave DR rectifier – diode bridge

waveforms



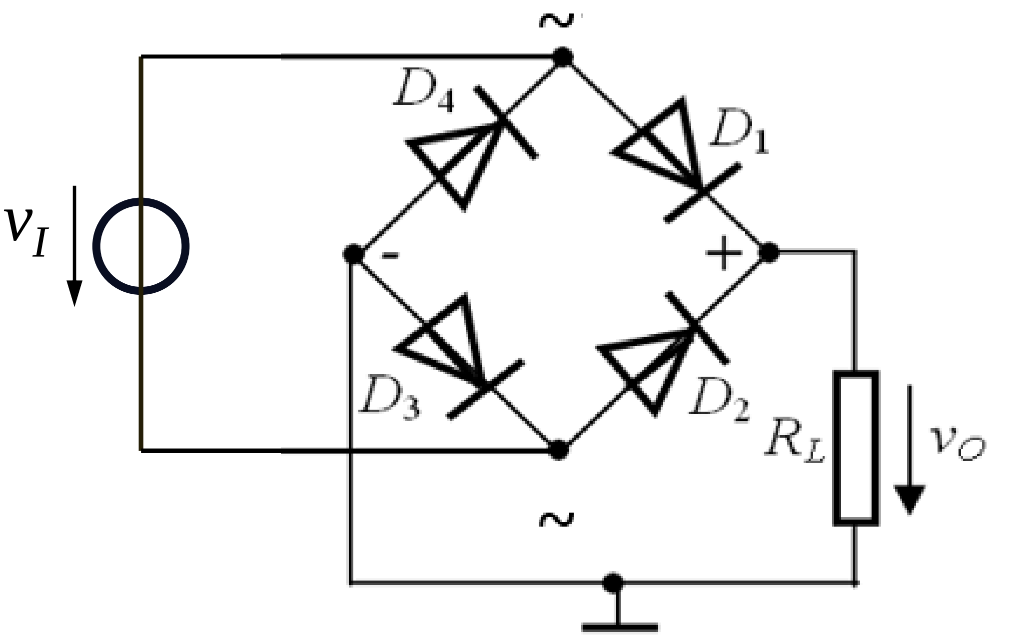
➢ Full-wave DR rectifier – center-tapped transformer





Example

$$v_I(t) = \hat{V}_I \sin \omega t$$



For the circuit in the figure, $R_L = 50\ \Omega$. Assume $\hat{V}_I = 5$ V.

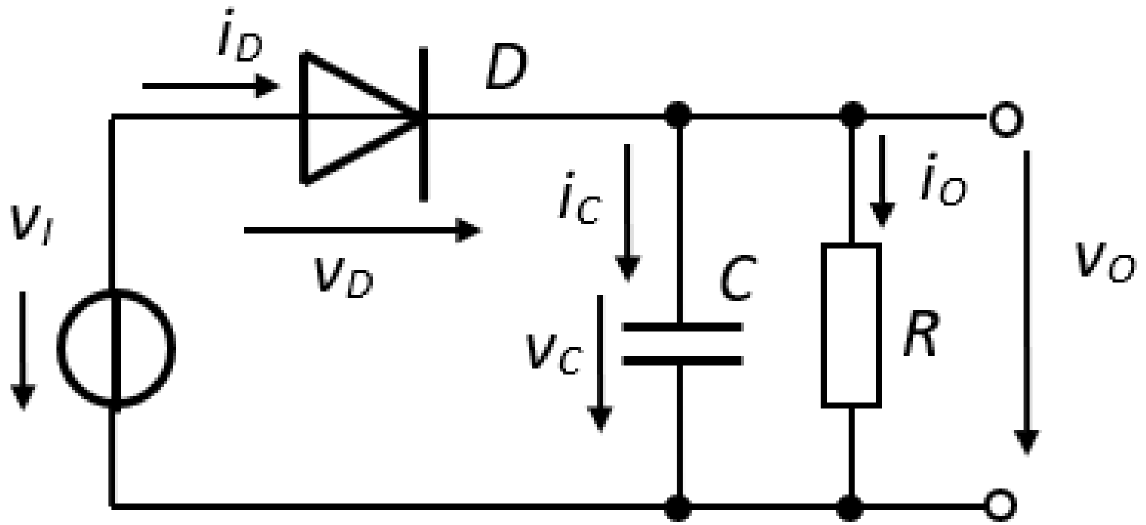
a) Plot $v_I(t)$, $v_O(t)$ and $i_O(t)$.

b) Compute the values of the maximum reverse voltage v_{DR} across each diode and the maximum forward current through each diode.

