Power Supplies

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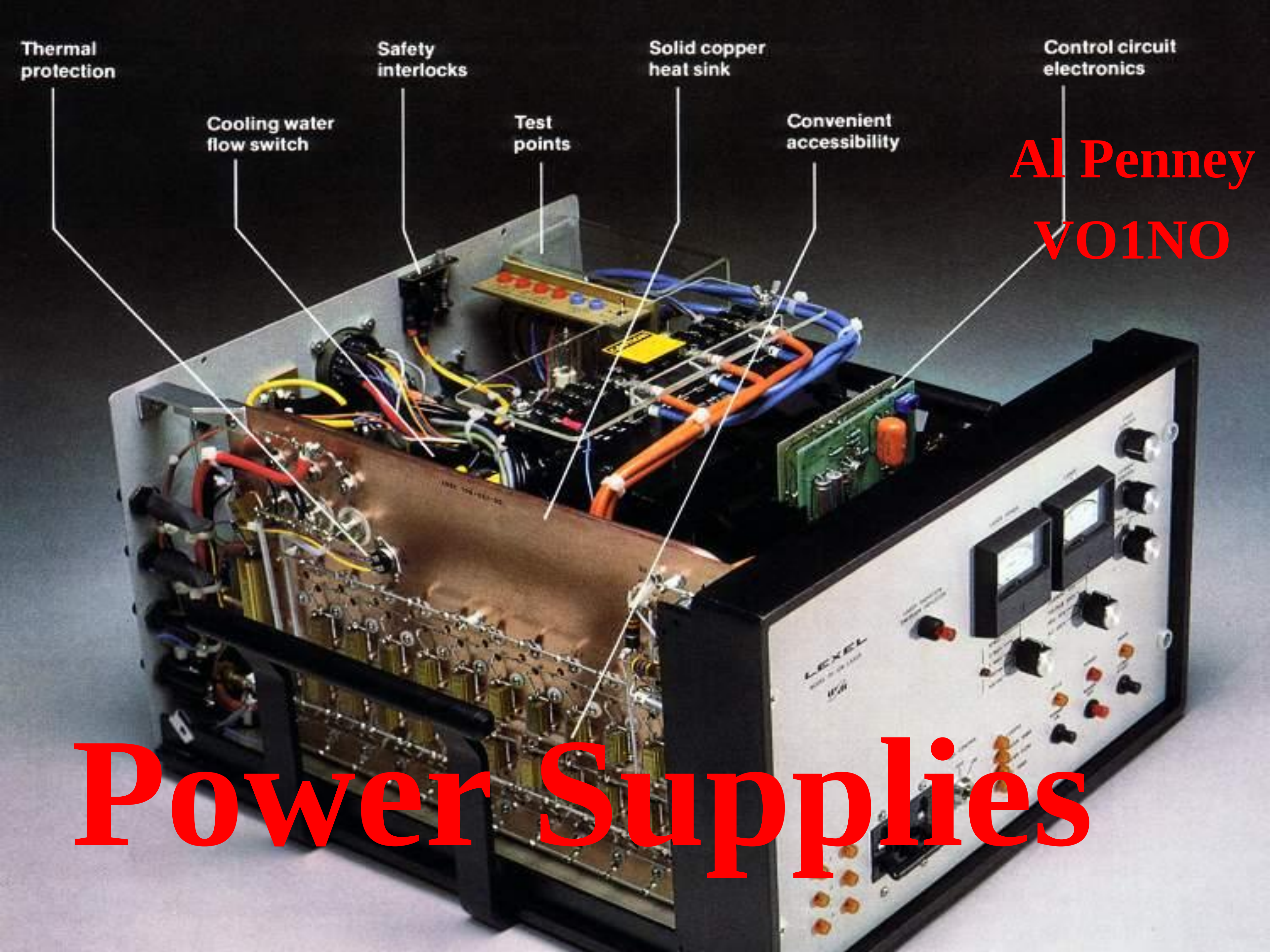

