SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECB202 – LINEAR INTEGRATED CIRCUITS

II YEAR/ IV SEMESTER

UNIT 3 – **WAVEFORM GENERATORS AND VOLTAGE REGULATORS**

TOPIC 6 – **Three terminal fixed and adjustable voltage regulators**

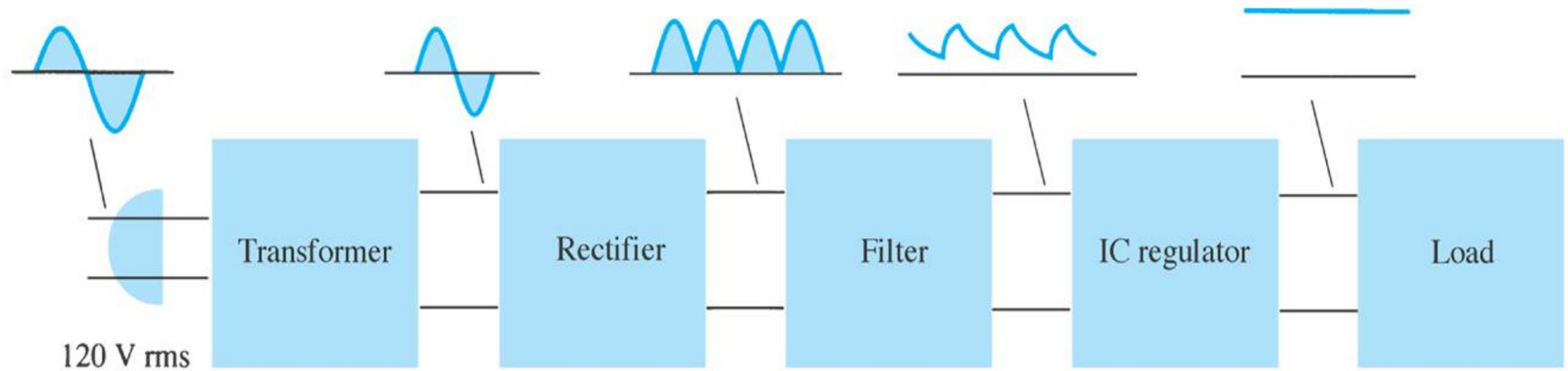
Outline

- Introduction
- Voltage Regulation
- Line Regulation
- Load Regulation
- Switching Regulator
- IC Voltage Regulator

Introduction

- Batteries are often shown on a schematic diagram as the source of DC voltage but usually the actual DC voltage source is a power supply.
- There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronics circuits and other devices.
- A more reliable method of obtaining DC power is to transform, rectify, filter and regulate an AC line voltage.
- A power supply can by broken down into a series of blocks, each of which performs a particular function.

Introduction



Power supply: a group of circuits that convert the ***standard ac voltage*** (120 V, 60 Hz) provided by the wall outlet to ***constant dc voltage***

Transformer : a device that step up or step down the ***ac voltage*** provided by the wall outlet to a desired amplitude through the *action* of a *magnetic field*

Introduction

Rectifier: a diode circuits that converts the ***ac input voltage*** to a ***pulsating dc voltage***

The pulsating dc voltage is **only suitable** to be used as a battery charger, but **not good enough** to be used as a dc power supply in a radio, stereo system, computer and so on.

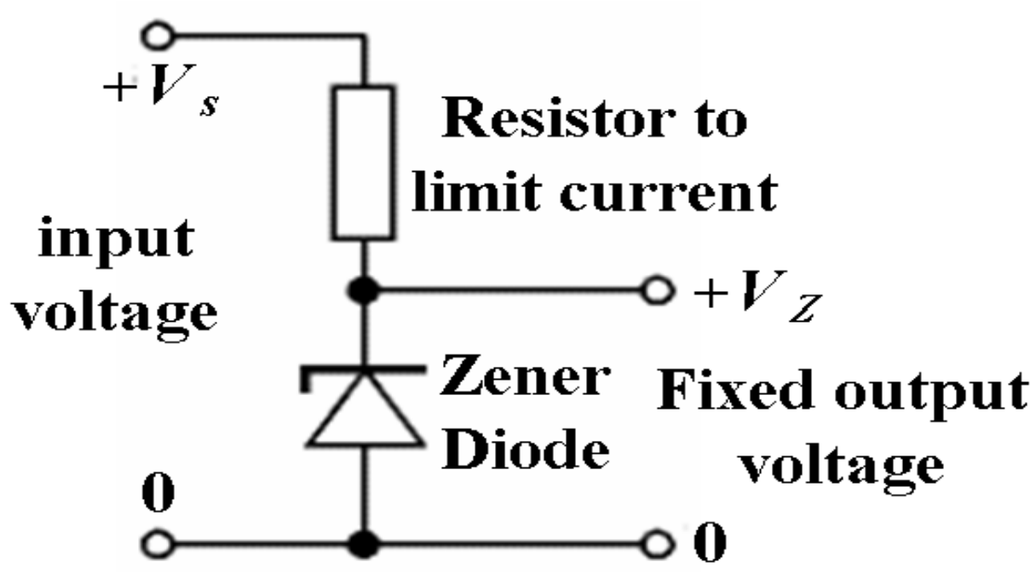
There are two basic types of rectifier circuits:

- Half-wave rectifier
- Full-wave rectifier - Center-tapped & Bridge full-wave rectifier

In summary, a full-wave rectified signal has **less ripple** than a half-wave rectified signal and is thus better to apply to a filter.

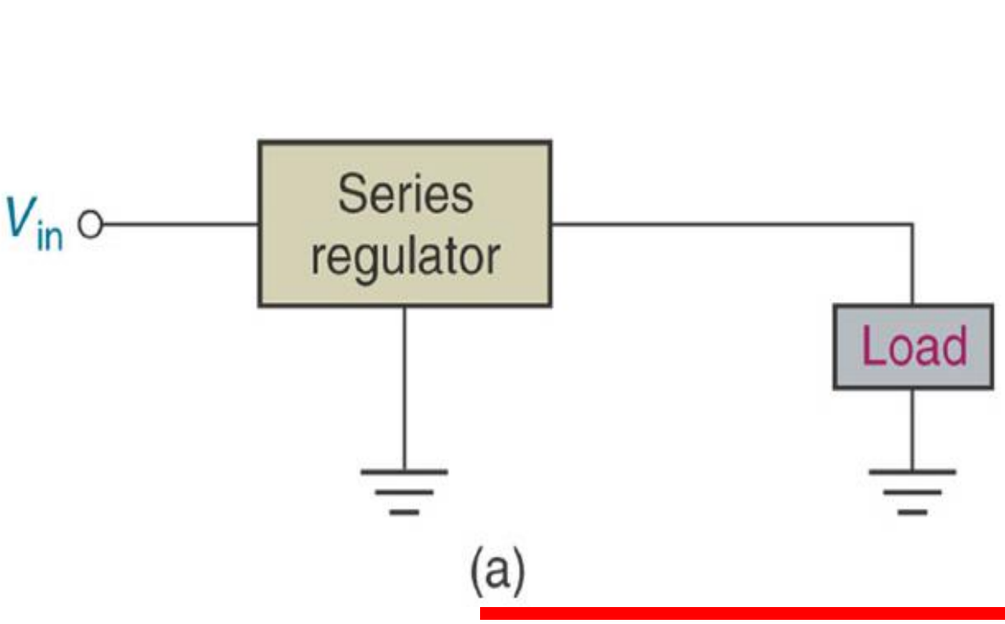
Introduction

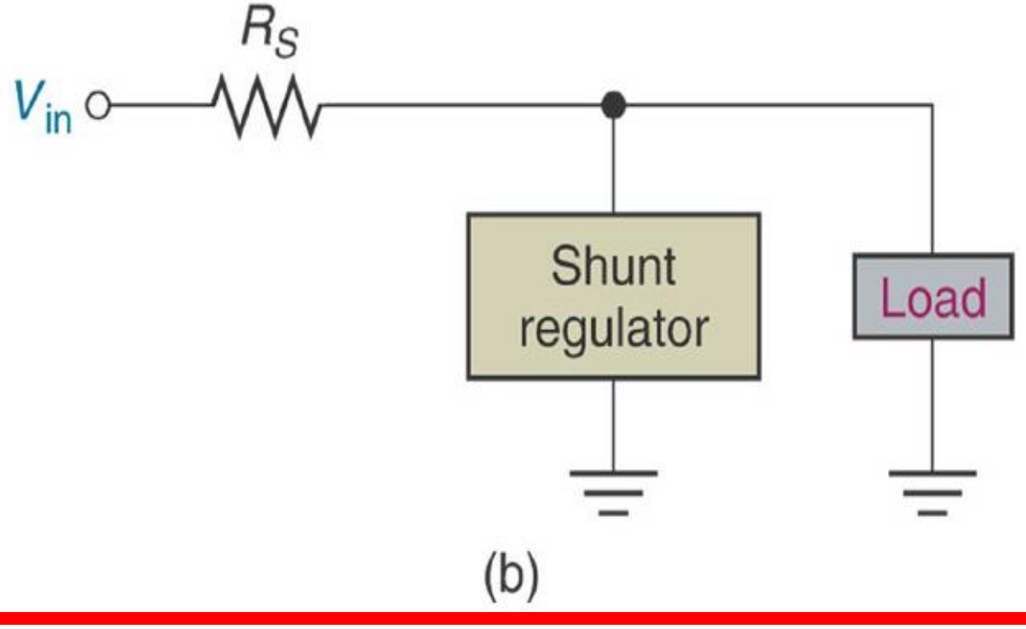
- Filter: a circuit used to reduce the fluctuation in the rectified output voltage or ripple. This provides a steadier dc voltage.
- Regulator: a circuit used to produces a constant dc output voltage by reducing the ripple to negligible amount. One part of power supply.
- Regulator - Zener diode regulator