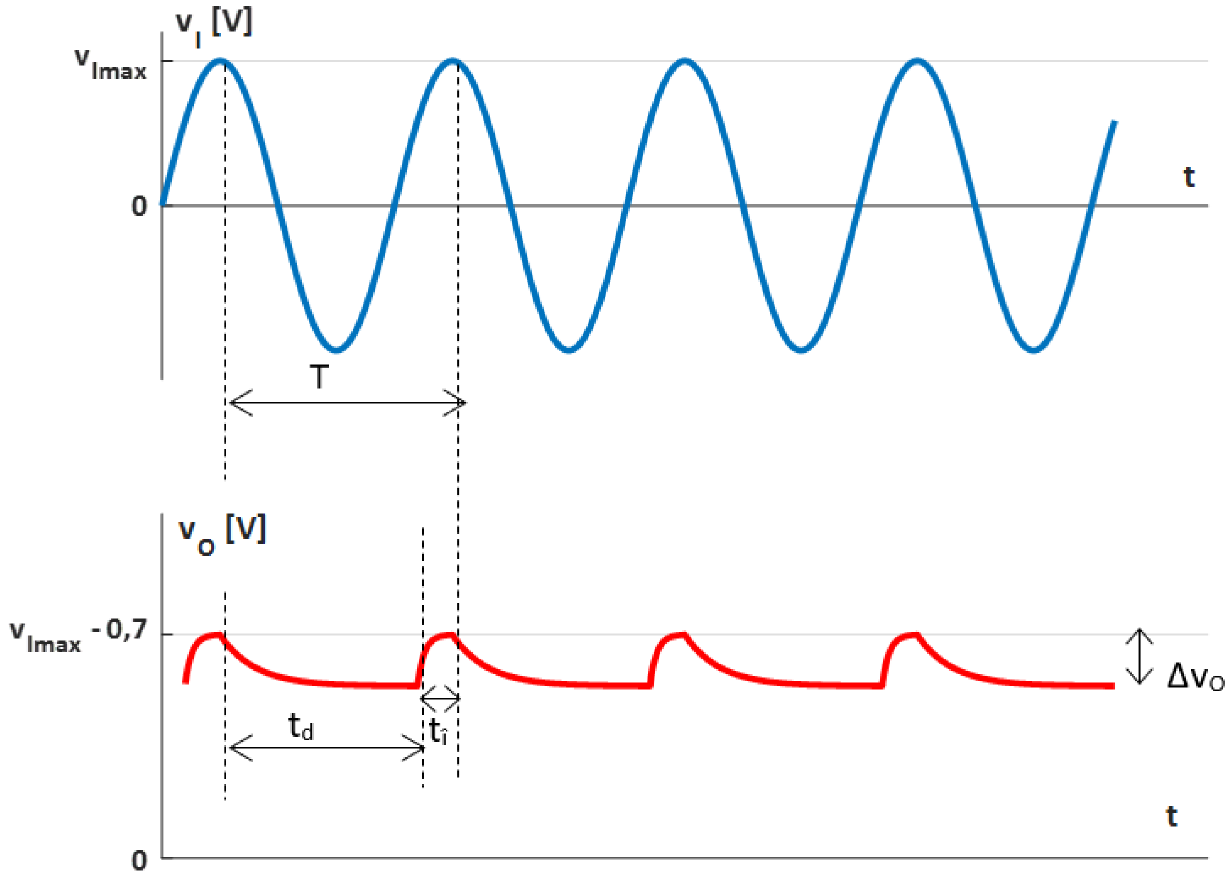
c) Repeat a) and b) assuming $\hat{V}_I = 100$ V.

