Welcome Back !!

to

Week # 5 of Class

for

EXTRA CLASS Radio License

George McCarville, WBØCNK Jan, 2026

Chapter 6

Radio Circuits and Systems

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Chapter 6

- 6.1 - Amplifiers
- 6.2 - Signal Processing
- 6.3 - Digital Signal Processing (DSP)
  - Software Defined Radio (SDR)
- 6.4 - Filters and Impedance Matching
- 6.5 - Power Supplies (presented today)

6.5 Power Supplies

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Power Supplies
Linear Voltage Regulators
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Introduction to Linear Voltage Regulators

The voltage of most simple power sources such as batteries or basic rectifier circuits, varies inversely with the load current.

- The more current the, more voltage drops.
- Voltage constantly varies as the device draws more or less power.

Why?

- Limited energy storage at the desired voltage.
- Lack of rapid energy conversion or storage at point of use.

A *voltage regulation circuit*

- Is usually included in most electronic devices to stabilize voltage and or current under changing load conditions.

Linear Voltage Regulators:

Linear voltage regulators are one major category of voltage regulators.
In these circuits, regulation is accomplished by varying the conduction of a *control element* in the load current. The control element is varied to maintain the output voltage at a constant level.

- How does a linear electronic voltage regulator work?
  - ➔ The conduction of a control element is varied to maintain a constant output voltage.

Power Supplies
Linear Voltage Regulators
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Introduction to Linear Voltage Regulators

- **Shunt Analog voltage regulator**

Because the Zener diode controls the output voltage by drawing current from the power source **in parallel with the load,** it is called a *shunt regulator.*

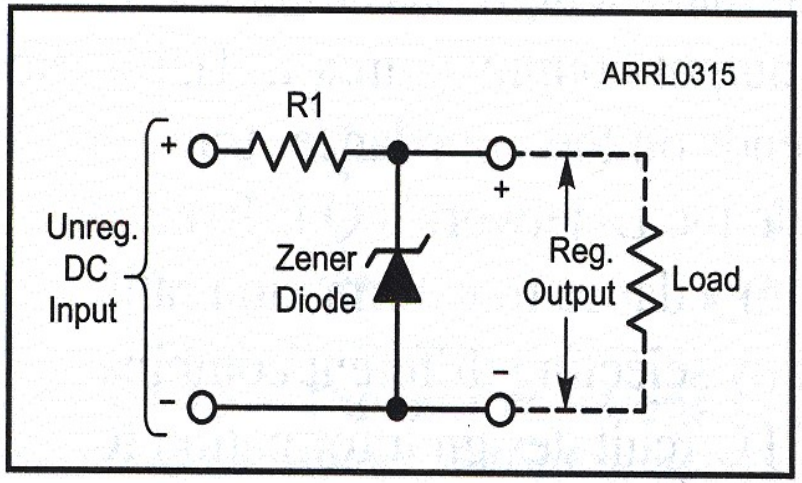

Figure 6-45 — A Zener-diode voltage regulator circuit in which R1 is the control element.

Recall:
Zener Diode:

- Conducts at it's avalanche voltage
- A Large change in avalanche current results in only a small change in voltage across the zener.
- Available for various common voltages.

- E7D05 Which of the following types of linear voltage regulator operates by loading the unregulated voltage source?
  - ► A shunt regulator

Power Supplies
Linear Voltage Regulators
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Shunt and series Regulators

- **Linear Series Analog voltage regulators**

- Control Element is the BJT pass transistor (Q1).
- Base current controlled by the error amplifier.
- The OP Amp error amplifier compares a fraction of the output voltage to the Zener Diode voltage reference and adjusts the pass transistor base current until the output voltage has the correct value. Recall Op Amps