- For low current power supplies - a simple voltage regulator can be made with a resistor and a zener diode connected in reverse.
- Zener diodes are rated by their breakdown voltage Vz and maximum power Pz (typically 400mW or 1.3W)



Types of Regulator

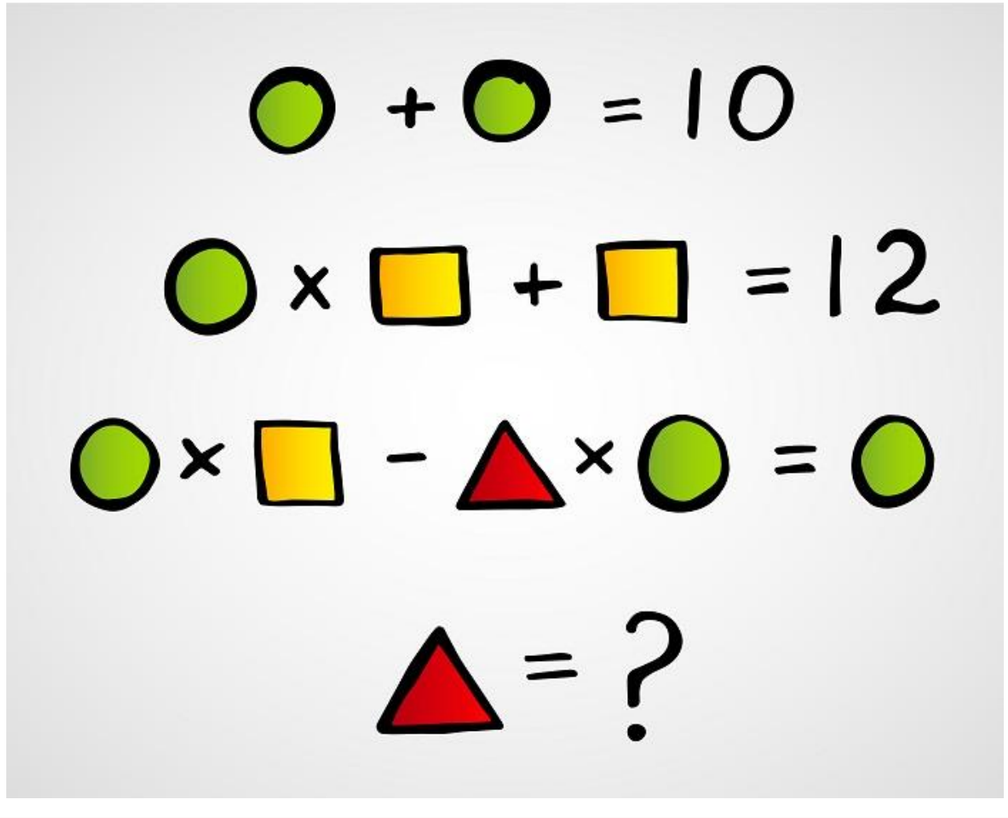
- Fundamental classes of voltage regulators are linear regulators and switching regulators.
- Two basic types of linear regulator are the series regulator and the shunt regulator .
- The series regulator is connected in series with the load and the shunt regulator is connected in parallel with the load.