➢ Half-wave DRC rectifier w/ capacitive filter (loaded positive peak detector)

- v_I is the voltage in the secondary winding of a step-down line transformer
- How can the output voltage (on a load resistor) be almost dc?



➢ Half-wave DRC rectifier w/ capacitive filter (loaded positive peak detector)



➢ Half-wave DRC rectifier w/ capacitive filter (loaded positive peak detector)

Between two successive voltage peaks, D – (off) and discharges through R

$$v_c(t) = e^{-\frac{t}{\tau}} \cdot V_C(0) + \left(1 - e^{-\frac{t}{\tau}}\right) \cdot V_C(\infty)$$

$$V_C(0) = V_{Omax}$$
$$V_C(\infty) = 0\ V$$

If RC >>T => the capacitor discharge during t_d can be approximated with a linear variation of the output voltage (across the capacitor)

$$e^{-\frac{T}{\tau}} \cong 1 - \frac{T}{\tau}$$

$$V_{Omin} \cong \left(1 - \frac{T}{\tau}\right) \cdot V_{Omax}$$

$$V_{Omax} - \Delta v_O \cong V_{Omax} - \frac{T}{\tau} \cdot V_{Omax}$$

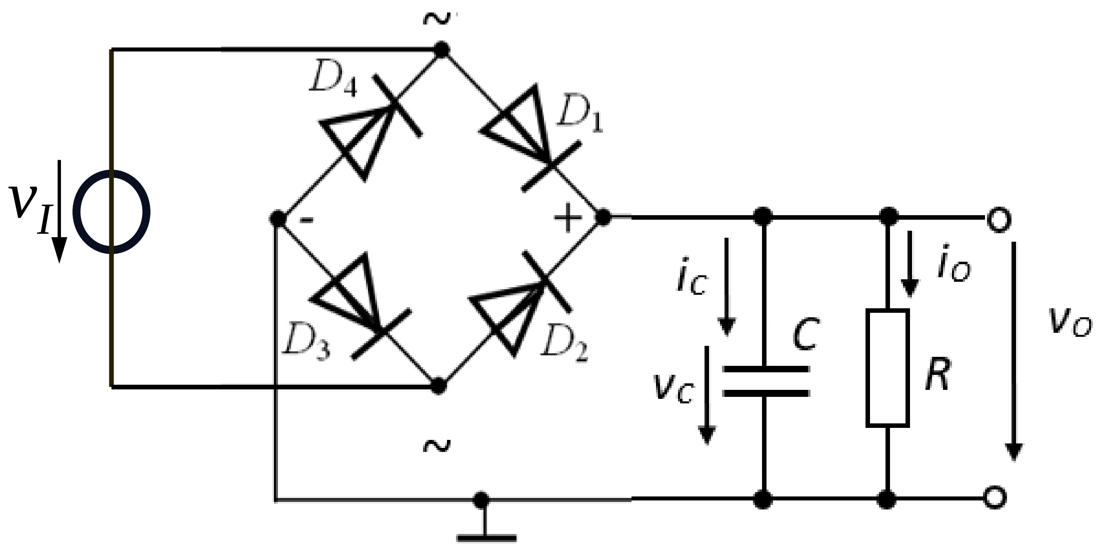
$$\Delta v_O \cong \frac{T}{\tau} \cdot V_{Omax}$$

Output voltage ripple (variation)

$$\Delta v_O \cong \frac{T}{R \cdot C} \cdot (V_{Imax} - 0.7)$$

$$\Delta v_O \cong \frac{V_{Imax} - 0.7}{R \cdot C \cdot f}$$

Full-wave DRC rectifier w/ capacitive filter



Output voltage ripple (variation)

