Electronic Circuits-1

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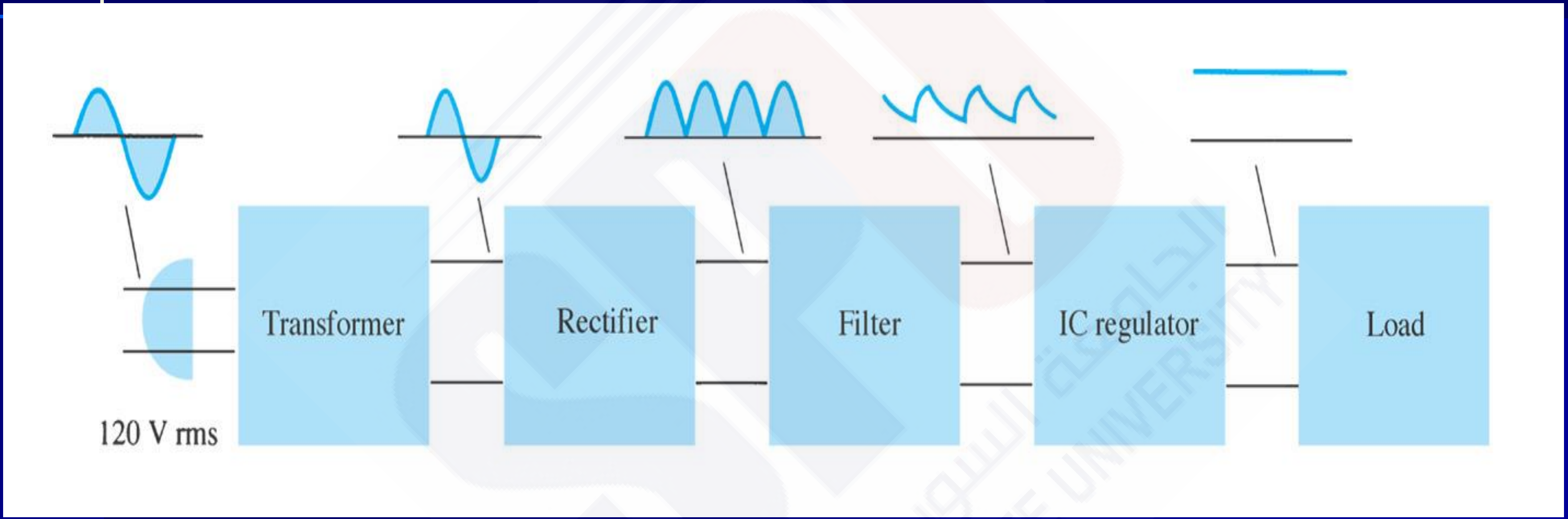
CONTENT

1. BJT Amplifier
2. FET Amplifier
3. Frequency Response of Amplifier
4. Operational Amplifier
5. Audio Power Amplifier
6. Linear-Digital ICs
7. Power Supplies
8. IC Technology (optional)

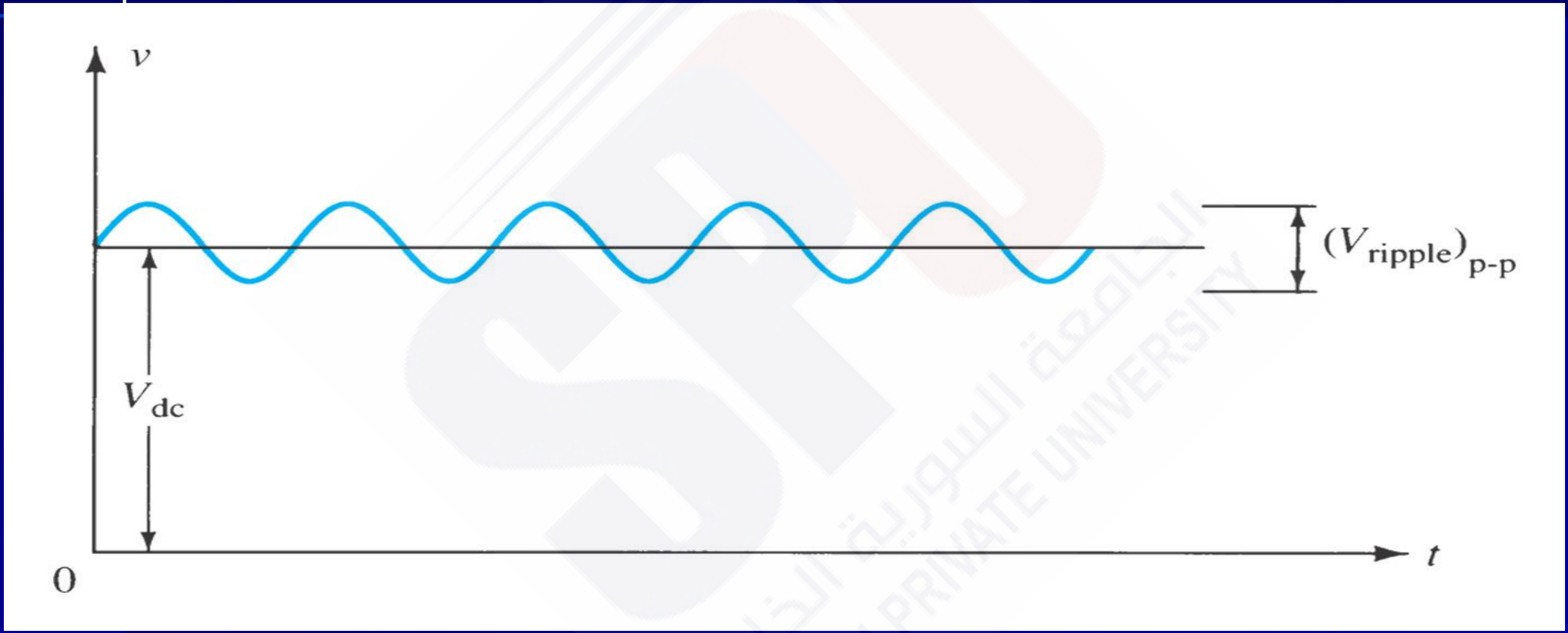
Chapter 8- Power Supplies

8.1 Introduction



Block Diagram of a typical power supply

8.2 General Filter Considerations



Ripple Factor

$$r = \frac{\text{ripple voltage(rms)}}{\text{dc voltage}} = \frac{V_r(rms)}{V_{dc}} \times 100\%$$

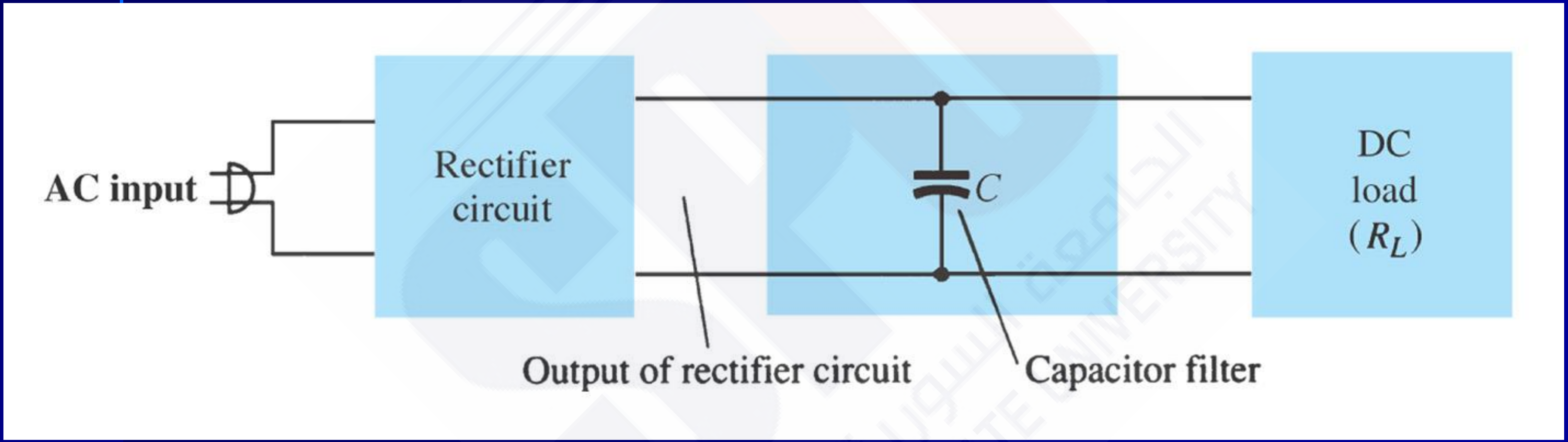
Voltage Regulation

$$\text{Voltage Regulation} = \frac{\text{no load voltage - full load voltage}}{\text{full load voltage}}$$

$$V.R. = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

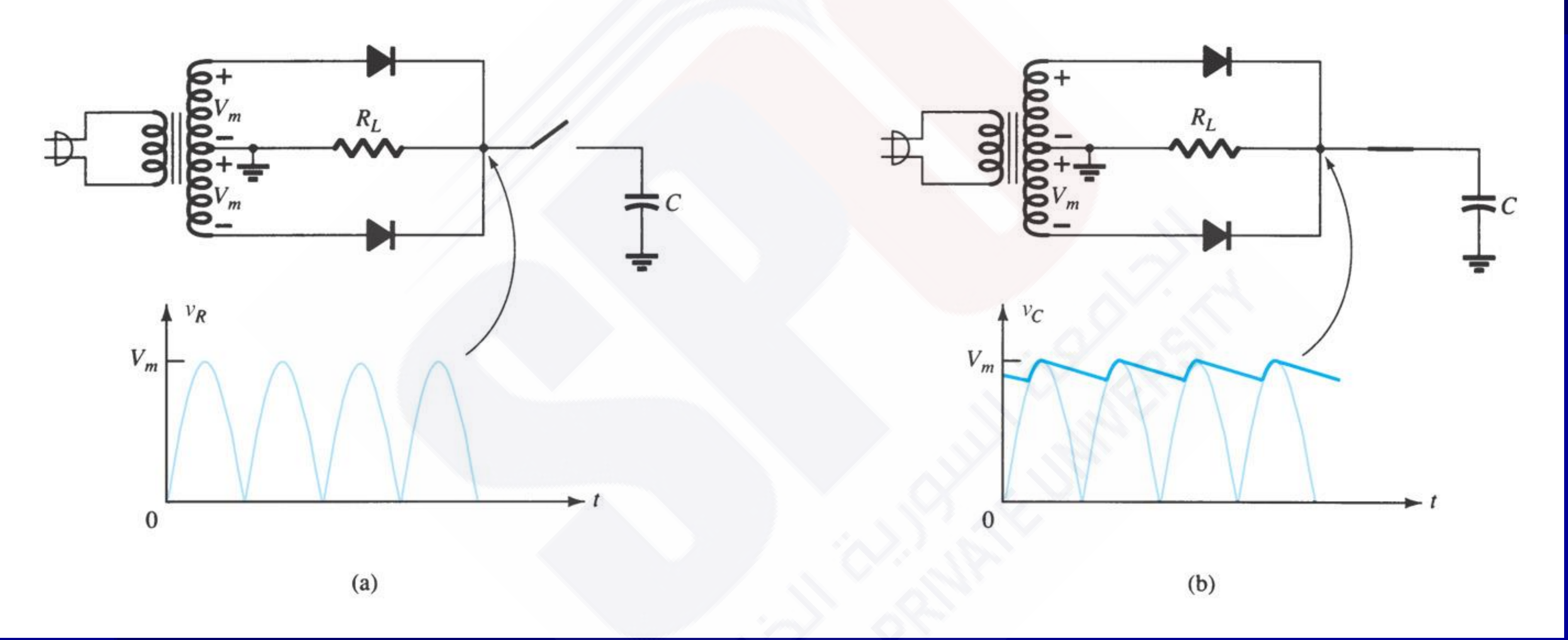
$$\text{Ideal Regulation} \Rightarrow \text{V.R.} = 0 \text{ (Ideal voltage source)}$$