Activity

In class activity



IC Voltage Regulators

- Regulation circuits in integrated circuit form are widely used.
- Their operation is no different but they are treated as a single device with associated components.
- These are generally three terminal devices that provide a positive or negative output.
- Some types have variable voltage outputs.
- A typical 7800 series voltage regulator is used for positive voltages.
- The 7900 series are negative voltage regulators.
- These voltage regulators when used with heatsinks can safely produce current values of 1A and greater.
- The capacitors act as line filtration.

IC Voltage Regulators

- Several types of both linear (series and shunt) and switching regulators are available in integrated circuit (IC) form.
- Single IC regulators contain the circuitry for:

  1) reference source
  2) comparator amplifier
  3) control device
  4) overload protection

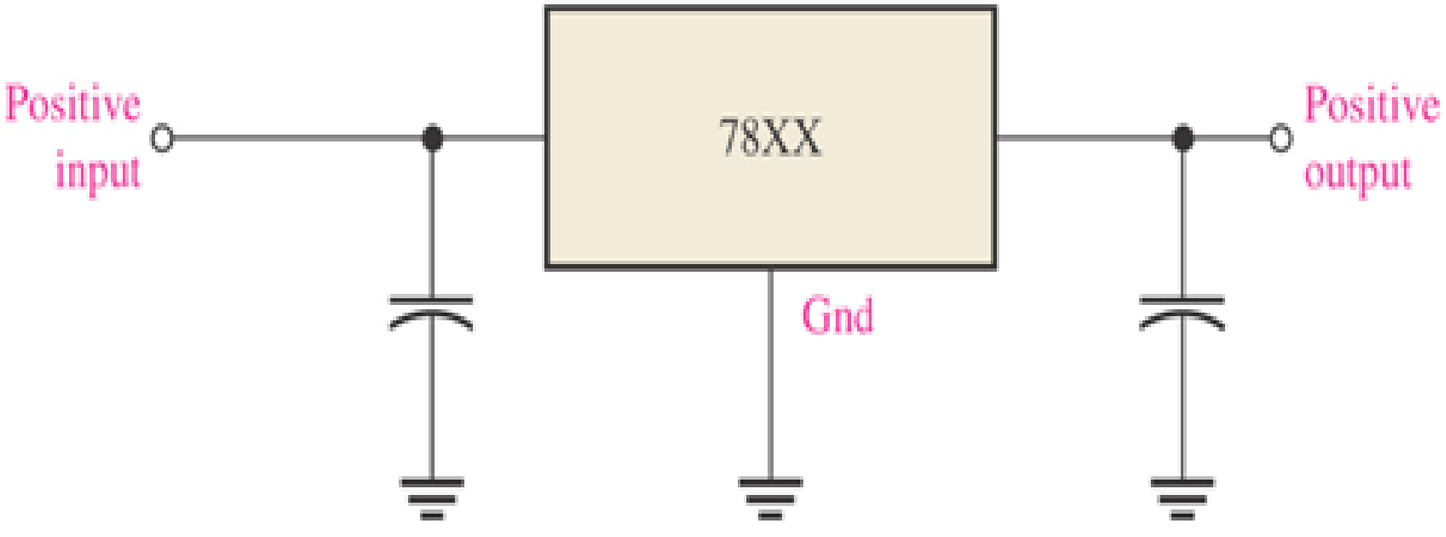
- Generally, the linear regulators are three-terminal devices that provides either positive or negative output voltages that can be either fixed or adjustable.

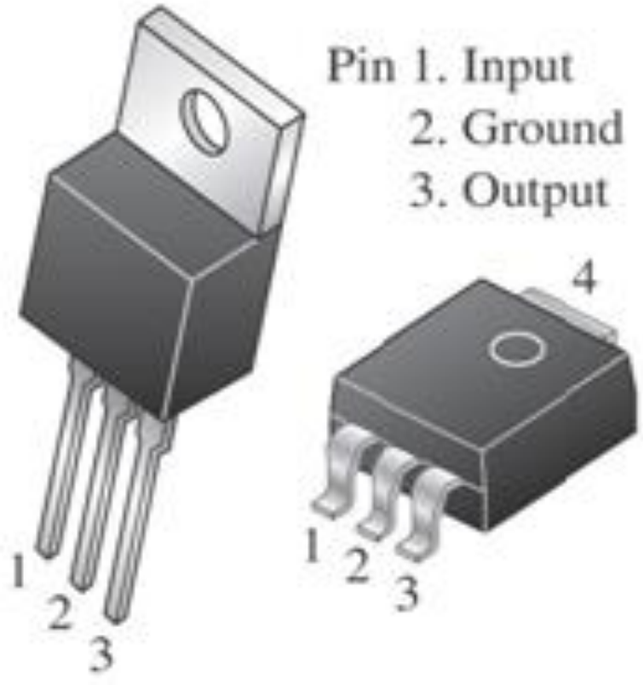
Fixed Voltage Regulator

- The fixed voltage regulator has an unregulated dc input voltage V_i applied to one input terminal, a regulated output dc voltage V_o from a second terminal, and the third terminal connected to ground.

