INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

J-601-1448
Electronic Principals

Lecture #6
Power Supplies (Voltage Regulators)

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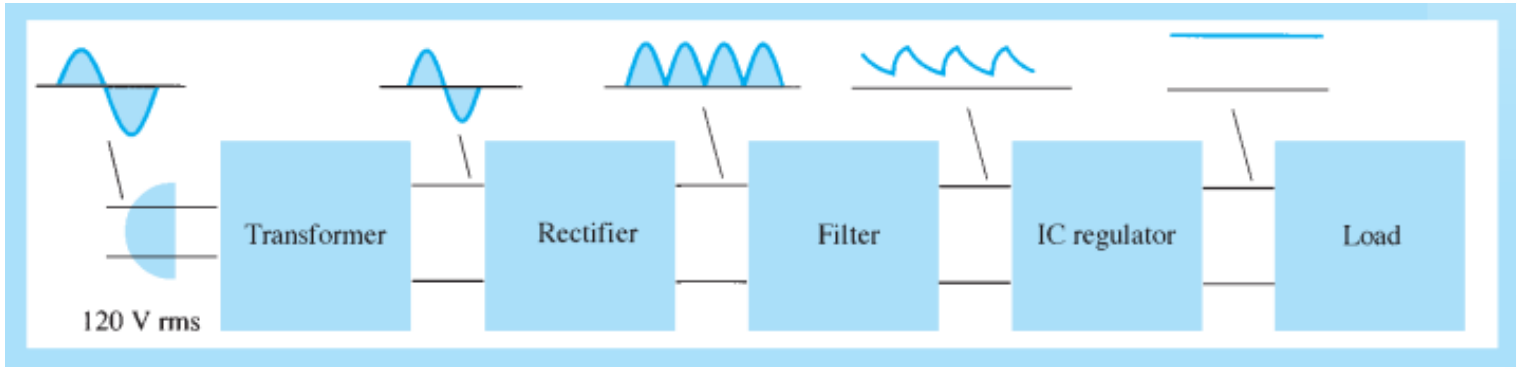
NOVEMBER 2014

Agenda

- Introduction
- General Filter Considerations
- Discrete Transistor Voltage Regulator
- IC Voltage Regulators

INTRODUCTION

Introduction



Block diagram showing parts of a power supply.

GENERAL FILTER CONSIDERATIONS

Ripple Voltage

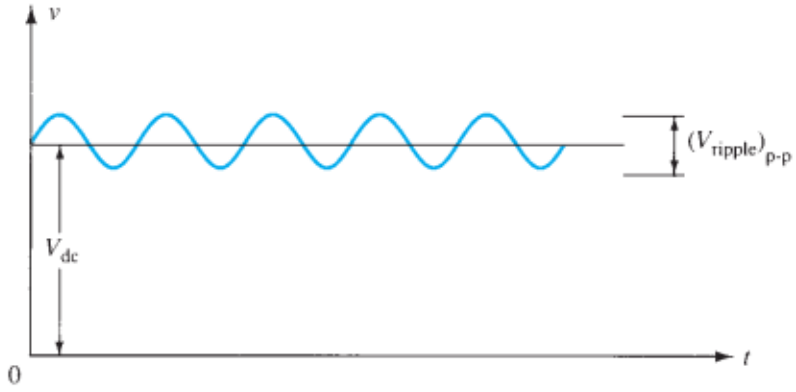


FIG. 15.2

Filter voltage waveform showing dc and ripple voltages.

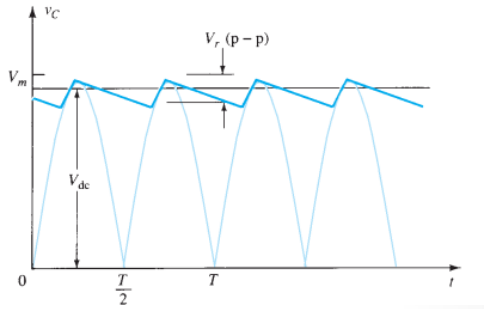
$$r = \frac{\text{ripple voltage (rms)}}{\text{dc voltage}} = \frac{V_r(\text{rms})}{V_{dc}} \times 100\%$$

Voltage regulation is given by

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

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

Capacitor Filter



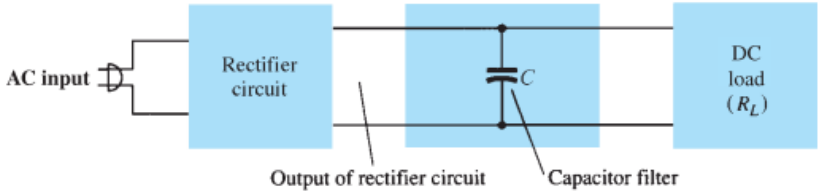


FIG. 15.3
Basic capacitor filter.