$$t_d \cong \frac{T}{2}$$

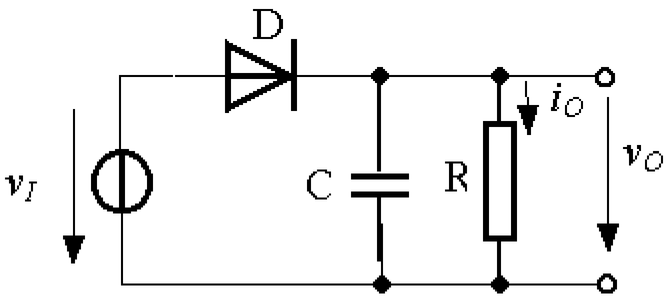
$$\Delta v_O \cong \frac{T}{2 \cdot R \cdot C} \cdot (V_{Imax} - 1.4)$$

$$\Delta v_O \cong \frac{V_{Imax} - 1.4}{2 \cdot R \cdot C \cdot f}$$

DRC rectifiers (power supply filtering)

Example

$\hat{V}_I = 10.7\text{V}$ f=50Hz $R_L = 100\Omega$ $\Delta v < 1.5\text{V}$ C = ?



$$\hat{V}_O = \hat{V}_I - 0.7\text{V} = 10\text{V}$$

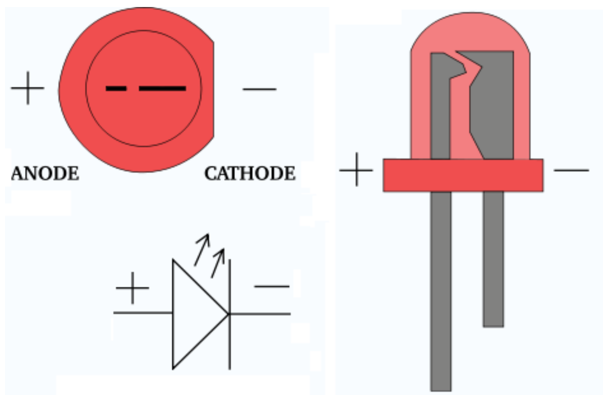
$$\Delta v = \frac{\hat{V}_O}{fRC} < 1.5\text{V}$$

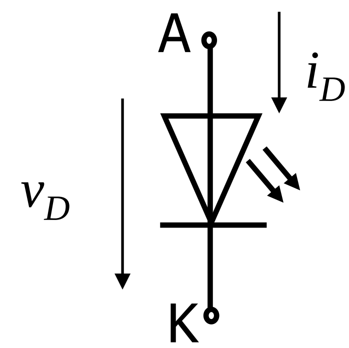
$$C > \frac{\hat{V}_O}{1.5\text{V} fR} = \frac{10}{1.5 \cdot 50 \cdot 100} = 1333\,\mu\text{F} \qquad C > 1333\,\mu\text{F}$$

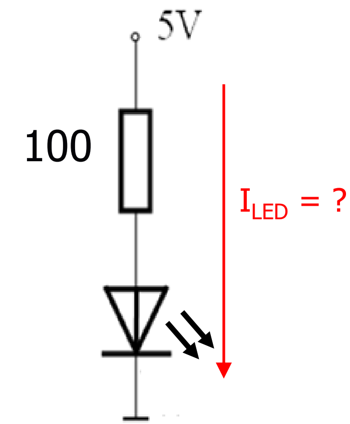
Solution: electrolytic capacitor, C =1500 µF/25 V

- What is the actual value of the output ripple?
- What should be a new value of C, to reduce the output ripple to half of the initial value?
- Solve again, assuming full-wave rectification.