8.3 Capacitor Filter

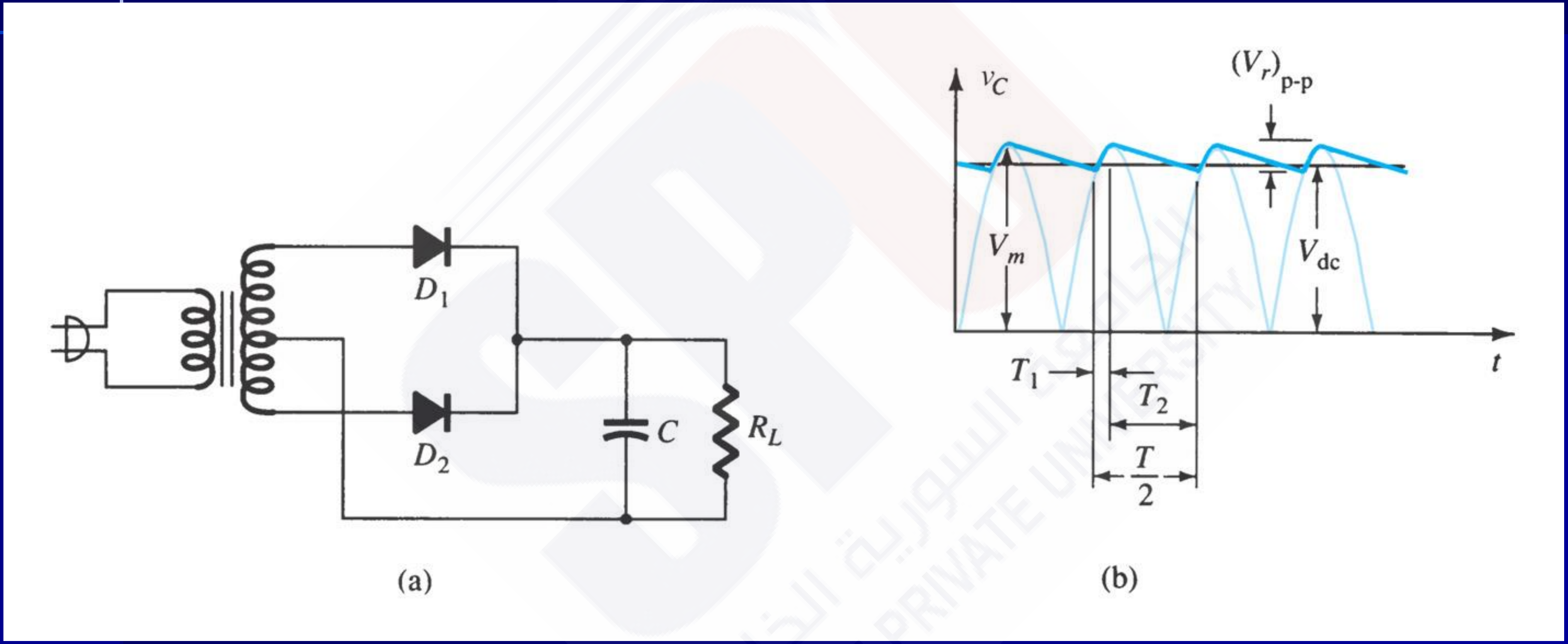


Simple Capacitor Filter

Simple Capacitor Filter

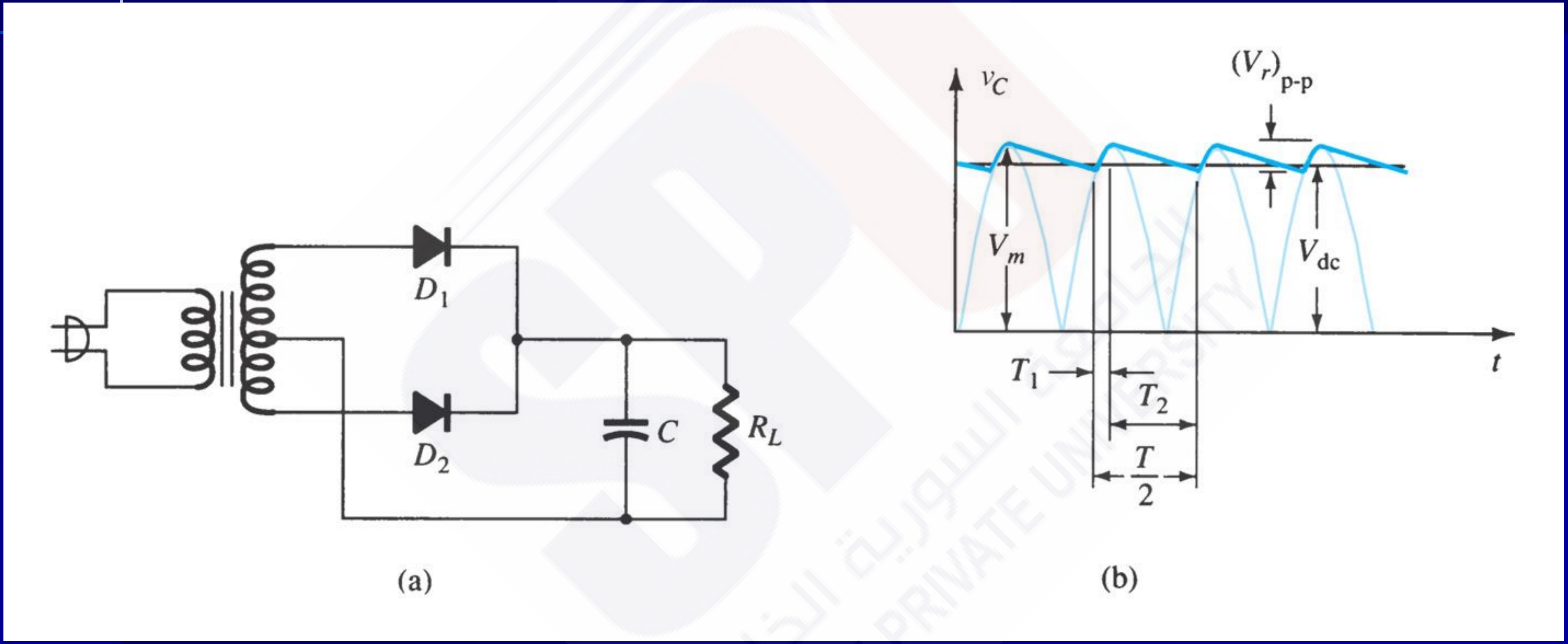


Simple Capacitor Filter



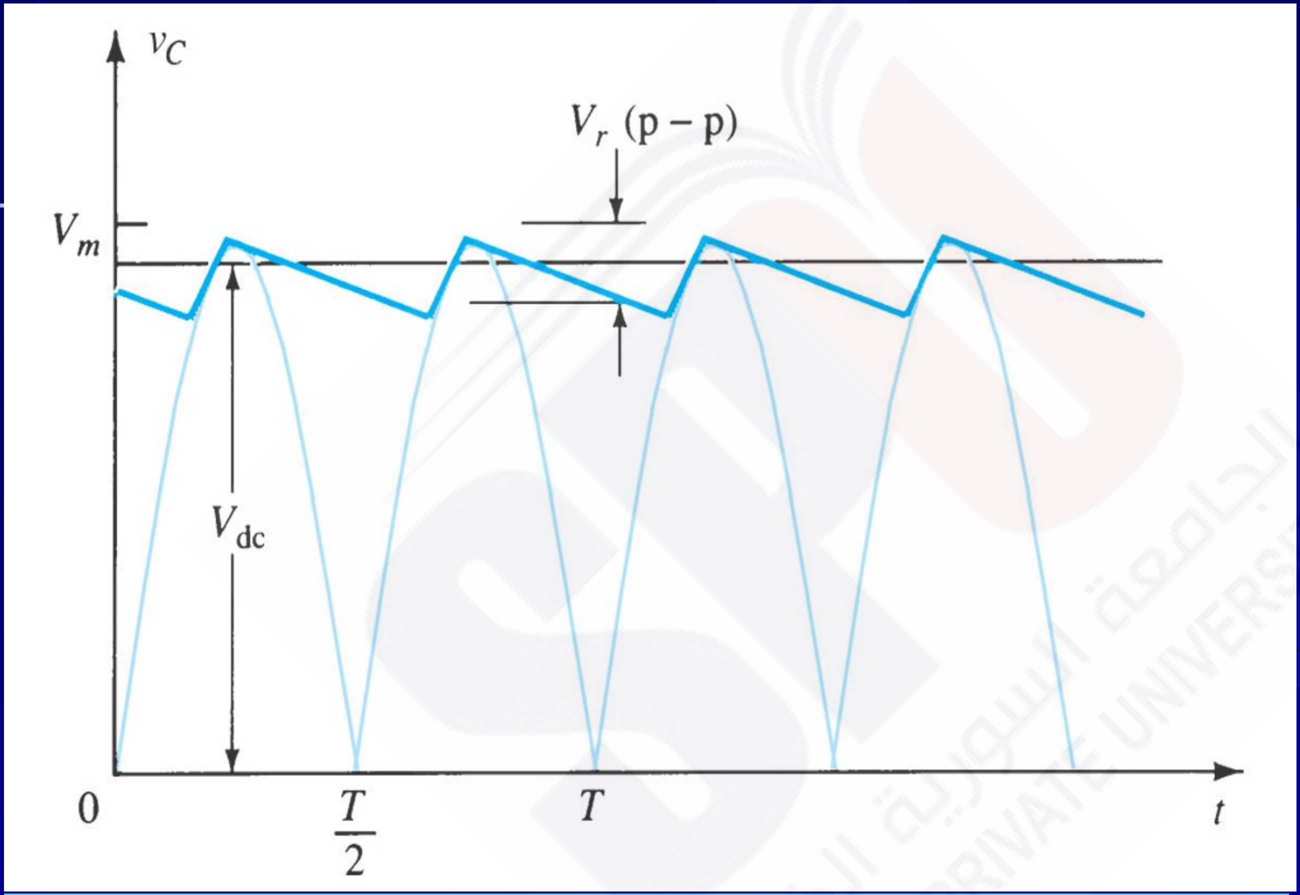
Effect of Load R_L

Simple Capacitor Filter



Effect of Load R_L : **$V_m = V_{dc}$ if $R_L = \infty$**

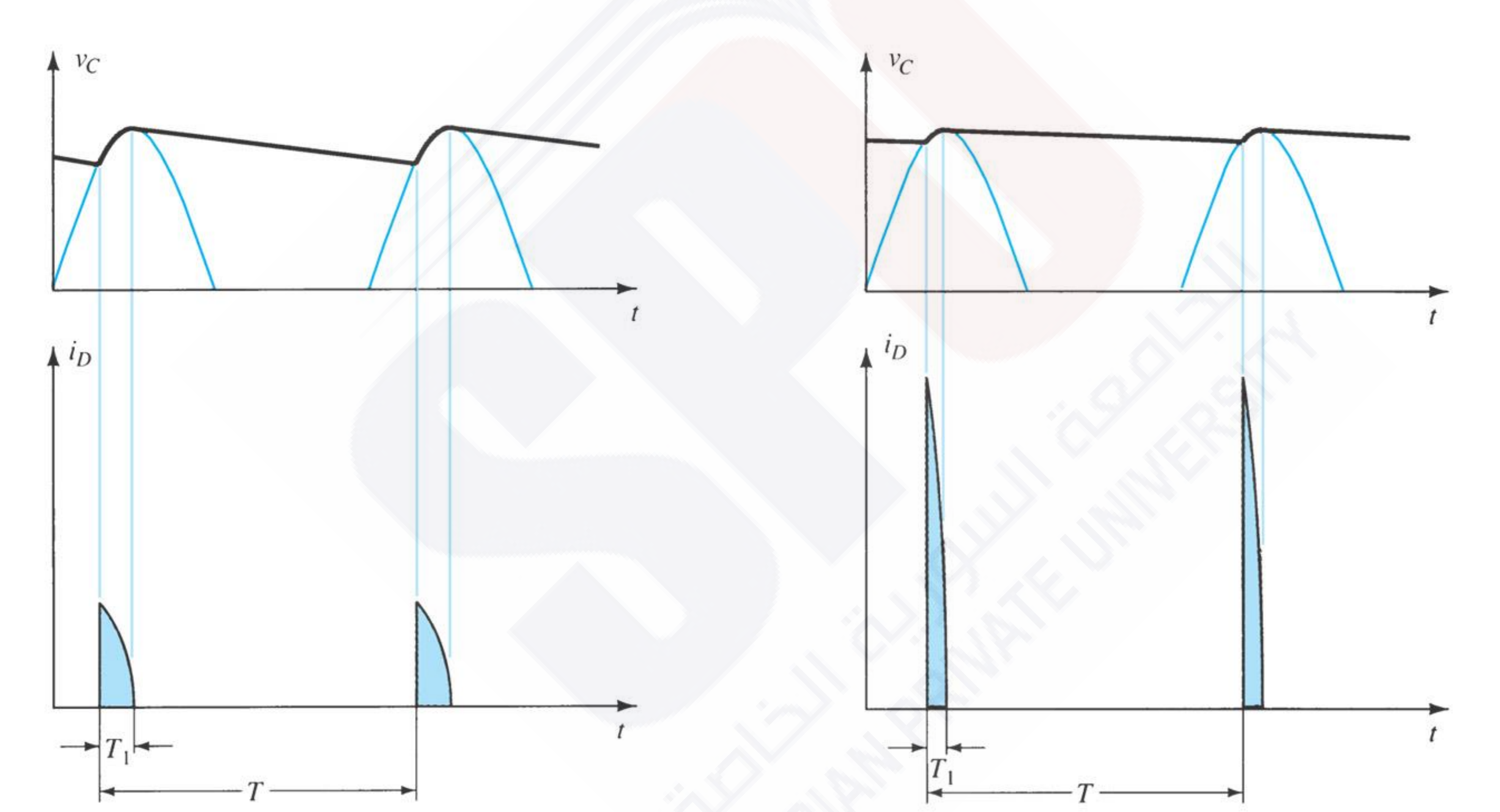
Output Waveform Times



$$Ripple\,Voltage : V_r(rms) = \frac{I_{dc}}{4\sqrt{3}\,fC} = \frac{2.4 I_{dc}}{C} = \frac{2.4 V_{dc}}{C R_L}$$

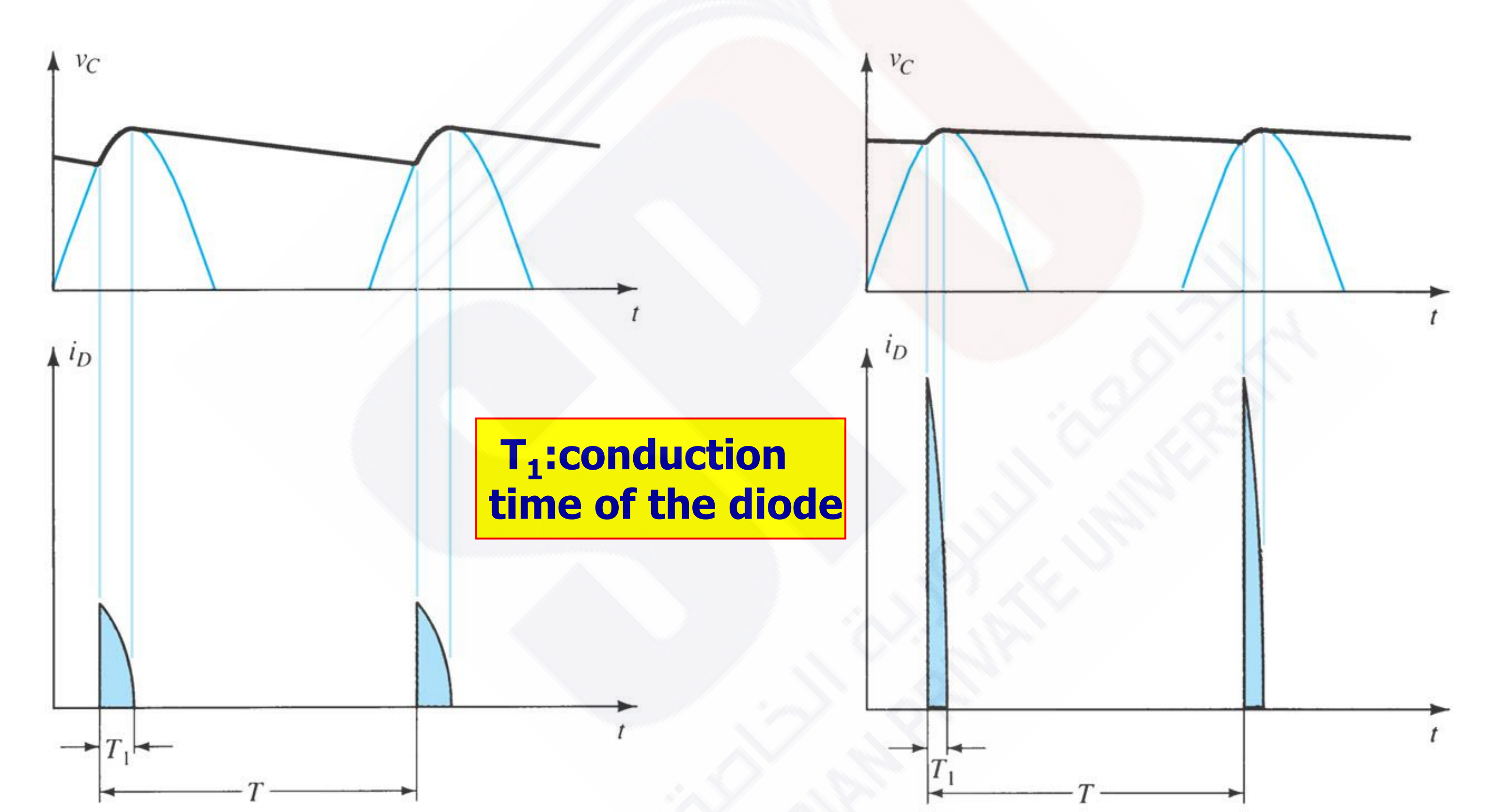
$f = 60\,Hz$, I_{dc} *in mA (ref. appendix C)*