Ripple Voltage V_r (RMS)

$$V_r(\text{rms}) = \frac{I_{dc}}{4\sqrt{3}fC} = \frac{2.4I_{dc}}{C} = \frac{2.4V_{dc}}{R_LC}$$

$$V_{dc} = V_m - \frac{I_{dc}}{4fC} = V_m - \frac{4.17I_{dc}}{C}$$

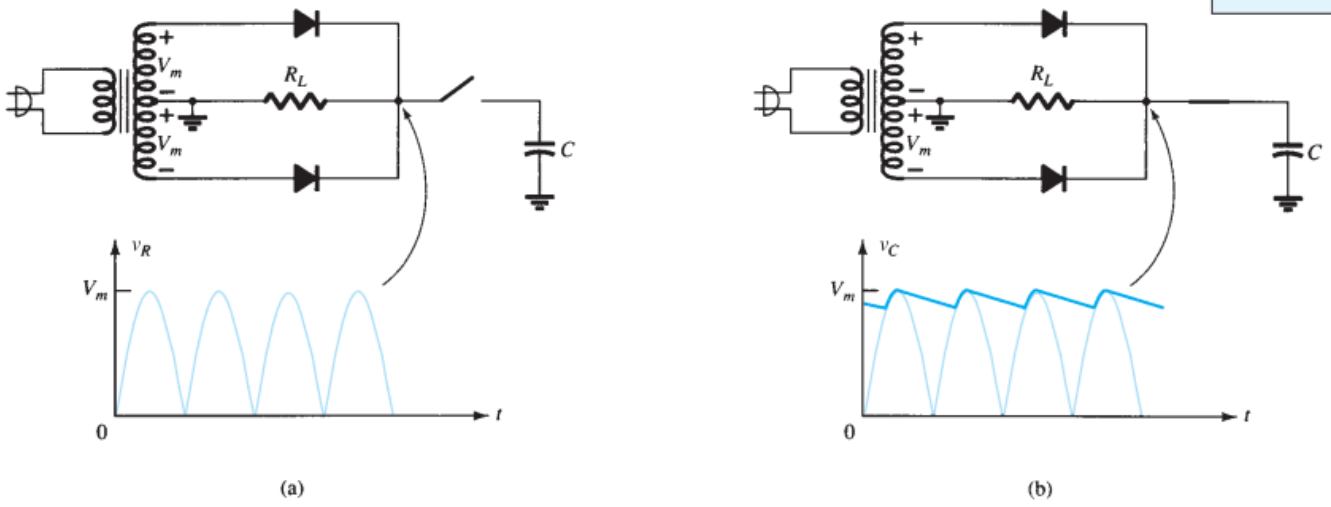


FIG. 15.4
Capacitor filter operation: (a) full-wave rectifier voltage; (b) filtered output voltage.

RC Filter

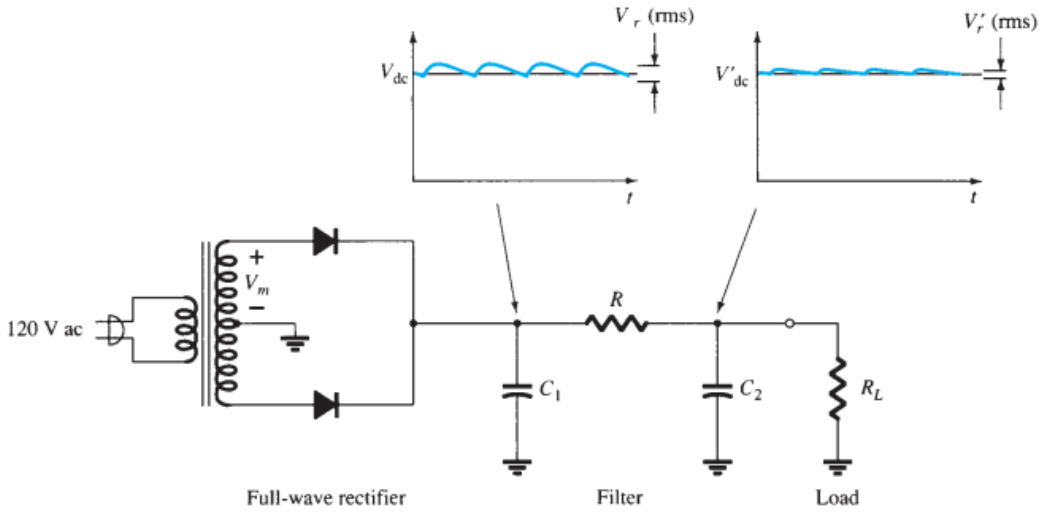


FIG. 15.9
Full-wave rectifier and RC filter circuit.