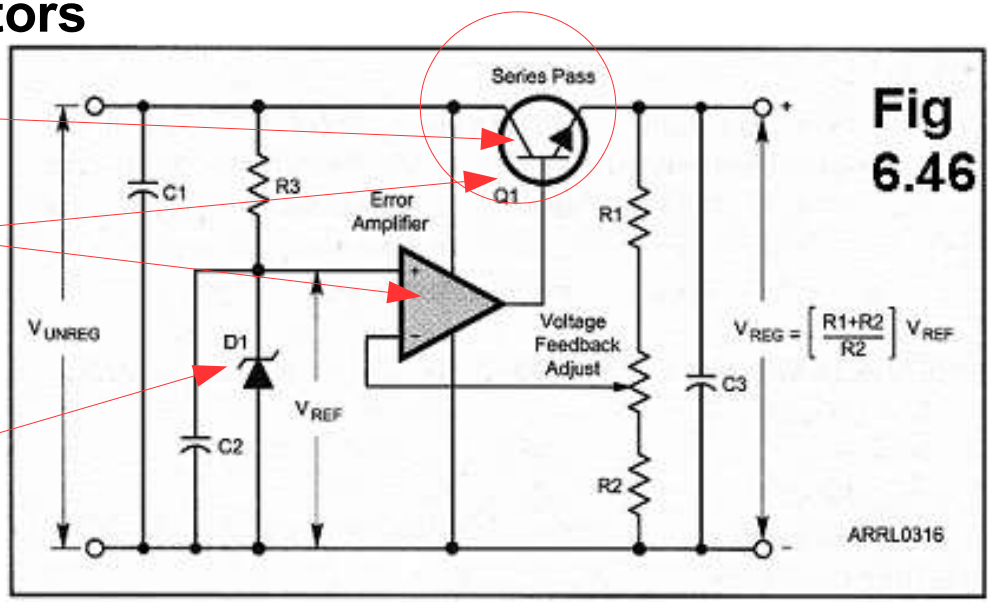

Fig 6.46

- E7D08 What type of circuit is shown in Figure 6.46?
  → Linear voltage regulator
- E7D03What device is used as a stable voltage reference? → A Zener diode
- E7D06What is the purpose of Q1 in the circuit shown in Figure 6-46?
  → It controls the current to keep the output voltage constant

Power Supplies
Linear Voltage Regulators
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Shunt and series Regulation

- **Linear Series Analog voltage regulators**
- **C1** serves to filter the unregulated input supply voltage.
- **C2** serves to bypass(route) hum, ripple and noise from the Zener output around the voltage reference.
- **R1 & R2 & Potentiometer** provide a sample of the output voltage and place a small load on the regulator.

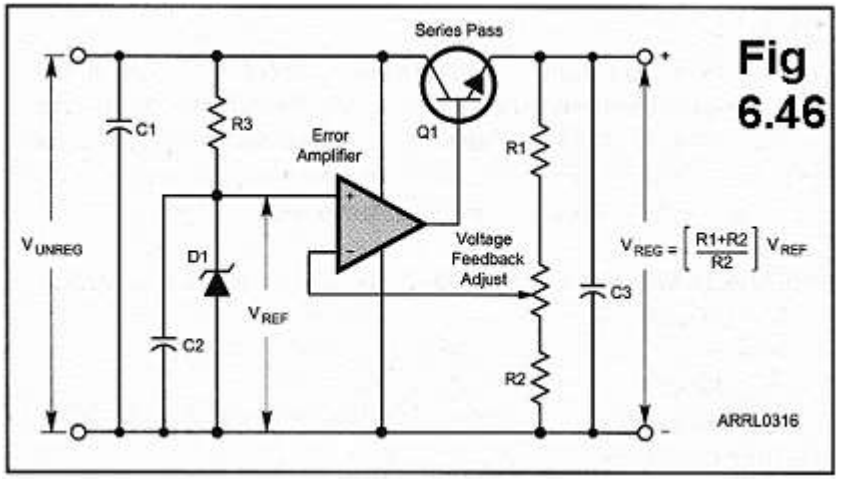

Fig 6.46

- A series regulator requires a minimum level of voltage drop called the *drop-out voltage* across the pass element so that it can respond to changes in the load current and maintain constant output voltage
- **C3** across the output terminals prevent the regulator from oscillating if the load is removed or is very small.

- E7D12 What is the dropout voltage of a linear voltage regulator?
  Minimum input-to-output voltage required to maintain regulation.
- D07 What is the purpose of C2 in the circuit shown in Figure 6.46?
  → It bypasses rectifier output ripple around D1

Power Supplies
Linear Voltage Regulators

Efficiency & Power Dissipation

Series and Shunt Regulators

- Both dissipate a lot of input power as heat to maintain constant voltage (Loss).

$$\text{Efficiency (in \%)} = 100\% \times \frac{\text{Power Out}}{\text{Power In}} \qquad \text{Eq. 6.5}$$

$$P_{DISS} = (V_{IN} - V_{OUT}) \times I_{OUT} \qquad \text{Eq. 6.6}$$

- **E7D13 Which of the following calculates power dissipated by a series linear voltage regulator? Voltage difference from input to output multiplied by output current**