Diode Conduction Period and Peak Diode Current



$$I_{dc} = \frac{T_1}{T} I_{peak} \;\; ; \;\; I_{peak} = \frac{T}{T_1} \; ; \;\; I_{dc} : \text{average current drawn from the filter}$$

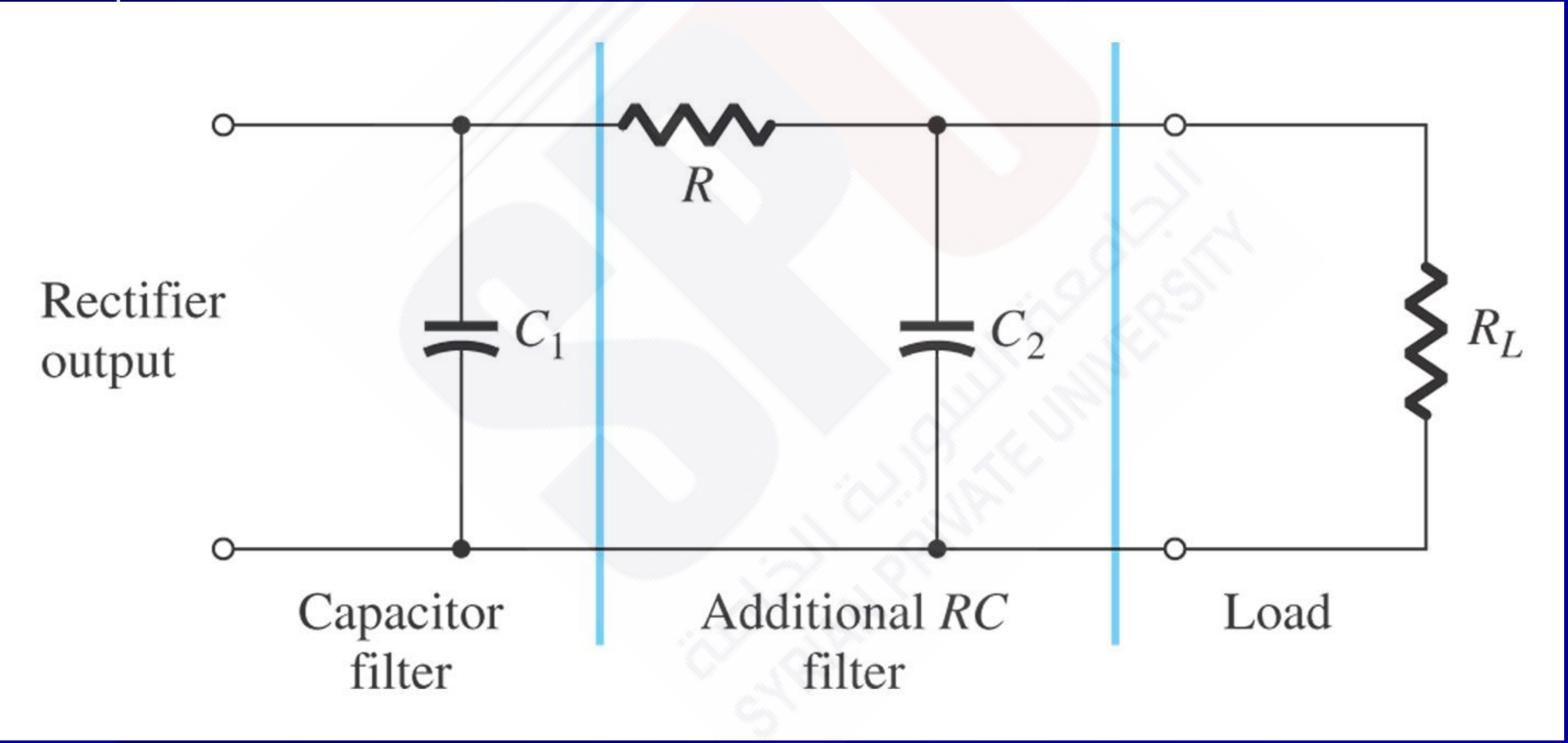
Diode Conduction Period and Peak Diode Current



T_1:conduction time of the diode

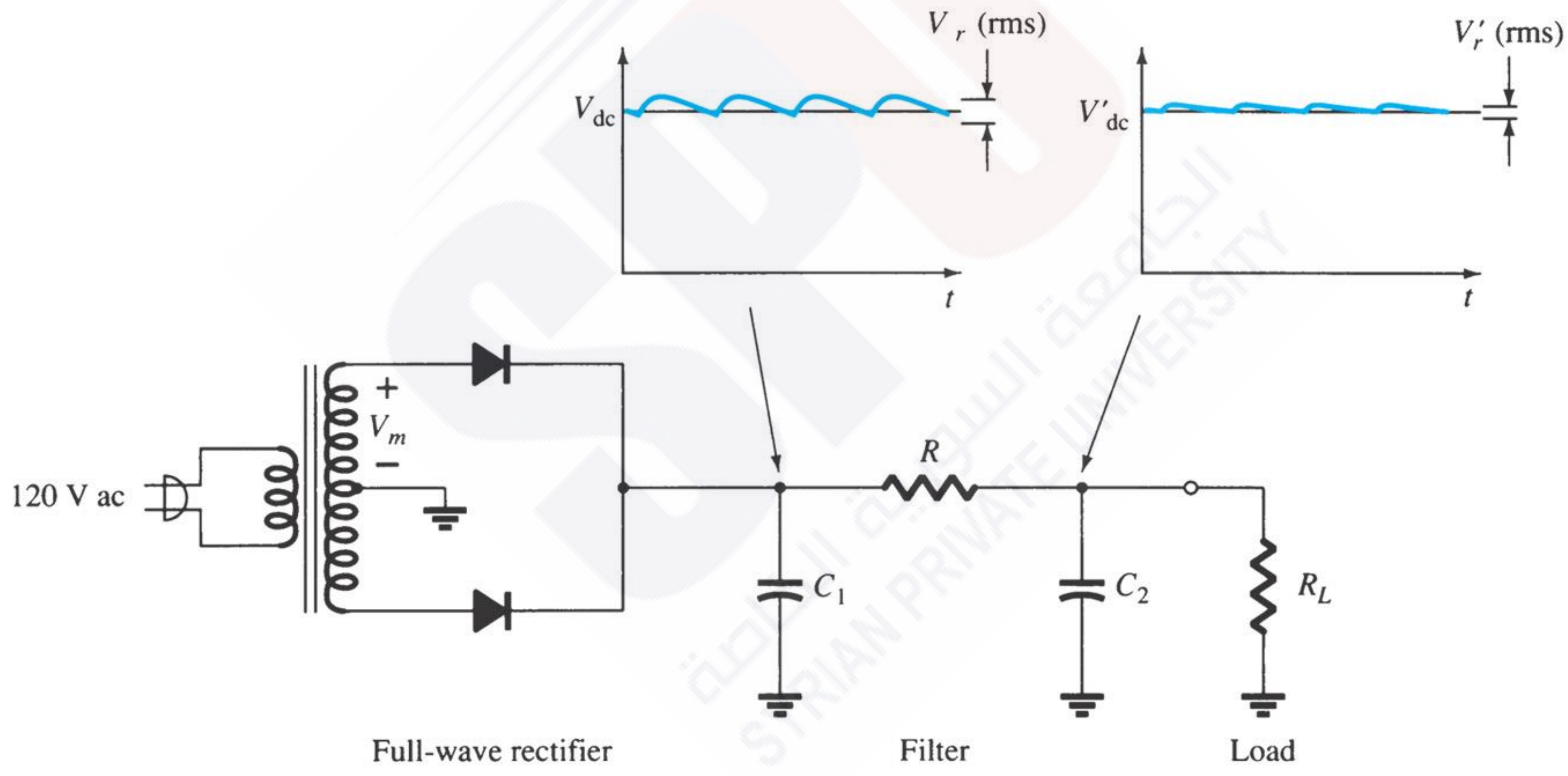
$$I_{dc} = \frac{T_1}{T} I_{peak} \;\; ; \;\; I_{peak} = \frac{T}{T_1} I_{dc} \;\; ; \;\; I_{dc} : \textit{average current drawn from the filter}$$

8.4 RC Filter

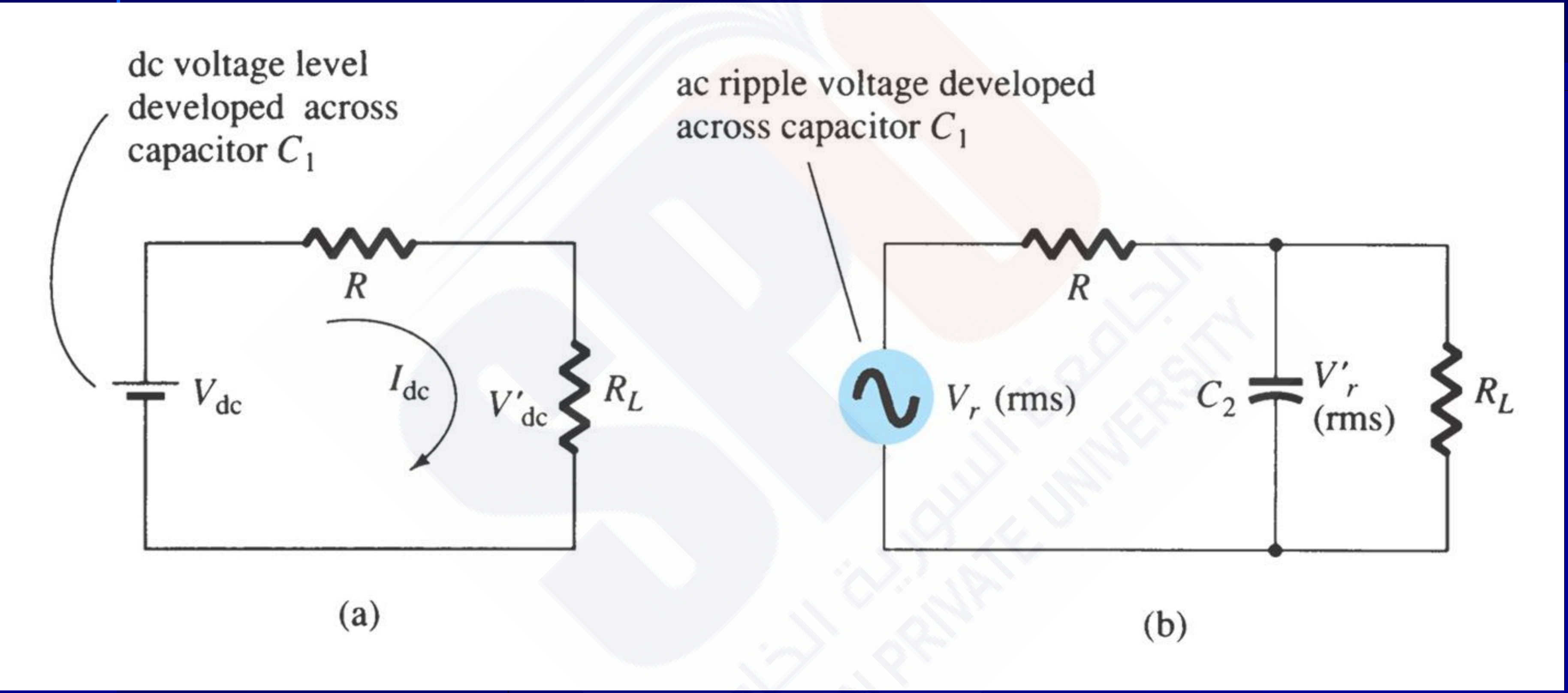


Rectifier
output
R
C1
C2
RL
Capacitor
filter
Additional RC
filter
Load

Full-wave rectifier and RC filter circuit

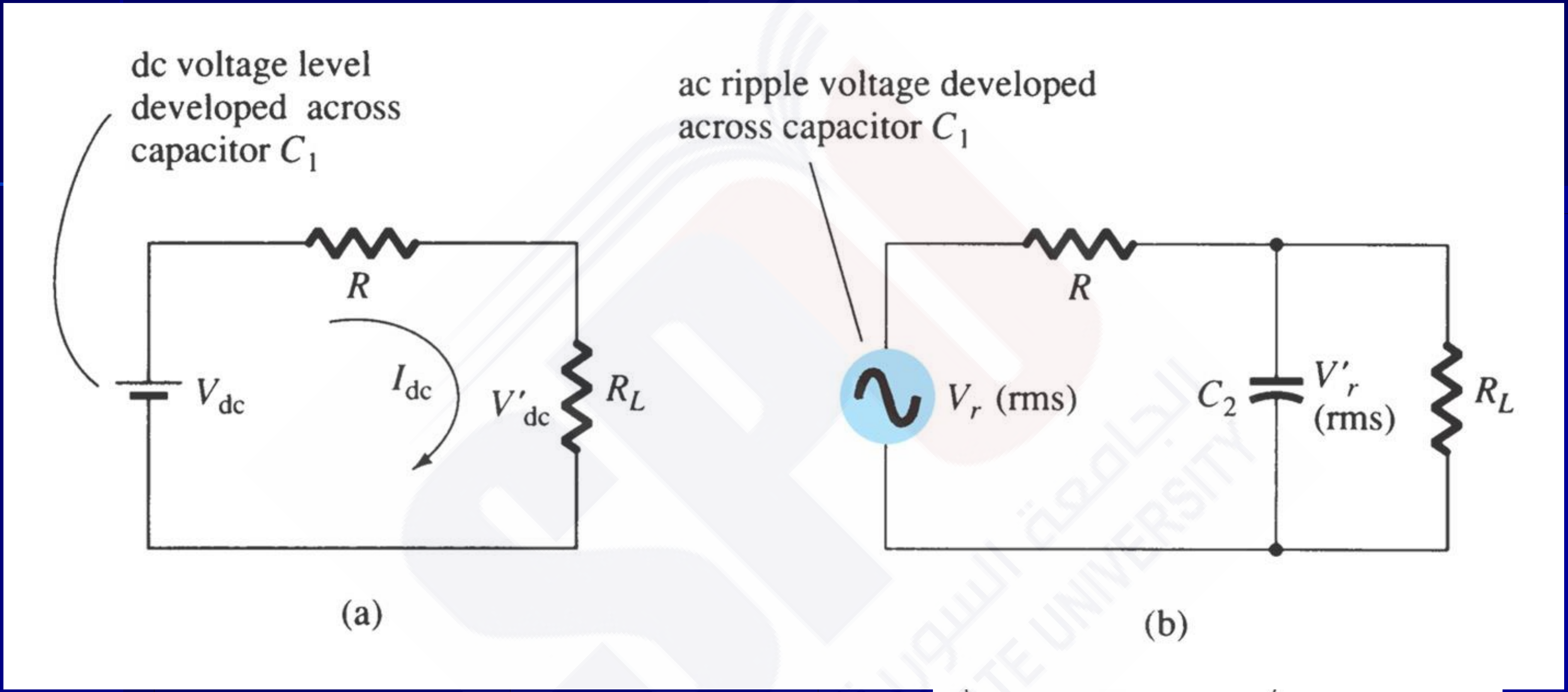


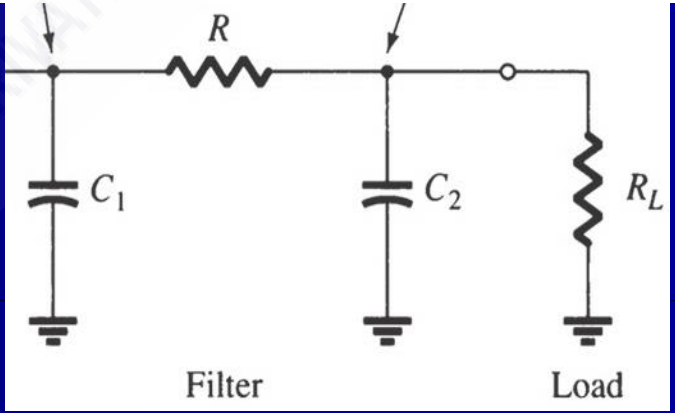
AC and DC Operation of RC Filter



$$V_r'(rms) \approx \frac{1.3}{RC} V_r(rms)$$

AC and DC Operation of RC Filter





$$V_r^{'}(rms) \approx \frac{1.3}{RC} V_r(rms)$$

EXAMPLE 15.7 Calculate the dc and ac components of the output signal across load R_L in the circuit of Fig. 15.11. Calculate the ripple of the output waveform.