$$V'_{dc} = \frac{R_L}{R + R_L} V_{dc}$$

$$V'_r(\text{rms}) \approx \frac{X_C}{R} V_r(\text{rms})$$

DISCRETE TRANSISTOR VOLTAGE REGULATOR

Series Voltage Regulator

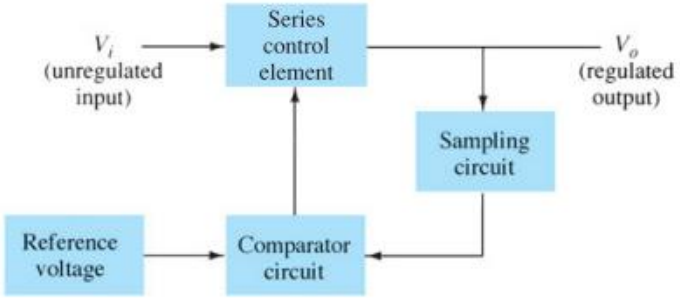
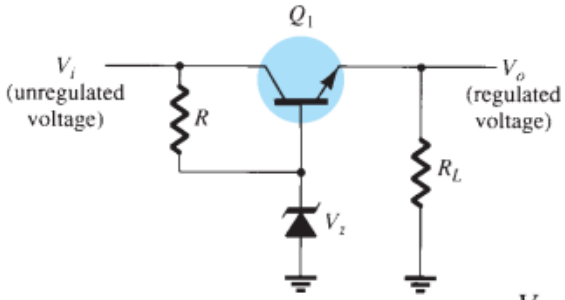


FIG. 15.12
Series regulator block diagram.



$$V_o = V_Z - V_{BE}$$

FIG. 15.13
Series regulator circuit.

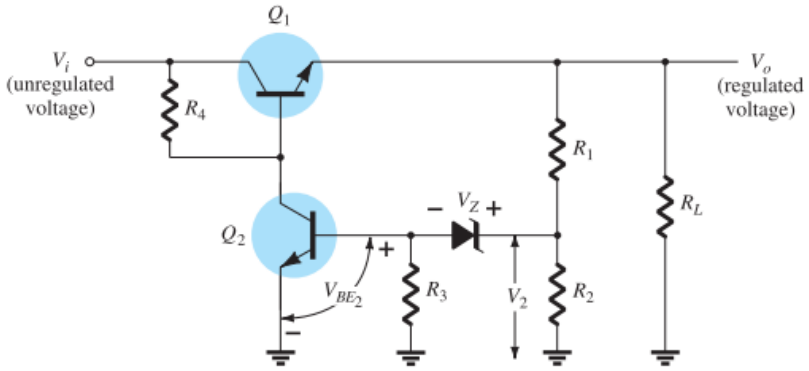


FIG. 15.15
Improved series regulator circuit.

$$V_o = \frac{R_1 + R_2}{R_2}(V_Z + V_{BE_2})$$

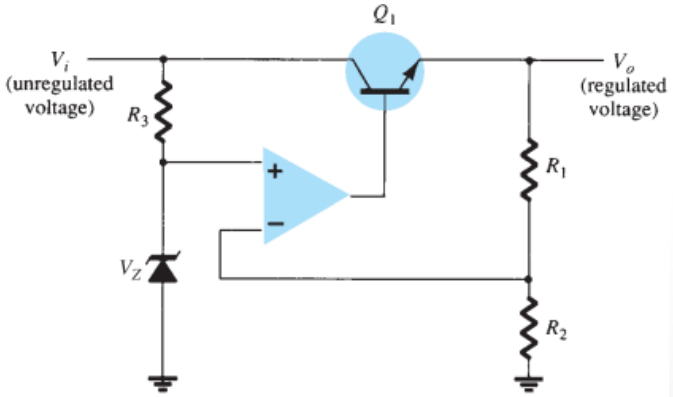


FIG. 15.16
Op-amp series regulator circuit.

$$V_o = \left(1 + \frac{R_1}{R_2}\right)V_Z$$

Shunt Voltage Regulator

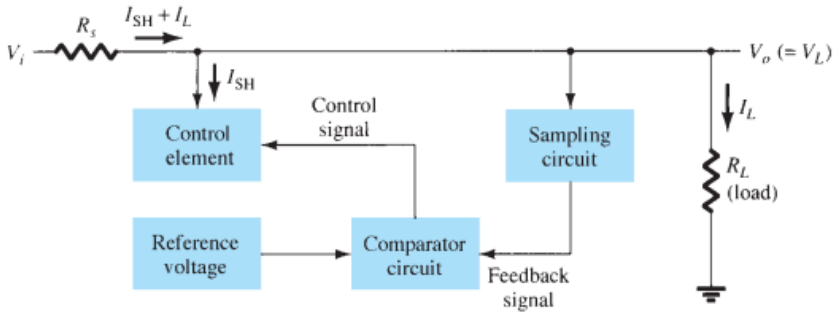


FIG. 15.20
Block diagram of shunt voltage regulator.