- **Fixed-Positive Voltage Regulator**

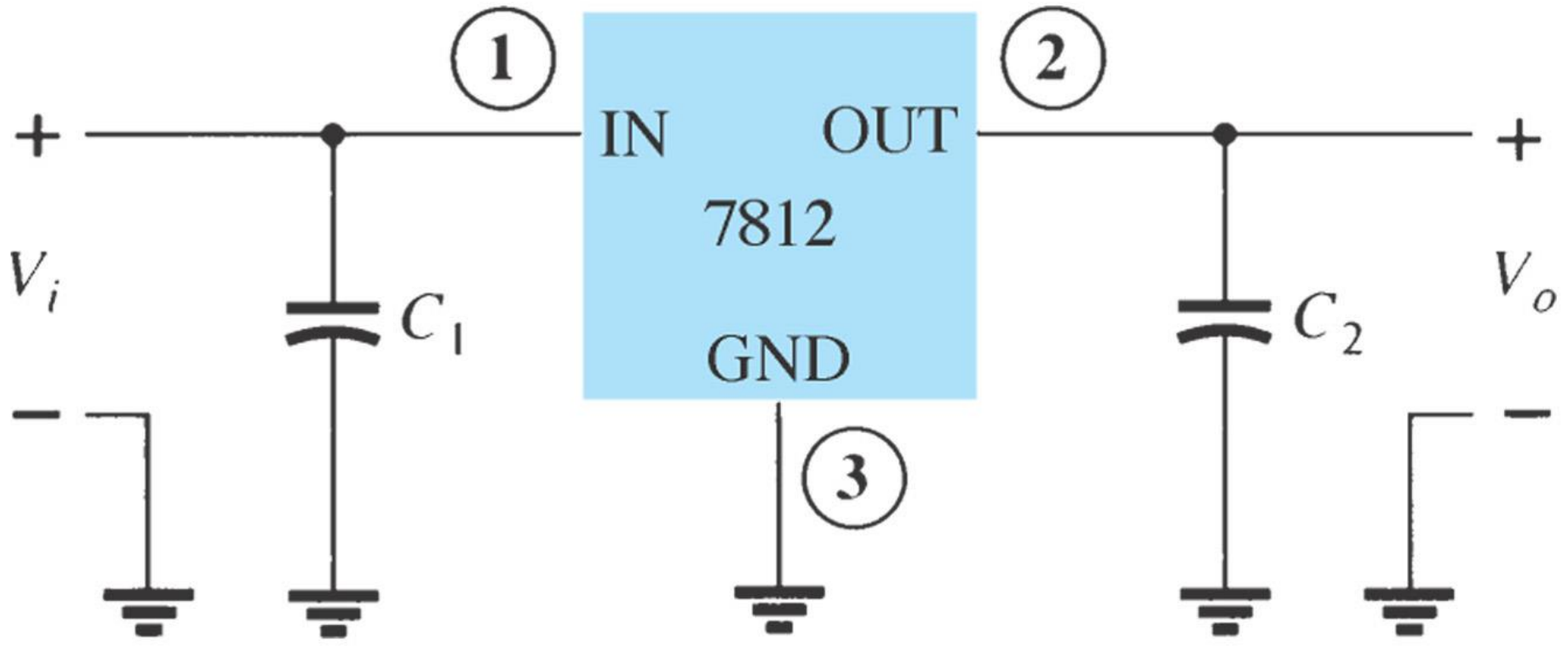
- The series 78XX regulators are the three-terminal devices that provide a fixed positive output voltage.