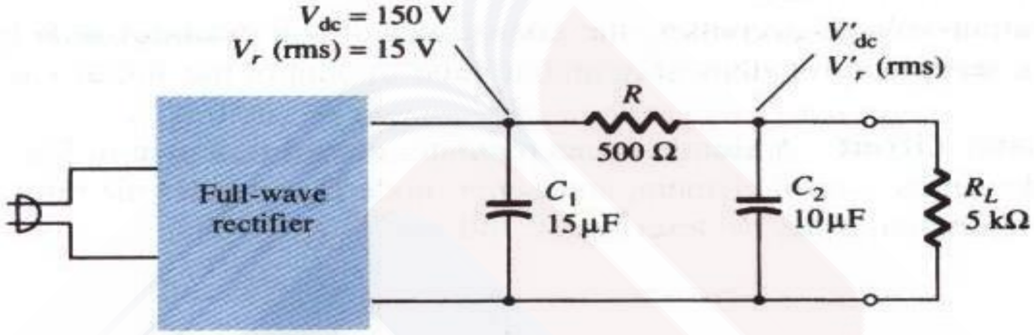


FIG. 15.11
RC filter circuit for Example 15.7.

Solution:

DC Calculation We obtain

$$\text{Eq. (15.13):}\quad V'_{dc} = \frac{R_L}{R + R_L} V_{dc} = \frac{5\text{ k}\Omega}{500 + 5\text{ k}\Omega}(150\text{ V}) = \mathbf{136.4\text{ V}}$$

AC Calculation The *RC*-section capacitive impedance is

$$\text{Eq. (15.15):}\quad X_C = \frac{1.3}{C} = \frac{1.3}{10} = 0.13\text{ k}\Omega = 130\ \Omega$$

The ac component of the output voltage, calculated using Eq. (15.14), is

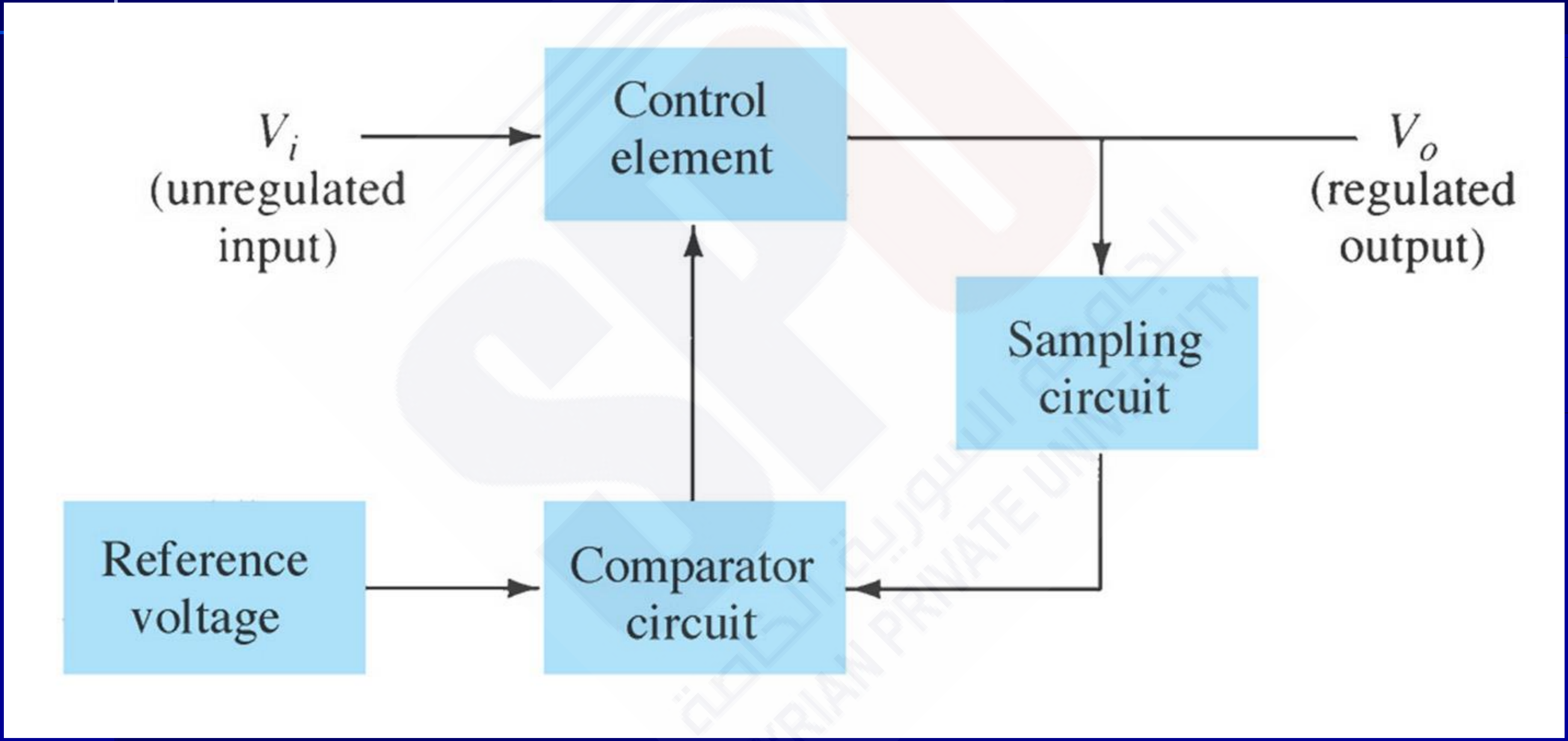
$$V'_r(\text{rms}) = \frac{X_C}{R} V_r(\text{rms}) = \frac{130}{500}(15\text{ V}) = \mathbf{3.9\text{ V}}$$

The ripple of the output waveform is then

$$r = \frac{V'_r(\text{rms})}{V'_{dc}} \times 100\% = \frac{3.9\text{ V}}{136.4\text{ V}} \times 100\% = \mathbf{2.86\%}$$

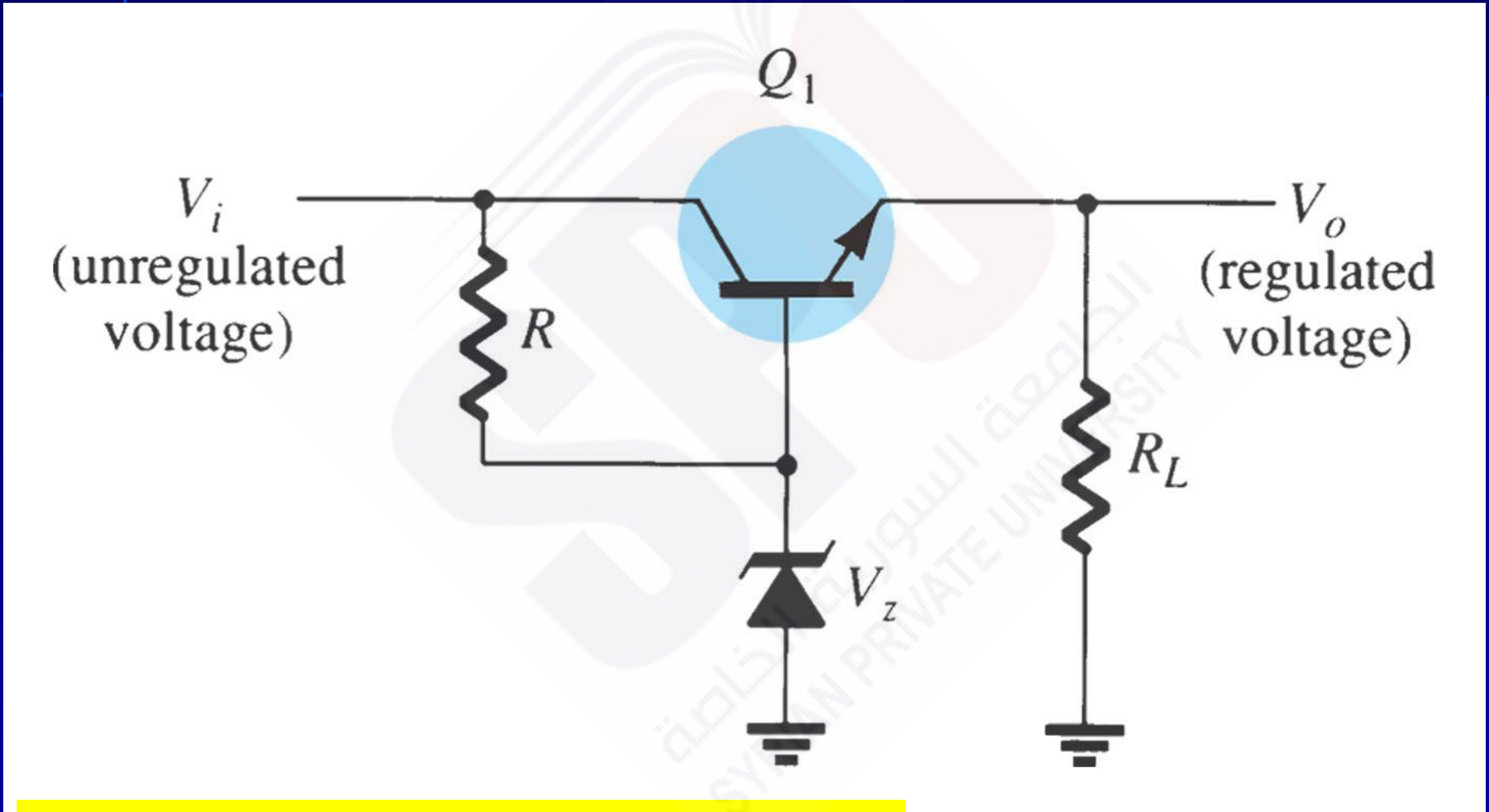
8.5 Discrete Transistor Voltage Regulation