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

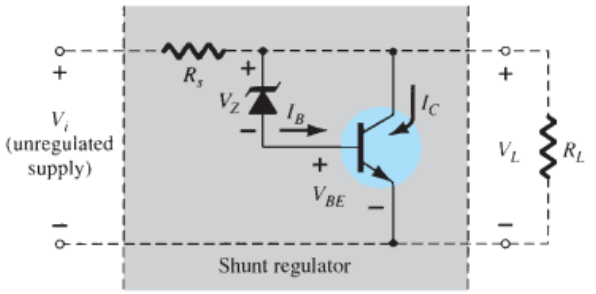


FIG. 15.21
Transistor shunt voltage regulator.

$$V_o = V_L = V_Z + V_{BE_2} + V_{BE_1}$$

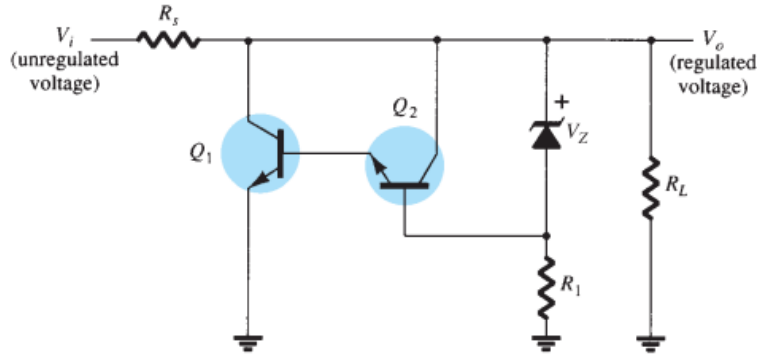


FIG. 15.23
Improved shunt voltage regulator circuit.

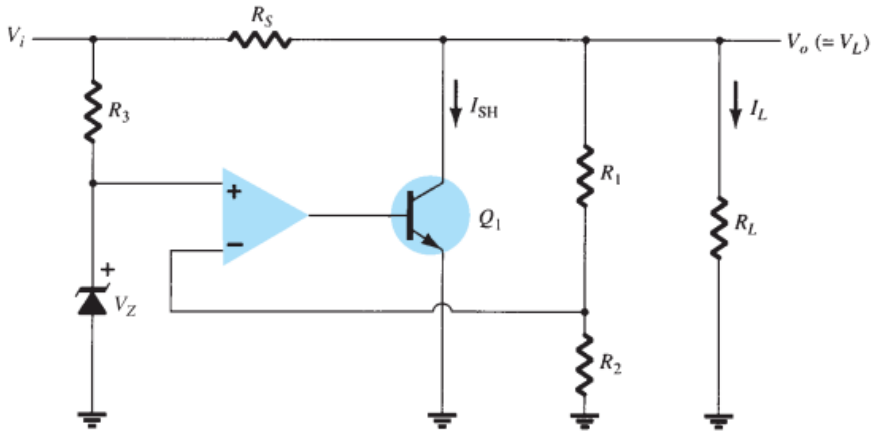


FIG. 15.24
Shunt voltage regulator using an op-amp.

IC VOLTAGE REGULATORS

Three-Terminal Voltage Regulators

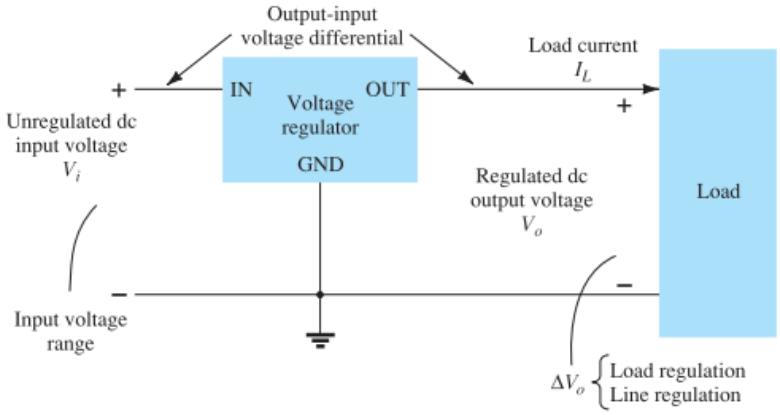


FIG. 15.25

Block representation of three-terminal voltage regulator.