Fixed Voltage Regulator

- An unregulated input voltage V_i is filtered by a capacitor C_1 and connected to the IC's IN terminal.
- The IC's OUT terminal provides a regulated +12 V, which is filtered by capacitor C_2.
- The third IC terminal is connected to ground (GND)



Fixed Voltage Regulator

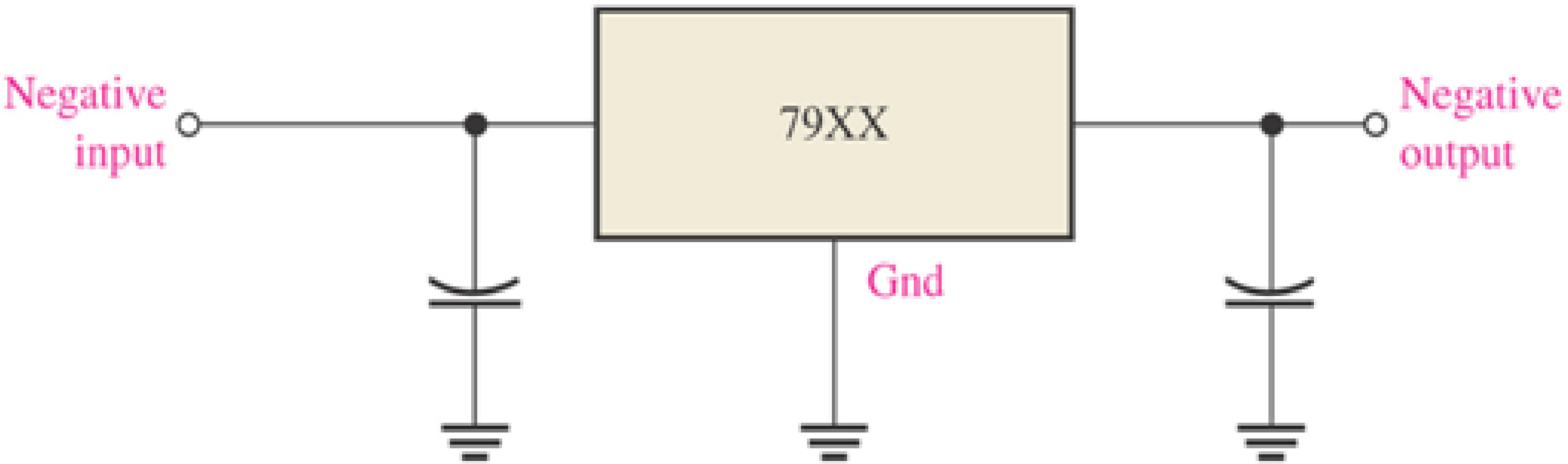
Positive-Voltage Regulators in the 78XX Series

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	+14.5
7815	+15	+17.7
7818	+18	+21.0
7824	+24	+27.1

Fixed Voltage Regulator

Fixed-Negative Voltage Regulator

- The series 79XX regulators are the three-terminal IC regulators that provide a fixed negative output voltage.
- This series has the same features and characteristics as the series 78XX regulators except the pin numbers are different.



Fixed Voltage Regulator

Negative-Voltage Regulators in the 79XX 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

Advantages and Applications of Fixed Regulators

Advantages:

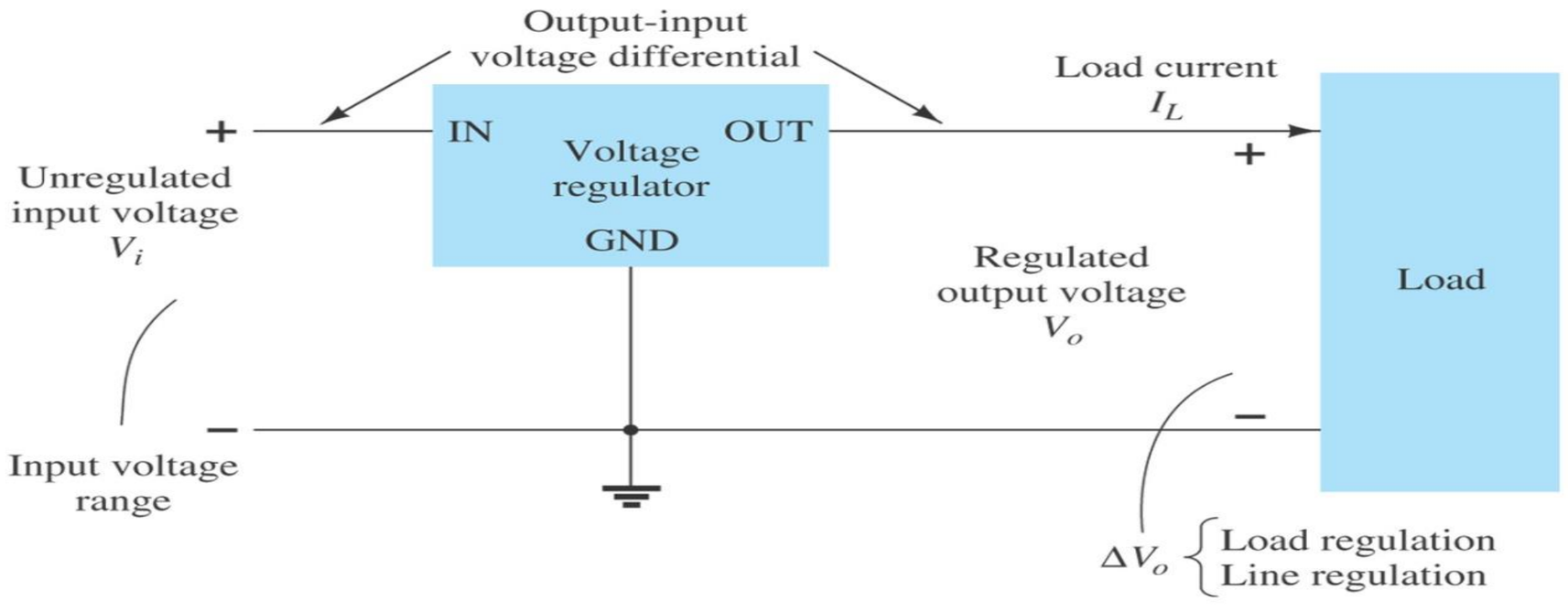
- Simple design and easy to use
- Short-circuit protection
- Thermal shutdown feature