Series Voltage Regulation **Shunt Voltage Regulation**



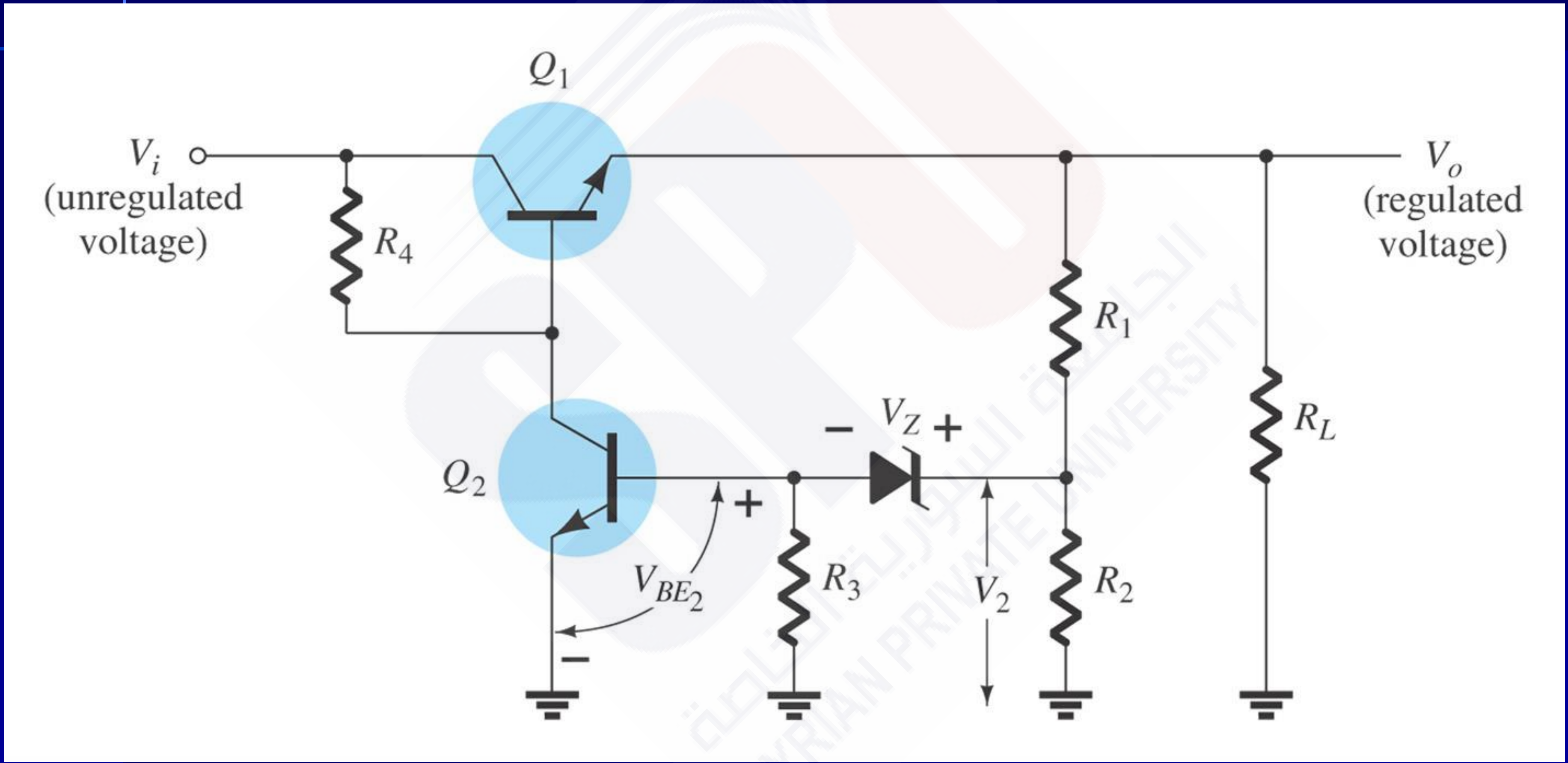
Series regulator block diagram

Series regulator circuit



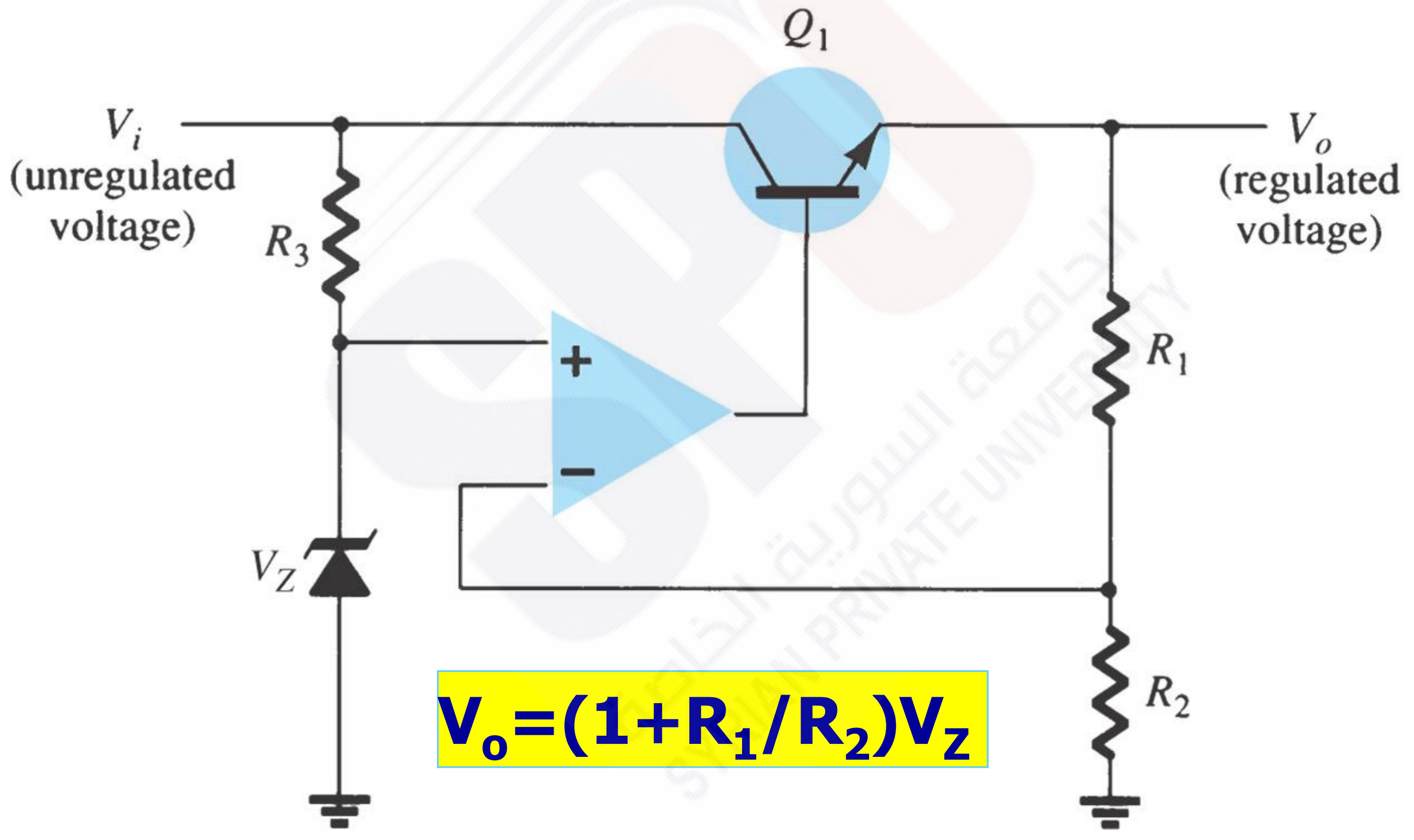
V_O increase→ V_{BE} decrease→ less I_L→V_O decrease

Improved Series regulator circuit



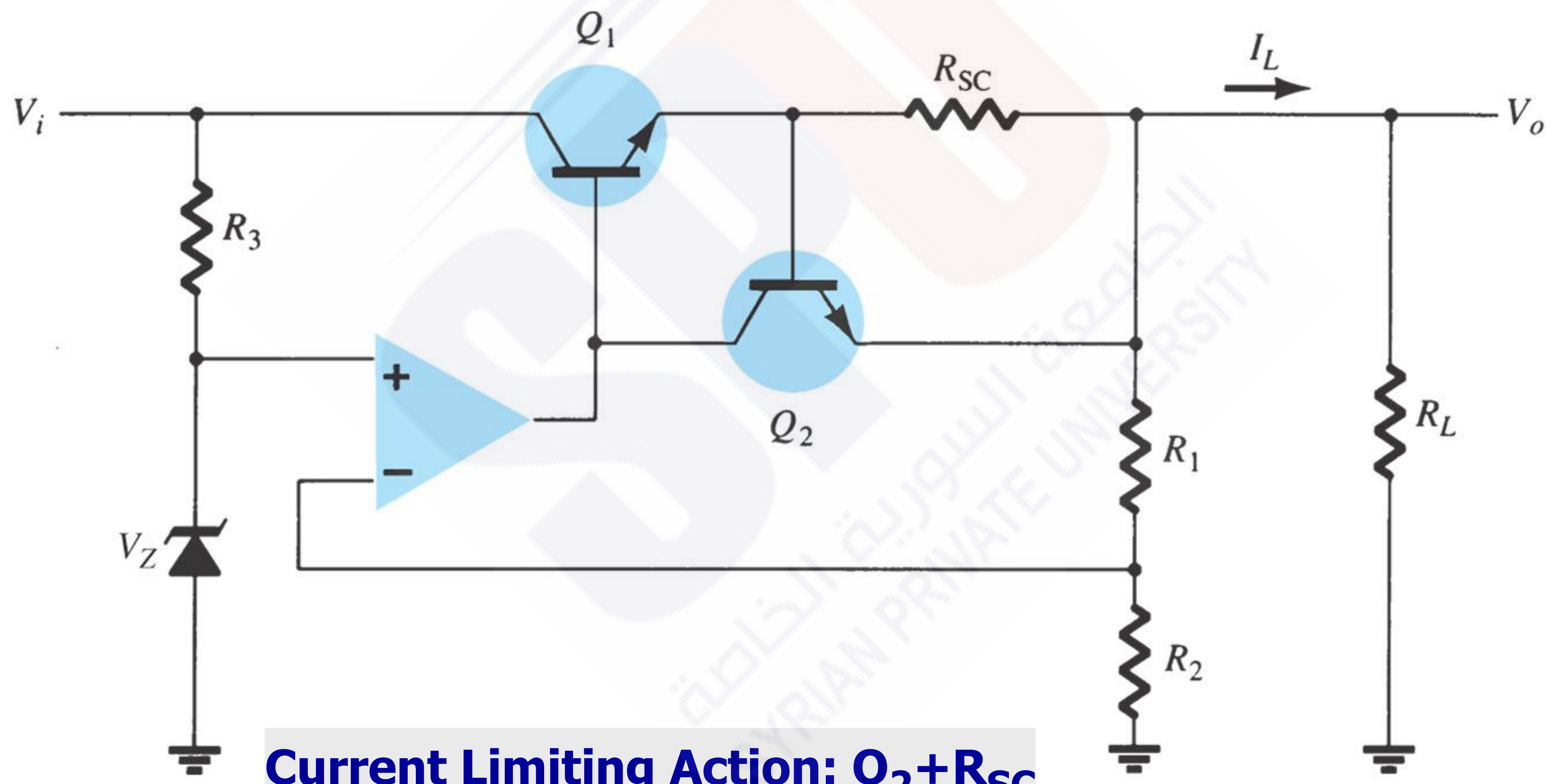
$$V_o=(V_z+V_{BE2})(R_1+R_2)/R_2$$

Op-amp series regulator circuit



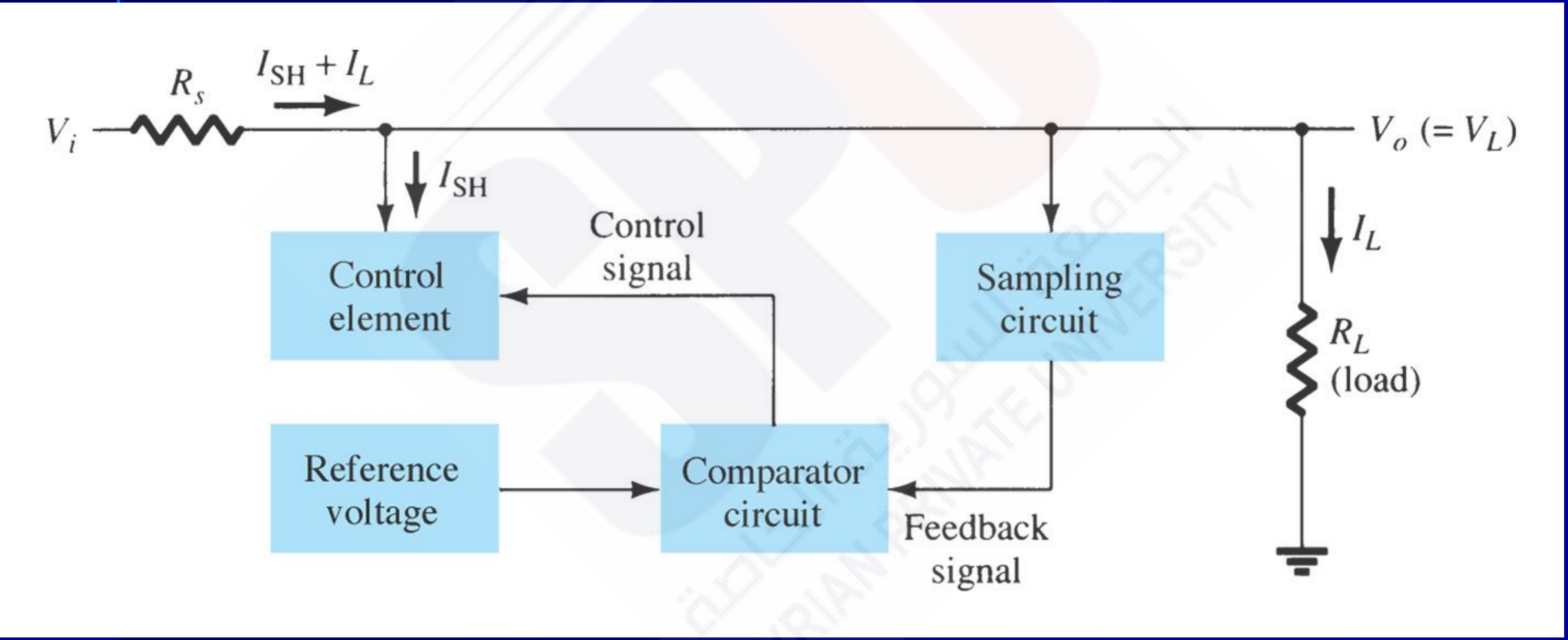
$$V_o = (1 + R_1/R_2)V_Z$$

Current-limiting voltage regulator

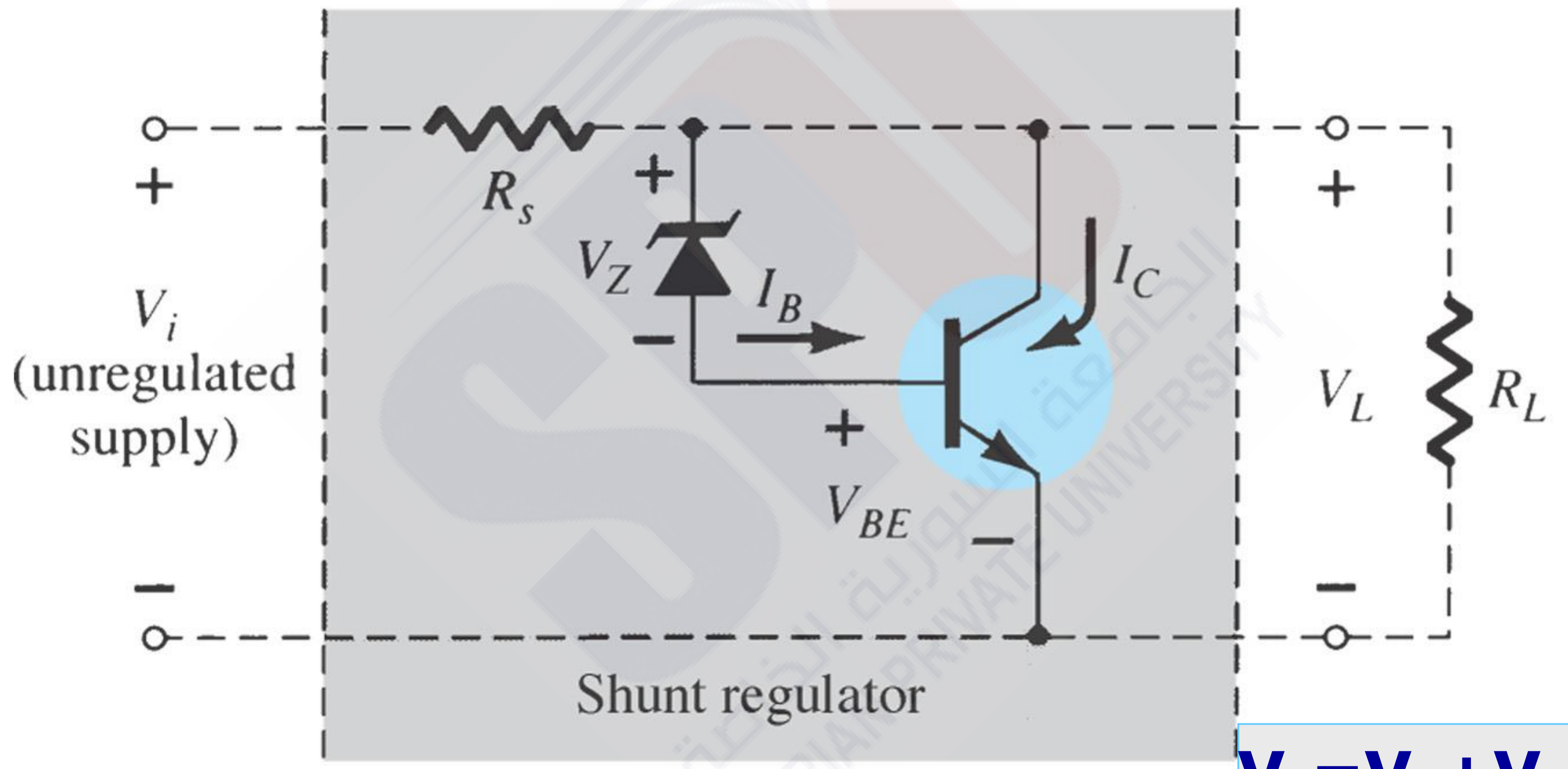


Current Limiting Action: Q_2+R_{SC}

Block diagram of shunt voltage regulator



Transistor shunt voltage regulator



$$V_L = V_Z + V_{BE}$$

EXAMPLE 15.11 Determine the regulated voltage and circuit currents for the shunt regulator of Fig. 15.22.