- Fixed-Positive-Voltage Regulators

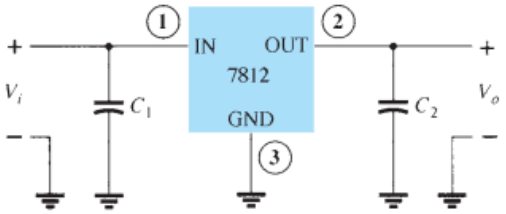


FIG. 15.26

Connection of a 7812 voltage regulator.

TABLE 15.1

Positive-Voltage Regulators in the 7800 Series

IC Part	Output Voltage (V)	Minimum V_i (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	14.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

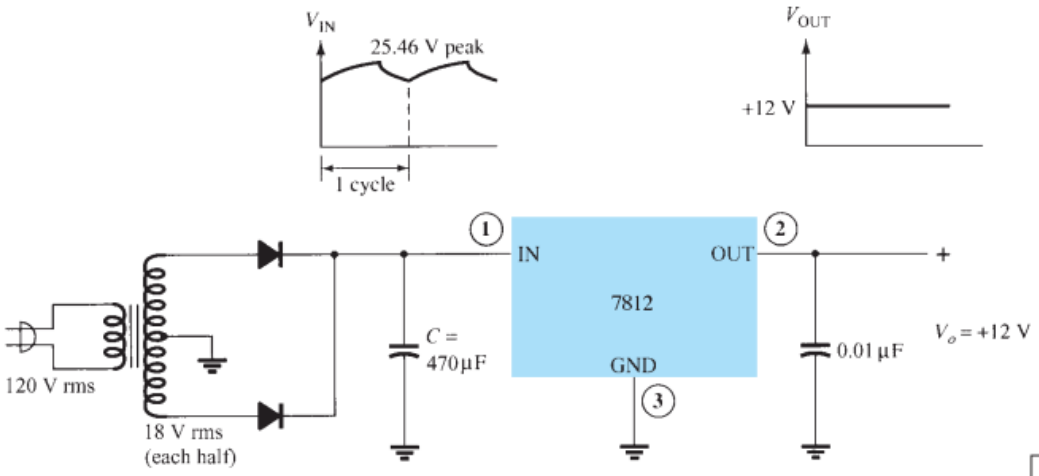
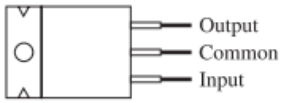


FIG. 15.27
A +12 V power supply.



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

- Fixed-Negative-Voltage Regulators

TABLE 15.2
Negative-Voltage Regulators in 7900 Series

IC Part	Output Voltage (V)	Minimum V_i (V)
7905	−5	−7.3
7906	−6	−8.4
7908	−8	−10.5
7909	−9	−11.5
7912	−12	−14.6
7915	−15	−17.7
7918	−18	−20.8
7924	−24	−27.1

Adjustable-Voltage Regulators

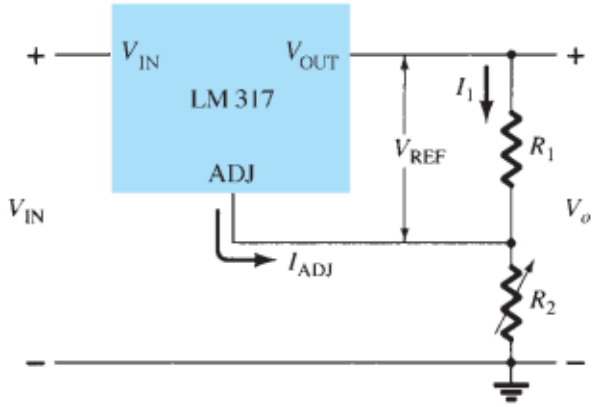


FIG. 15.30
Connection of LM317 adjustable-voltage regulator.

$$V_o = V_{\text{ref}}\left(1 + \frac{R_2}{R_1}\right) + I_{\text{adj}}R_2$$

- For more details, refer to:
  - Chapter 15, Electronic Devices and Circuits, Boylestad.
- The lecture is available online at:
  - https://speakerdeck.com/ahmad_elbanna
- For inquires, send to:
  - ahmad.elbanna@feng.bu.edu.eg