Applications:

- Microcontroller power supplies
- Battery chargers
- Consumer electronics

Switching Regulator

- The switching regulator is a type of regulator circuit which its efficient transfer of power to the load is greater than series and shunt regulators because the transistor is not always conducting.
- The switching regulator passes voltage to the load in pulses, which then filtered to provide a smooth dc voltage.



Switching Regulator

- The switching regulator is more efficient than the linear series or shunt type.
- This type regulator is ideal for high current applications since less power is dissipated.
- Voltage regulation in a switching regulator is achieved by the on and off action limiting the amount of current flow based on the varying line and load conditions.
- With switching regulators 90% efficiencies can be achieved.

Adjustable Voltage Regulators

- Unlike fixed regulators, adjustable regulators allow the output voltage to be set to a desired level using external resistors.
- **Common ICs:**
  - **LM317**: Positive Adjustable Regulator (1.2V to 37V output)
  - **LM337**: Negative Adjustable Regulator (-1.2V to -37V output)
- These regulators provide better flexibility for applications where variable voltage is required.

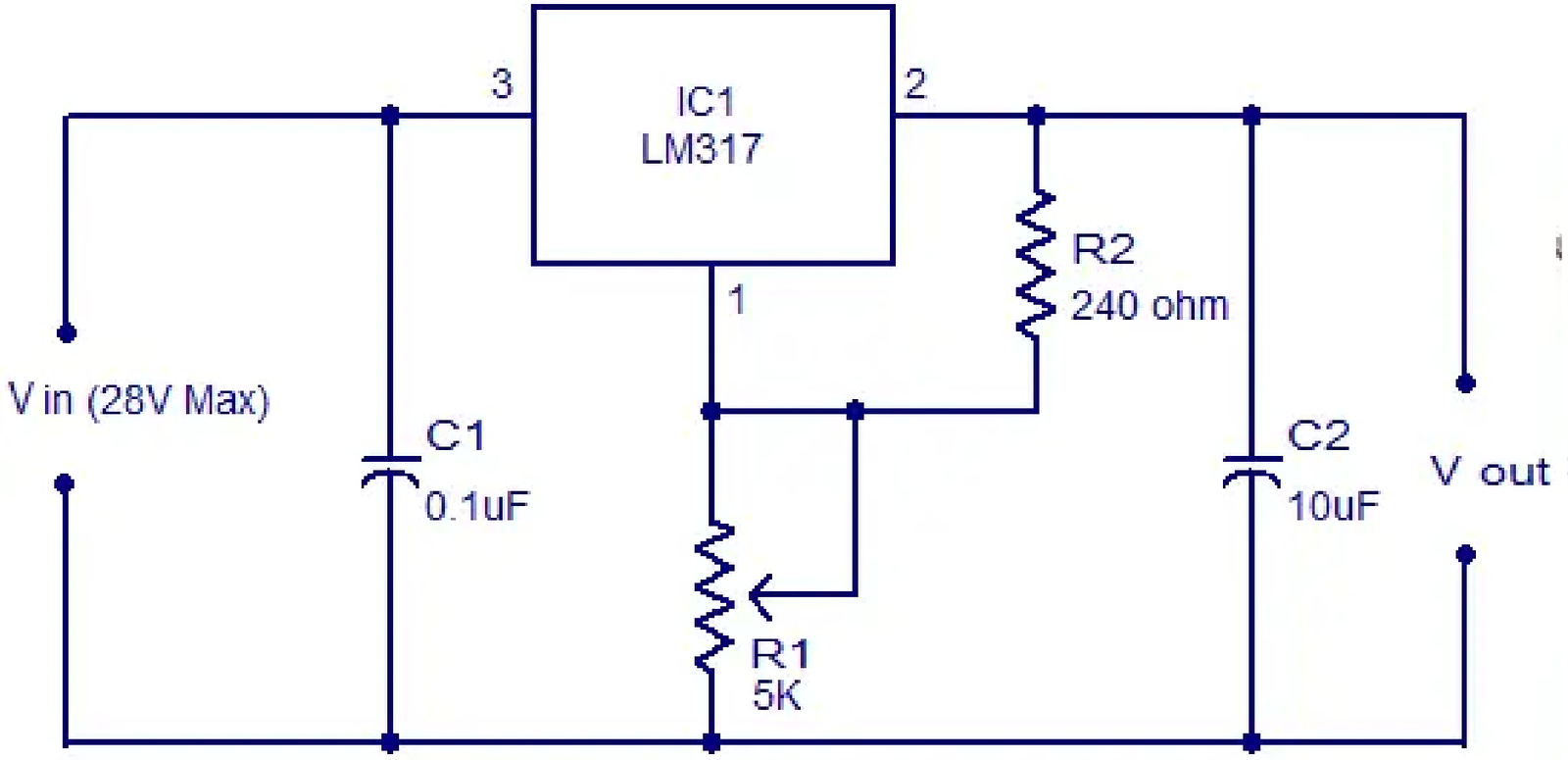
LM317 (Positive Adjustable Voltage Regulator)

•The LM317 operates by comparing a reference voltage (typically 1.25V) with the voltage divider network formed by two external resistors.

•The output voltage is given by:

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

- Where Vref = 1.25V, Iadj is typically negligible.



LM337 (Negative Adjustable Voltage Regulator)

- Similar to LM317 but regulates negative voltages.
- Uses the same formula as LM317 but for negative voltage values.

Design Considerations for Voltage Regulators

Heat Dissipation:

Voltage regulators dissipate power as heat, requiring heat sinks for stable operation.