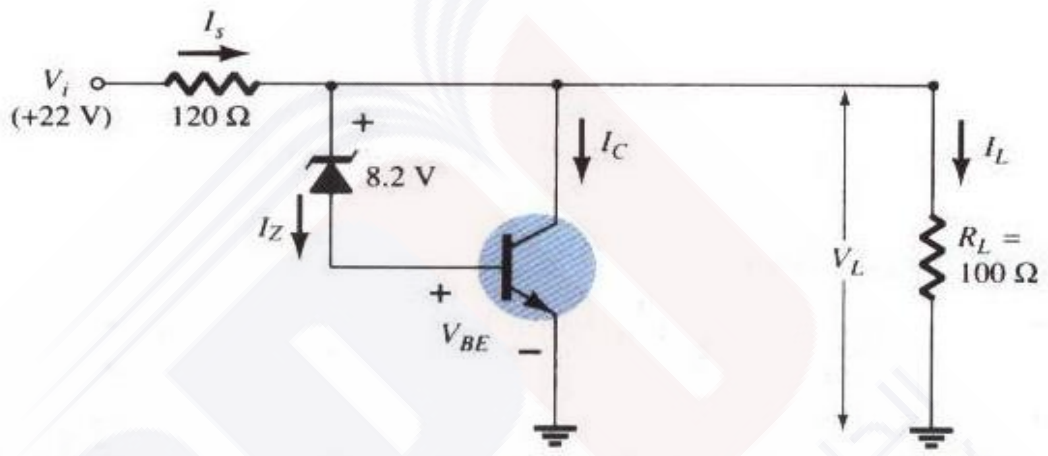


FIG. 15.22
Circuit for Example 15.11.

Solution: The load voltage is

$$\text{Eq. (15.19):}\quad V_L = 8.2\text{ V} + 0.7\text{ V} = \mathbf{8.9\text{ V}}$$

For the given load,

$$I_L = \frac{V_L}{R_L} = \frac{8.9\text{ V}}{100\ \Omega} = \mathbf{89\text{ mA}}$$

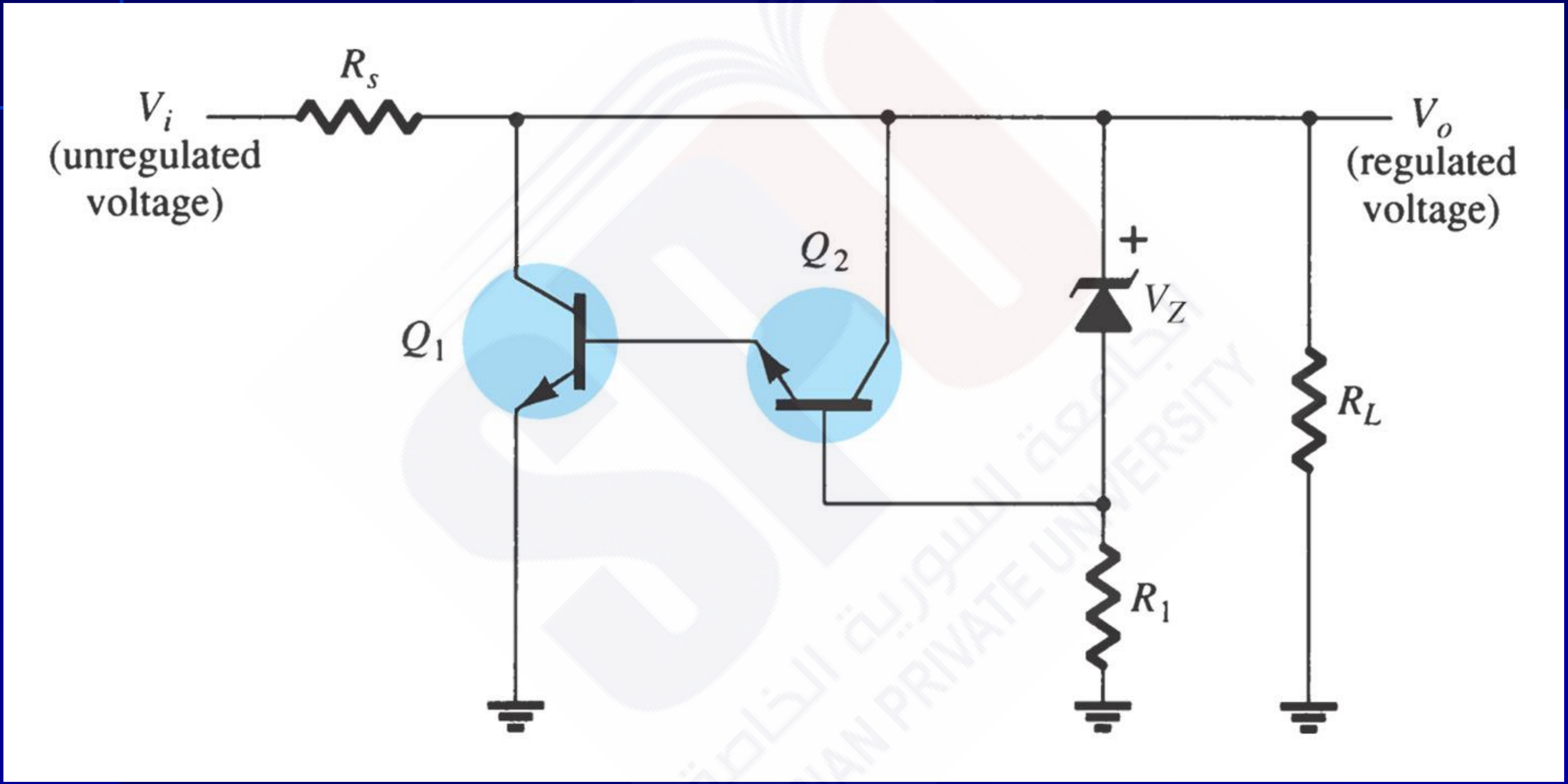
With the unregulated input voltage at 22 V, the current through R_S is

$$I_S = \frac{V_i - V_L}{R_S} = \frac{22\text{ V} - 8.9\text{ V}}{120} = \mathbf{109\text{ mA}}$$

so that the collector current is

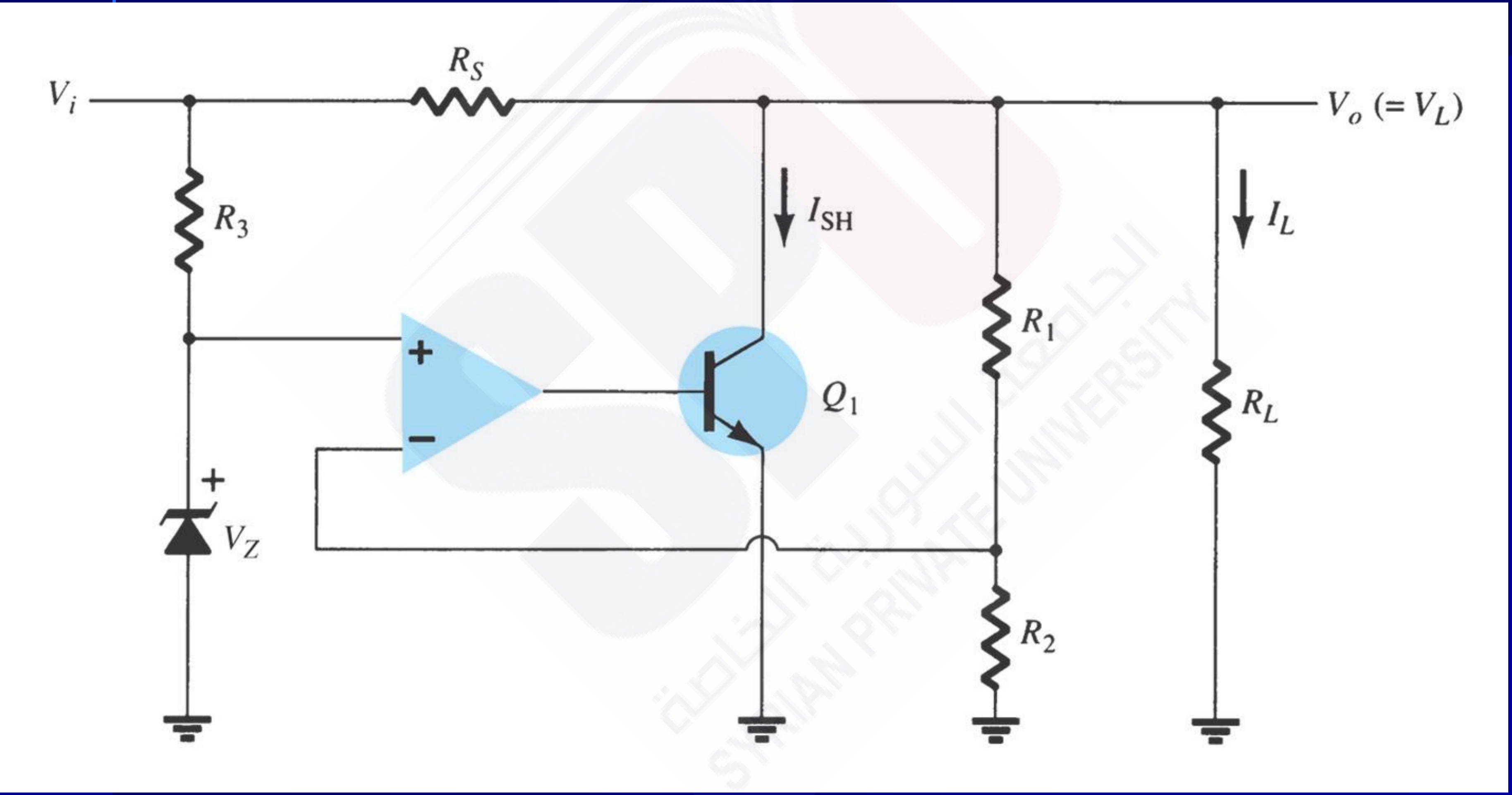
$$I_C = I_S - I_L = 109\text{ mA} - 89\text{ mA} = \mathbf{20\text{ mA}}$$