- **E7D04 Which of the following describes a three-terminal voltage regulator? A series regulator**

Power Supplies

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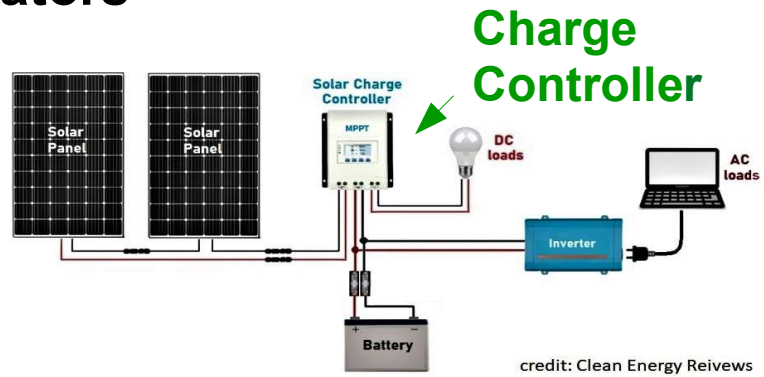
Battery Charging Regulators

1st of 2 categories of <u>Special</u> Voltage Regulators



<u>Charge Controller:</u>

Special voltage regulator for charging batteries.

- Are Important if using an intermittent power source like wind or solar panels etc.
- Applies current at the correct rate
  - Initially enough to reach correct voltage
  - Then just enough to maintain the optimum voltage
- Each different type of battery chemistry requires a different type of controller
  - Lead acid,Lithium,NiMH etc.
- How long will a fully charge battery will power your equipment?

$$\frac{\text{Battery Energy Rating amp-hours}}{\text{Your Current Needs amps}} = \text{hours}$$

Example:

$$\frac{\text{150 Amp hours}}{\text{12 Amps}} = \text{12.5 hours}$$

- **E7D09 How is battery operating time calculated?**
  - → **Capacity in amp-hours divided by average current**

Power Supplies

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Switching Regulators

2nd of Two categories of Special Voltage Regulators

Switching Regulator:

- Supplies equipment with DC power.
- The Control Voltage is switched **entirely ON** or **entirely OFF**
- Usually done with a BJT or MOSFET.
- Highly efficient, but poor designs can cause RF interference.

- The switching circuit stores energy in the magnetic field of inductors or transformers, then releases it to an output filter.

- Duty Cycle of the control element controls the rate energy is stored & released and is automatically adjusted for the correct output voltage.

- Switching frequencies – Are usually in the tens of Kilohertz
  - This reduces physical sizes needed of transformers, inductors & capacitors.
- **E7D02 How does a switchmode voltage regulator work?**
  - ► **By varying the duty cycle of pulses input to a filter**

Power Supplies

Switching Regulators

E7D10 Why is a switching type power supply less expensive and lighter than an equivalent linear power supply?

→ The high frequency inverter design uses much smaller transformers and filter components for an equivalent power output

E4E12 What causes interference received as a series of carriers at regular intervals across a wide frequency range?

→ Switch-mode power supplies.

Power Supplies
High Voltage Techniques
Capacitors

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High Voltage Power Supplies

- Have unique construction requirements.
- Circuits require special physical spacing between leads & components to prevent arcing.
- At turn on: A step-start [relay] charges the capacitors gradually -then fully This is to limit inrush current through rectifier diodes etc.
- Capacitors connected in series require resistors across them to:
  - equalizing voltages across the caps,
  - provide a minimum load,
  - serve as bleeder resistors to discharge the caps when power is off.
- Safety cautions: **Lethal voltages**
  Older oil filled capacitors may contain PCBs(cancer).

- **E7D14**

What is the purpose of connecting equal-value resistors across power supply filter capacitors connected in series? → All of these are correct:

A. Equalize the voltage across each capacitor
B. Discharge the capacitors when voltage is removed
C. Provide a minimum load on the supply
D. All these choices are correct

Power Supplies
High Voltage Techniques
Capacitors

High Voltage Power Supplies

High Voltage
Power Transformer

High Voltage
Capacitors

Power conditioning
board with **Step Start**.

E7D15 What is the purpose of a step-start circuit in a high-voltage power supply? → To allow the filter capacitors to charge gradually

END

END

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