Power dissipation: $P = (V_{in} - V_{out}) \times I_{load}$

Capacitor Placement:

Input capacitor: Improves transient response.

Output capacitor: Enhances voltage stability and reduces ripple.

Protection Circuits:

Overcurrent Protection: Limits excessive current draw.

Overtemperature Shutdown: Prevents overheating damage.

Short Circuit Protection: Shuts down the regulator if excessive current is drawn.

Applications of Adjustable Voltage Regulators

Adjustable voltage regulators are widely used in circuits requiring variable power supplies:

Power Supplies for Experimental Circuits: Used in laboratory power sources where adjustable voltage is required.

Battery Chargers: Used in smart battery chargers for efficient charging.

LED Drivers: Helps control brightness in LED lighting systems.

Industrial Control Circuits: Used in automation and sensor-based systems where variable voltage is necessary.

Comparison of Fixed vs. Adjustable Voltage Regulators

Feature	Fixed Regulators (78xx, 79xx)	Adjustable Regulators (LM317, LM337)
Output Voltage	Fixed (e.g., 5V, 12V)	Adjustable via resistors
Components Required	Minimal	Requires external resistors
Flexibility	Limited	High
Efficiency	Moderate	Better for variable loads
Applications	Standard power supplies	Custom power supplies, testing labs

Conclusion

- **Three-terminal voltage regulators** simplify voltage regulation in electronics.
- **Fixed regulators** (78xx, 79xx) are easy to use for standard applications.
- **Adjustable regulators** (LM317, LM337) provide flexibility for applications requiring variable voltages.
- **Key Design Considerations:**
  - Heat dissipation and thermal management.
  - Proper selection of capacitors for stability.
  - Protection circuits for reliability and safety.

Assessment

1.List the types of voltage regulators.

Answer: Linear regulators and switching regulators.

2. The switching regulator is more efficient than the linear series or shunt type.

THANK YOU