Improved shunt voltage regulator

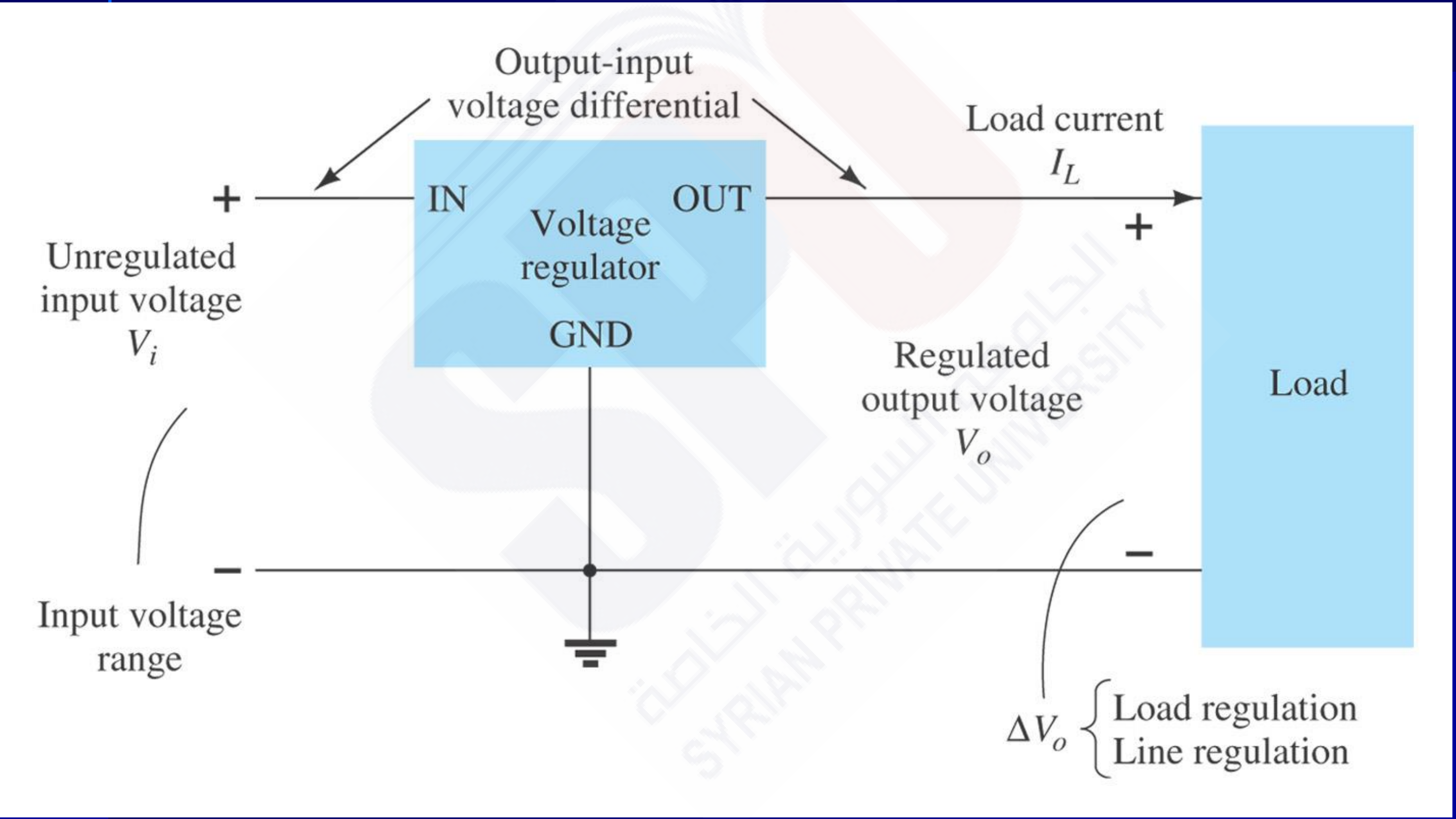


$$V_L = V_Z + V_{BE1} + V_{BE2}$$

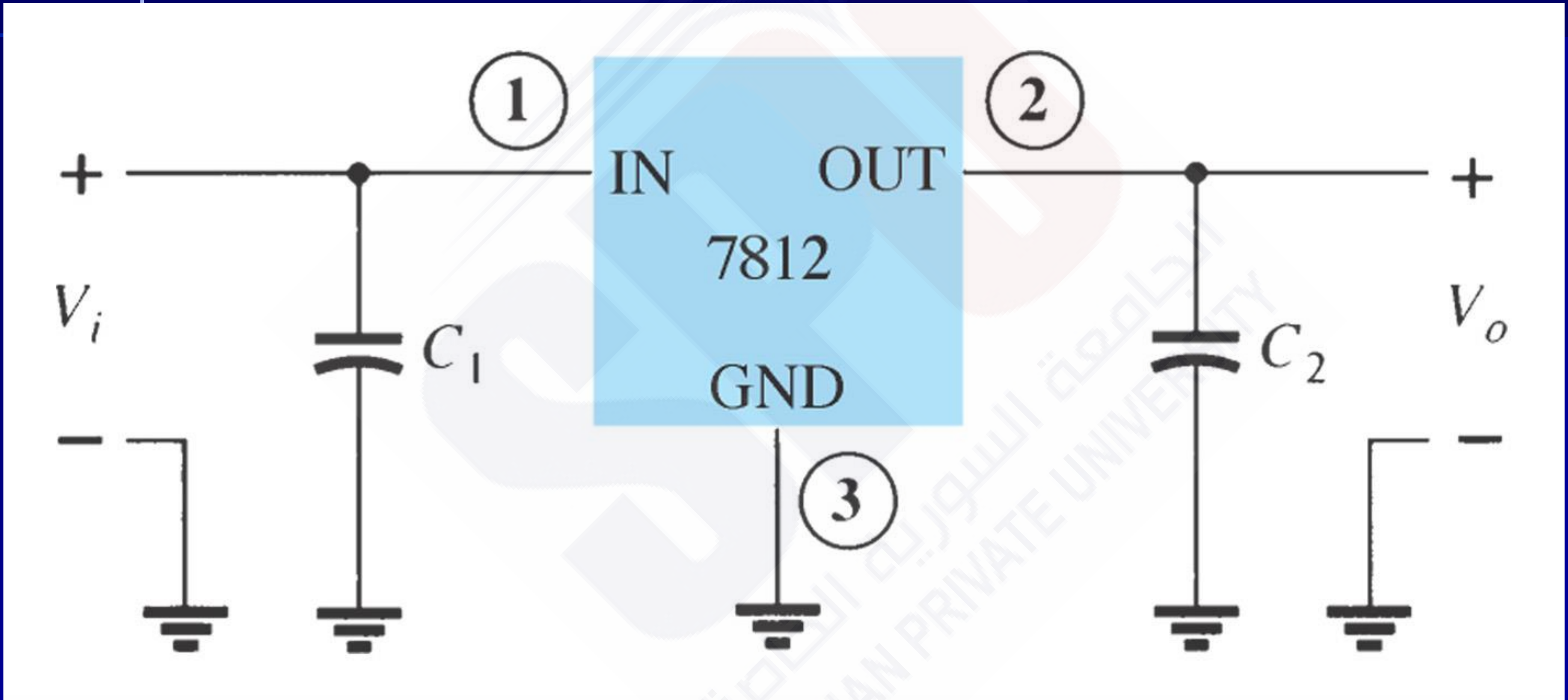
Shunt voltage regulator using op-amp



Block representation of three-terminal voltage regulator

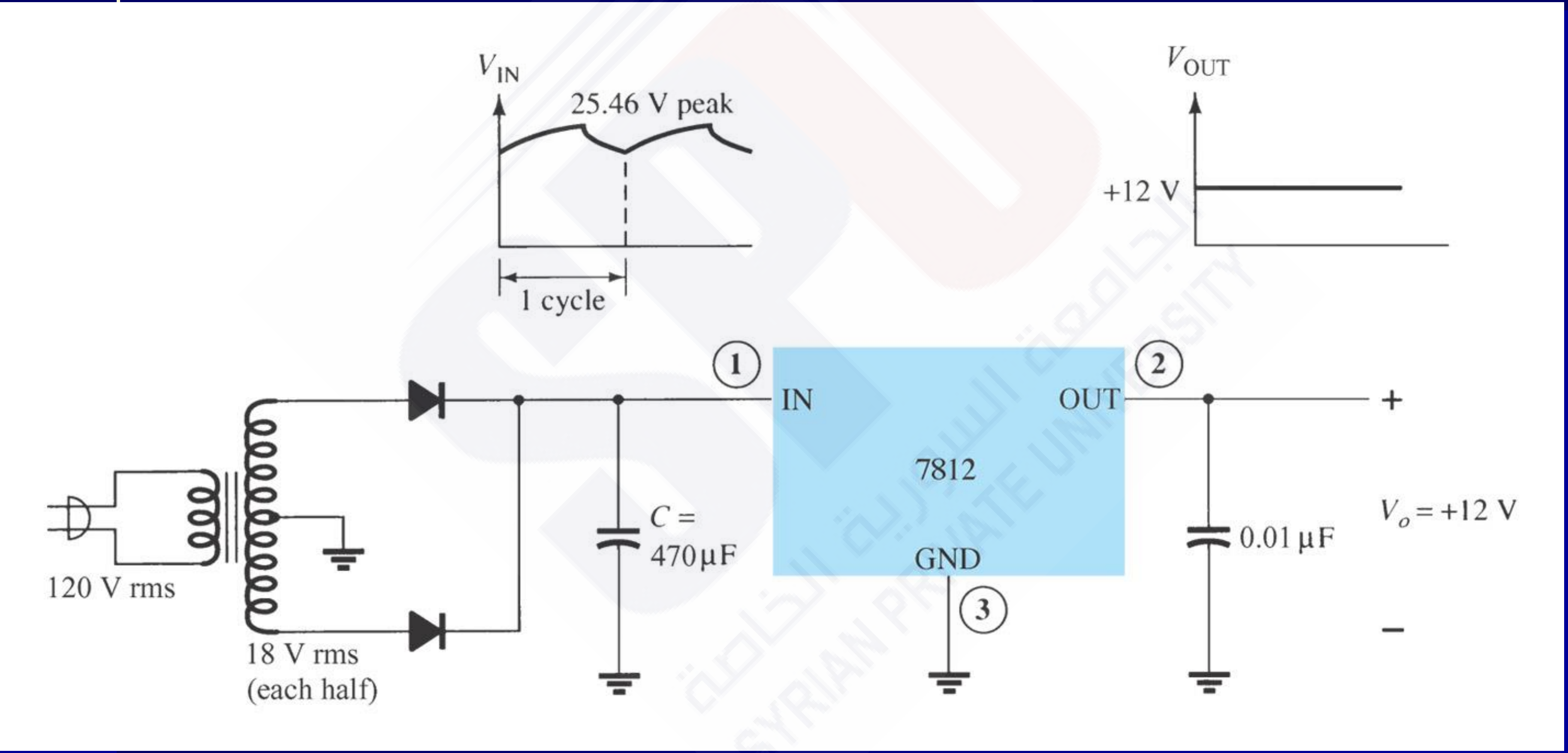


8.6 IC Voltage Regulators

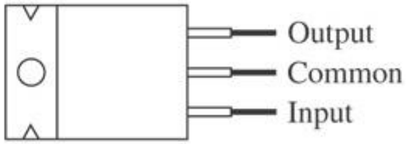


Reference Source + Comparator Amp + Control Device + Overload Protection

A +12 V power supply



Specification data-sheet of voltage regulator ICs



Nominal output voltage	Regulator
5 V	7805
6 V	7806
8 V	7808
10 V	7810
12 V	7812
15 V	7815
18 V	7818
24 V	7824

Absolute maximum ratings:

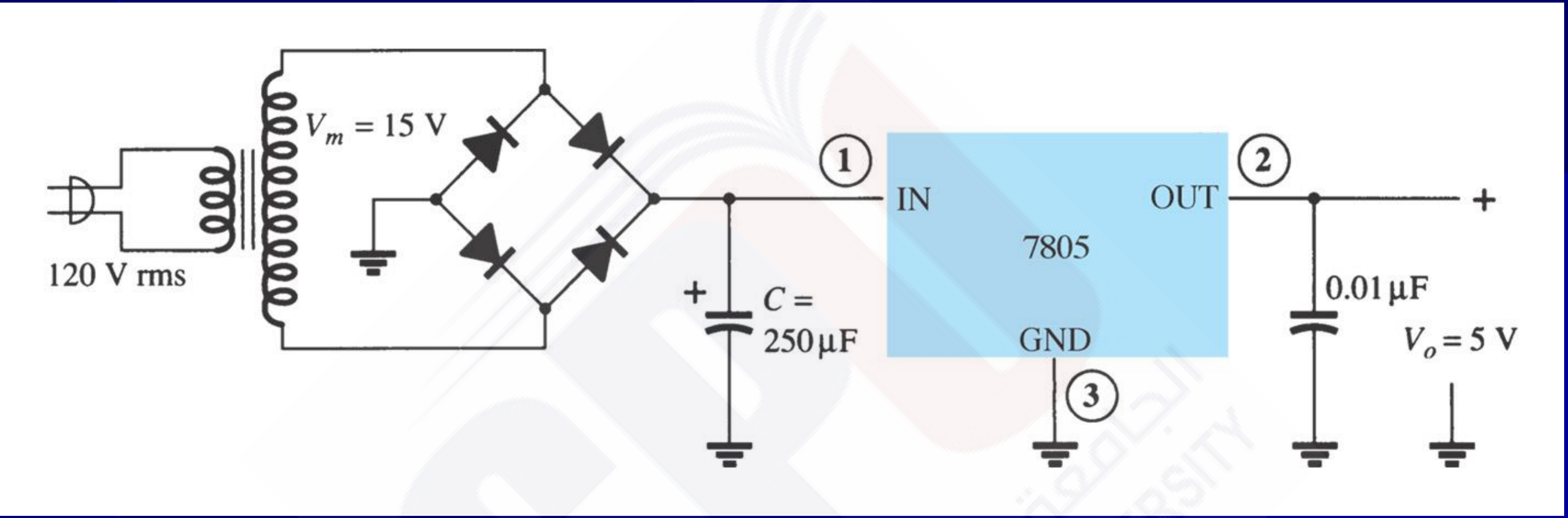
Input voltage	40 V
Continuous total dissipation	2 W
Operating free-air temperature range	−65 to 150°C

μA 7812C electrical characteristics:

Parameter	Min.	Typ.	Max.	Units
Output voltage	11.5	12	12.5	V
Input regulation		3	120	mV
Ripple rejection	55	71		dB
Output regulation		4	100	mV
Output resistance		0.018		Ω
Dropout voltage		2.0		V
Short-circuit output current		350		mA
Peak output current		2.2		A

IC	VO (V)	Min.Vi (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5

A +5-V power supply



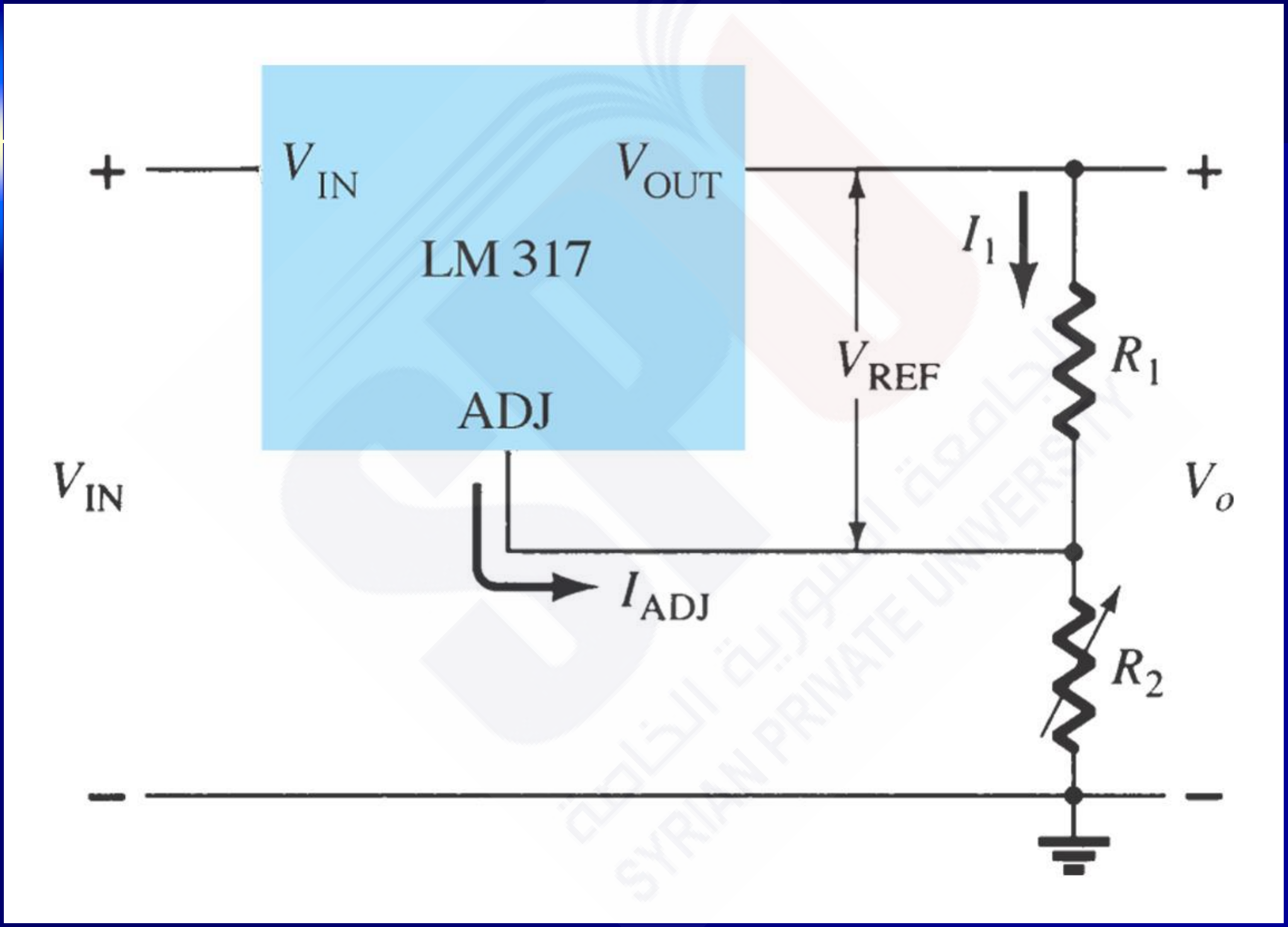
Calculate $V_{imin} = V_{dc} - V_r(p)$, when I_L = 400 mA ?