➢ LED – light emitting diode



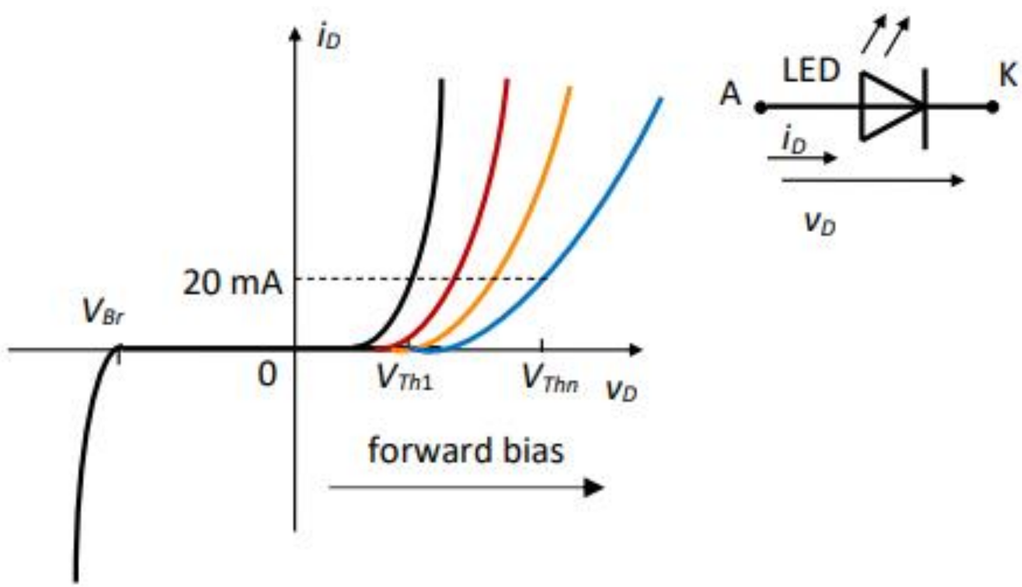




- behavior similar to conventional diodes
- $V_{LED, on}$ = 1.5 V…3 V (forward voltage drop)
- in forward bias, the LED lights up:
    - red, yellow, green, blue, white
    - IR – remote control
- emits radiation in the visible, infrared, or laser range
- typical current: 5 mA to 20 mA
- power LED: 3.5 V @ 500 mA

➢ LED – excerpt from datasheet

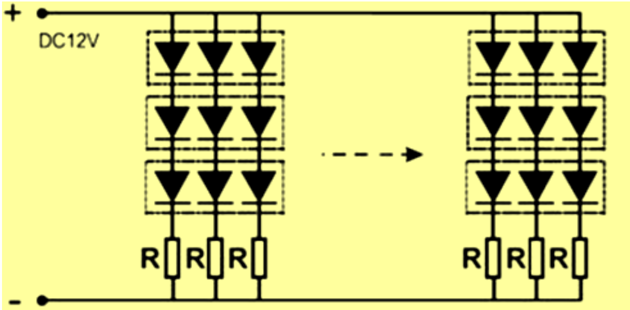
ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified) **TLHR440., TLHO440., TLHY440., TLHG440., TLHP440.**				
PARAMETER	**TEST CONDITION**	**SYMBOL**	**VALUE**	**UNIT**
Reverse voltage		V_R	6	V
DC forward current		I_F	30	mA
Surge forward current	$t_p \leq 10$ µs	I_{FSM}	1	A
Power dissipation	$T_{amb} \leq 60$ °C	P_V	100	mW