Power Requirements

- Most Amateur Radio gear today requires **13.8 volts DC (Direct Current).**
- Wall outlets provide **120 volts AC (Alternating Current)** however.
- **To convert AC to DC** at the **proper voltage**, we use **Power Supplies.**

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Typical Power Requirements

• TS-870S HF Transceiver	20.5 amps
• FT-7800R Dual Band FM Txcvr	8.5 amps
• FT-100 HF/VHF/UHF Transceiver	22.0 amps
• IC-7600 HF/6M Transceiver	23.0 amps

Power Supply Requirements

- **Voltage** must be **raised or lowered** to the desired value.
- **Voltage** must be changed from **AC to DC.**
- The DC that is produced will contain a lot of **ripple**, and must be **filtered.**
- The DC voltage must be **regulated** so that it **remains fairly constant.**

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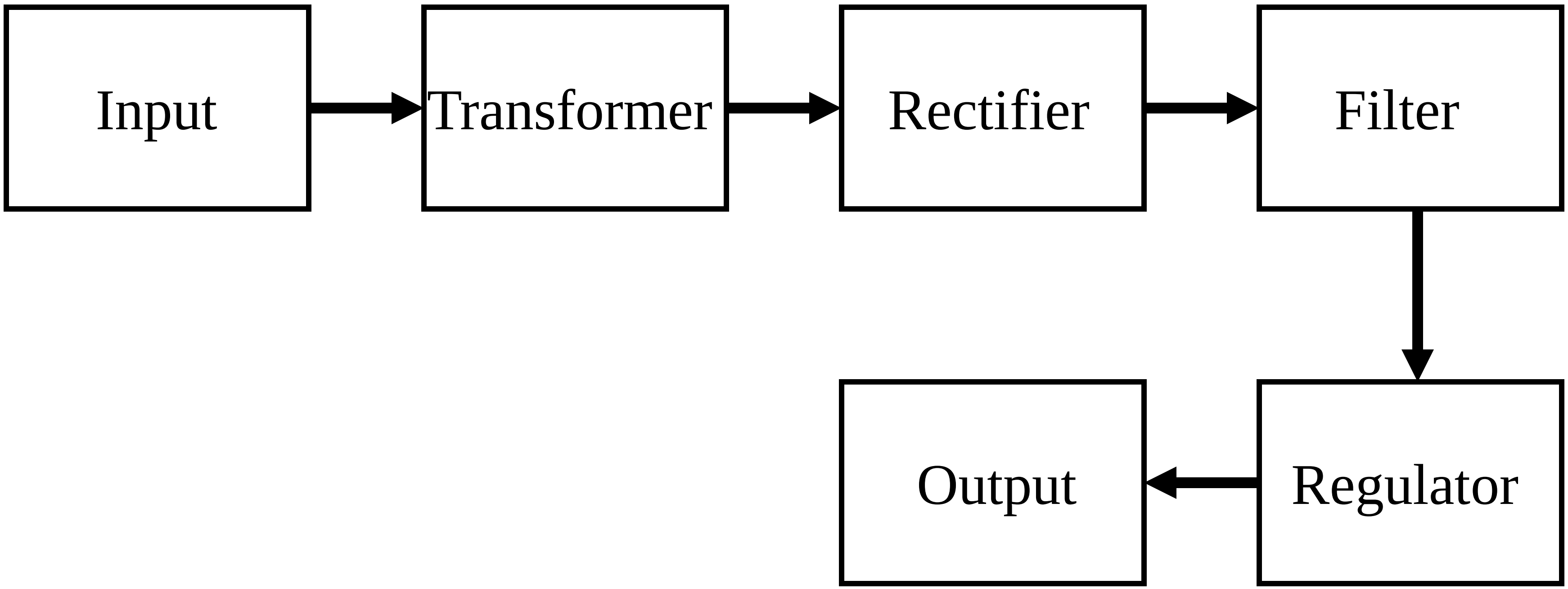
Power Supply Block Diagram



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Changing the Voltage

- A transformer is used to step the voltage up or down.
- The ratio of turns in the primary and secondary windings determine the amount of voltage change:

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

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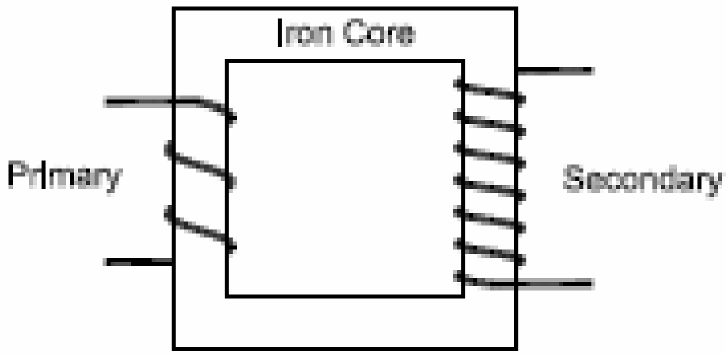
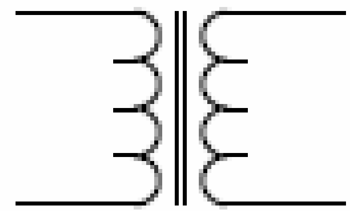
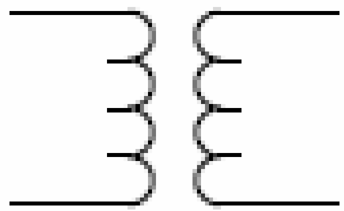
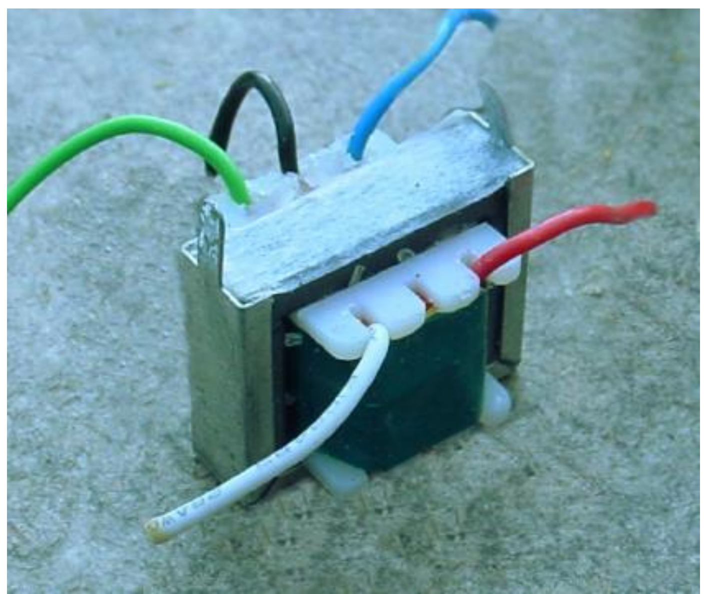
Transformers









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Example

- *Input voltage is 120 VAC. You require an output voltage of 13.8 VAC. The Primary winding has 240 turns. How many turns does the Secondary winding need?*

Example (2)

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

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Example (3)

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

- $120 / 13.8 = 240 / T_{sec}$
- $T_{sec} =$

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Example (4)

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

- $120 / 13.8 = 240 / T_{sec}$
- $T_{sec} = 240 \times 13.8 / 120$

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Example (5)

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

- $120 / 13.8 = 240 / T_{sec}$
- $T_{sec} = 240 \times 13.8 / 120$
- $T_{sec} =$

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Example (6)

$$\frac{\text{Primary Voltage}}{\text{Secondary Voltage}} = \frac{\text{\# Turns Primary winding}}{\text{\# Turns Secondary winding}}$$

- $120 / 13.8 = 240 / T_{sec}$
- $T_{sec} = 240 \times 13.8 / 120$
- T_{sec} = 27.6 turns, rounded to 28 turns

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Power Rating of the Transformer

- Determined by the **size of the core** and the **diameter of the wire.**
- Power rating usually **stamped on the side** of the transformer, and is **expressed in Volt-Amperes** (abbreviated **VA**).
- **Power = Voltage x Current**
- Calculate power requirements of the equipment using the power supply and compare it with the Power rating of the transformer.