$$V_r(peak) = \sqrt{3}V_r(rms) = \sqrt{3}\,\frac{2.4I_{dc}}{C} = \sqrt{3}\,\frac{2.4(400)}{250} = 6.65V$$

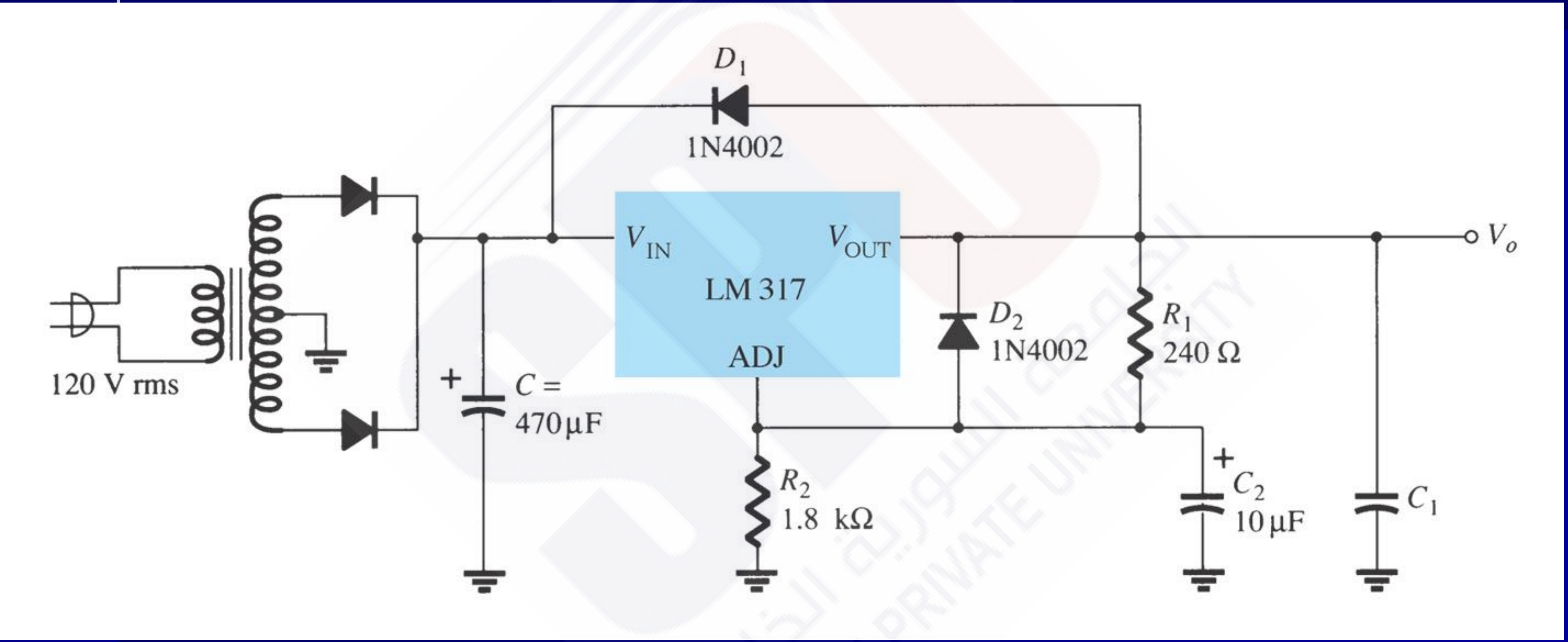
$$V_{dc} = V_m - V_r(peak) = 15V - 6.65V = 8.35V$$

$$V_i(low) = V_{dc} - V_r(peak) = 15 - 6.65 = 8.35V$$

Connection of LM317 adjustable-voltage regulator

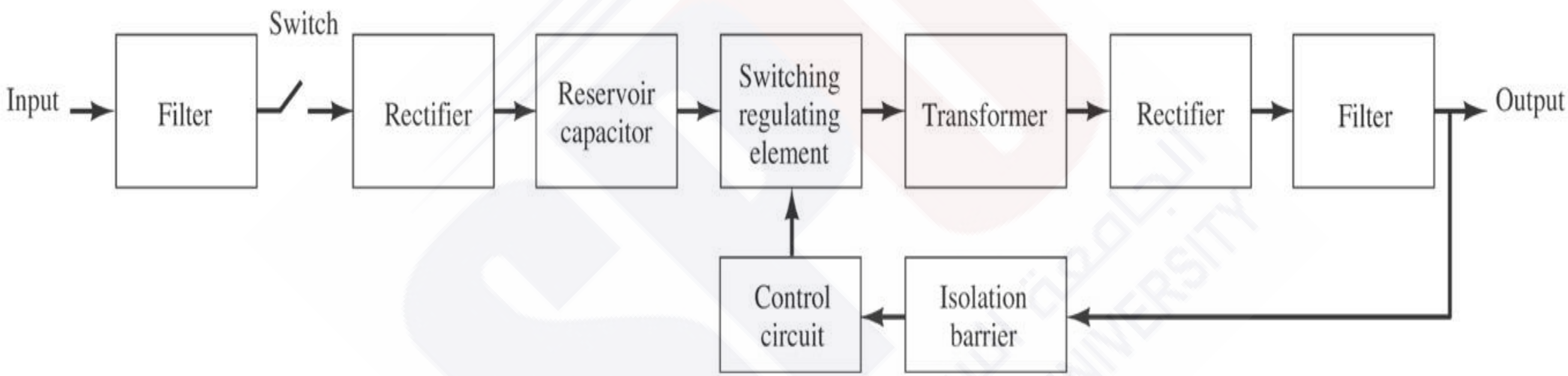


Positive adjustable-voltage regulator Example



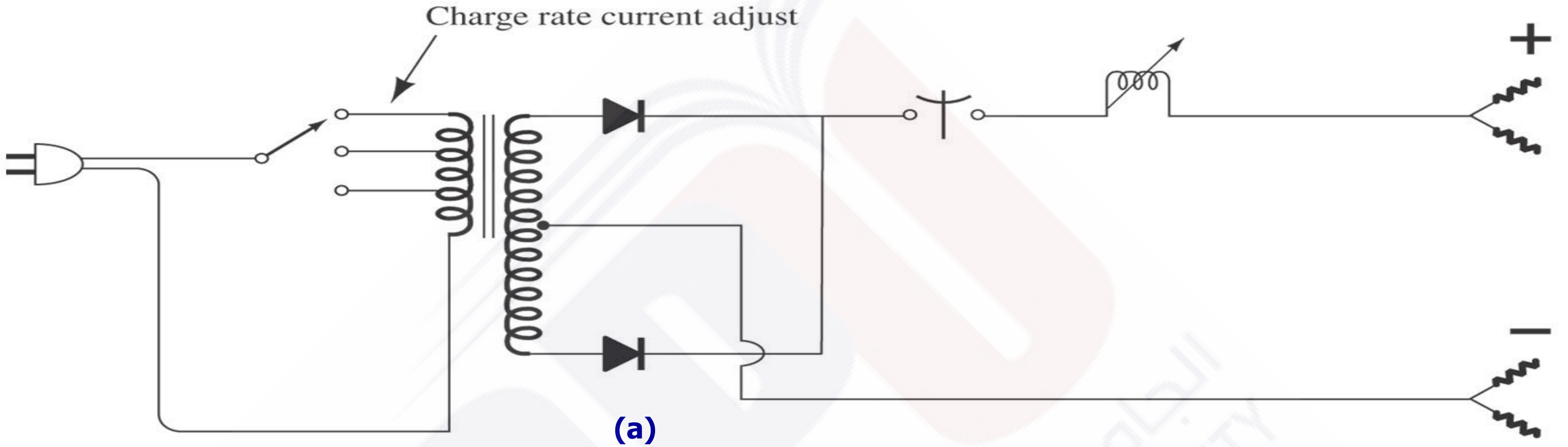
Determine the regulated V_o ?

8.7 Applications

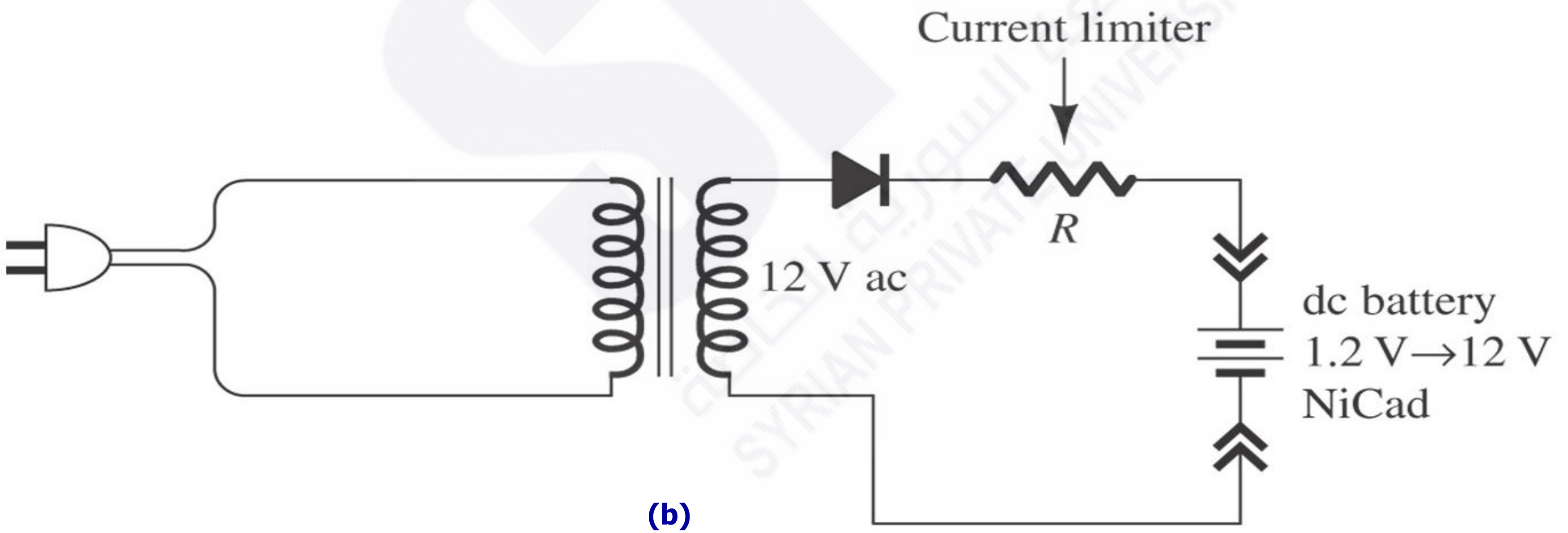


Block diagram of chopper power supply

Battery charger circuits: (a) Single charging circuit; (b) typical NiCad charging circuit

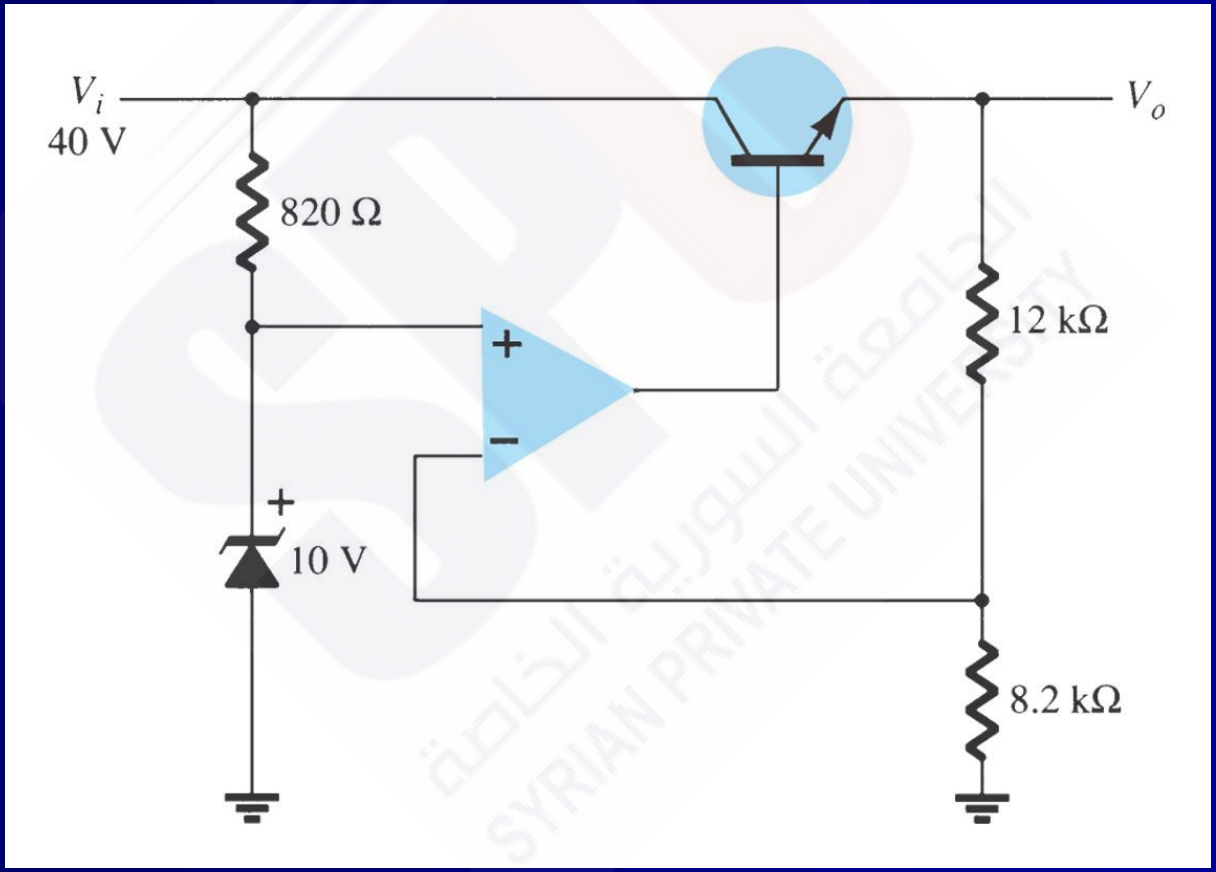


(a)



(b)

Calculate V_o ?



Calculate the I_{Lmax} to maintain regulated V_o