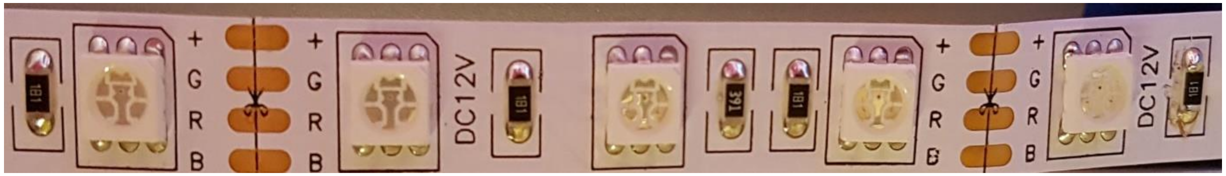
LEDs and photodiodes

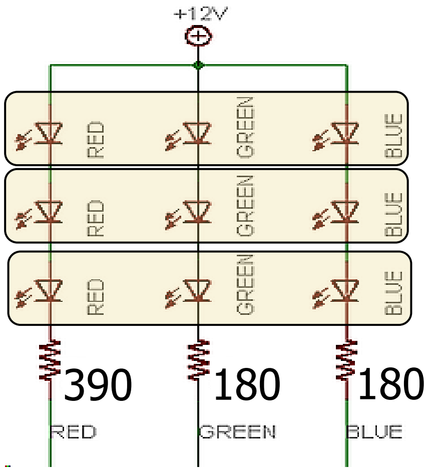
➢ LED strips

Single Color LED Strip



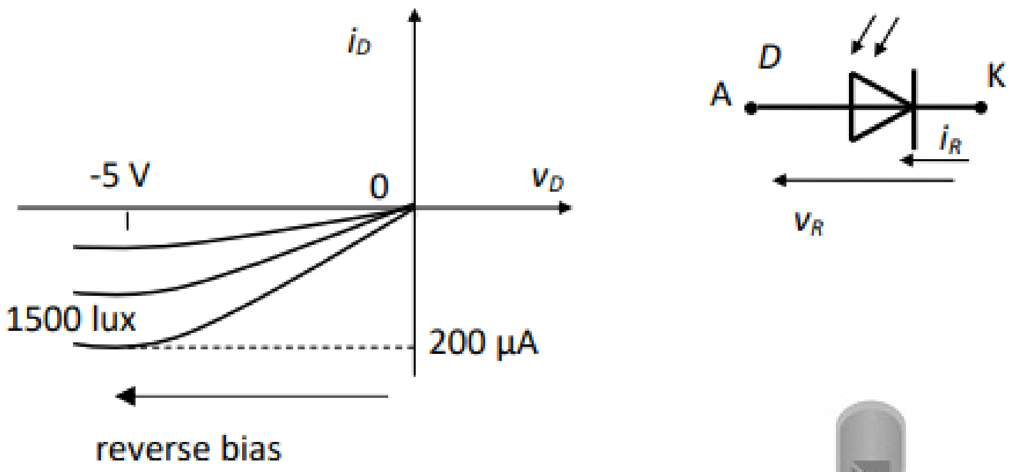
RGB LED Strip

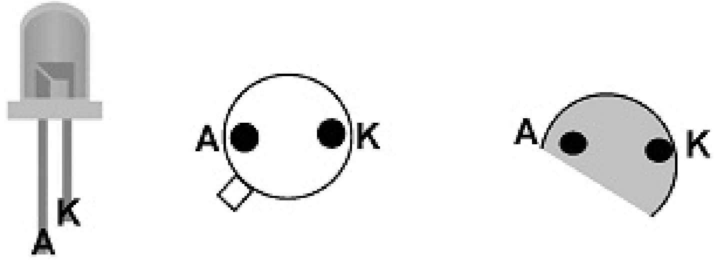




LEDs and photodiodes

➢ Photodiodes





- photosensitive pn-junction
- transforms light into electrical signal (current)
- used in reverse bias

➢ Photodiodes - excerpt from datasheet

EVERLIGHT

EVERLIGHT ELECTRONICS CO., LTD.

DEVICE NUMBER : DPD-033-071 REV : 1.0
ECN : PAGE : 1/7

5mm Silicon PIN Photodiode,T-1 3/4

MODEL NO : PD333-3C/H0/L2

■ Features :

- Fast response time
- High photo sensitivity
- Small junction capacitance

■ Description :

PD333-3C/H0/L1 is a high speed and high sensitive PIN photodiode in a standard 5 ϕ plastic package. The device is spectrally matched to infrared emitting diode.

■ Applications :

- High speed photo detector
- Camera
- Infrared remote controller for TVs VCR, audio equipment, air conditioner, etc.

■ Absolute Maximum Ratings at Ta = 25℃

Parameter	Symbol	Rating	Unit	Notice
Reverse Voltage	V_R	32	V	
Power Dissipation	Pd	150	mW	
Lead Soldering Temperature	Tsol	260	℃	4mm from mold body less than 5 seconds
Operating Temperature	Topr	-25 ~ +85	℃	
Storage Temperature	Tstg	-40 ~ +85	℃	

Summary

Only now we can safely say diodes are not a secret anymore, after studying:

- DR rectifiers – half-wave and full-wave
- DRC rectifiers (power supply filtering)
- LEDs and photodiodes

Next week: Zener diodes. Operational amplifiers.