Power Rating Example

- *Radio draws 20 amps at 13.8 VDC.*
- *Transformer rated at 250 VA.*
- *Is the transformer big enough for the job?*

Power Rating Example (2)

- Power = Voltage x Current
- Power =

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Power Rating Example (3)

- Power = Voltage x Current
- Power = 13.8 VDC x 20 Amps =

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Power Rating Example (4)

- Power = Voltage x Current
- Power = 13.8 VDC x 20 Amps = 276 Watts

Power Rating Example (5)

- Power = Voltage x Current
- Power = 13.8 VDC x 20 Amps = 276 Watts

- Transformer is rated at 250 VA, so….

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Power Rating Example (6)

- Power = Voltage x Current
- Power = 13.8 VDC x 20 Amps = 276 Watts

- Transformer is rated at 250 VA, so….

- The transformer is **NOT** big enough for the task!

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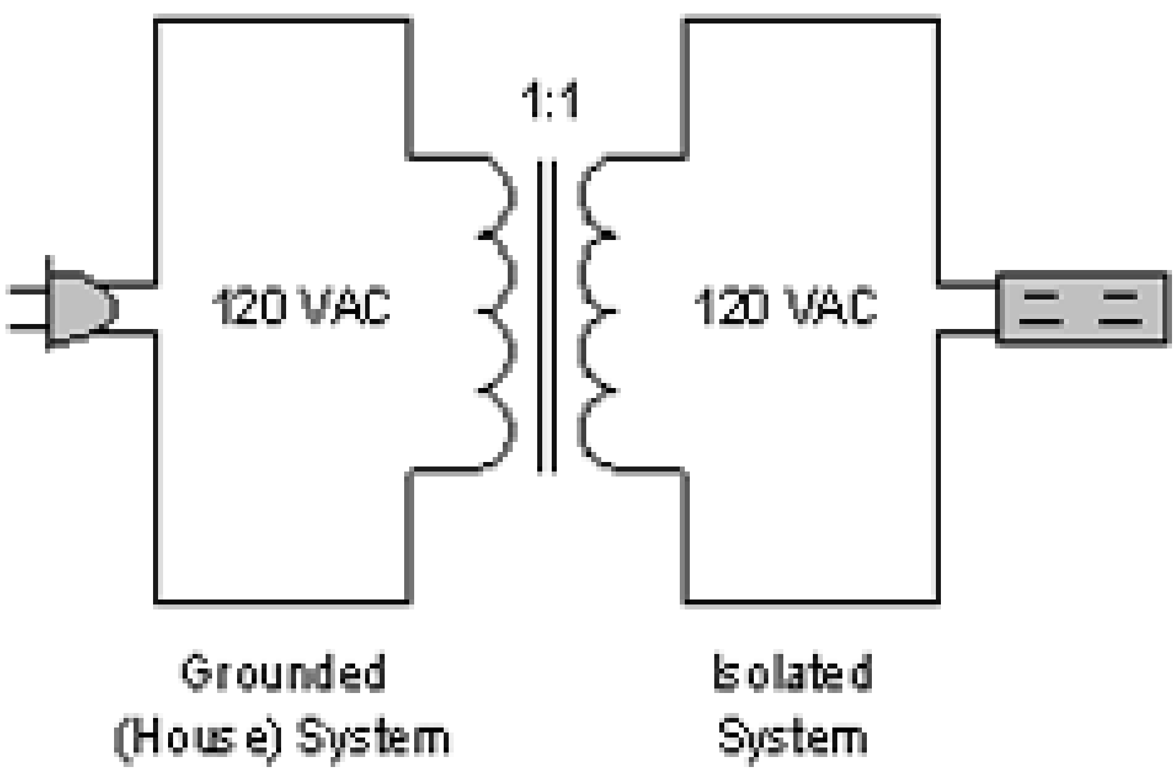
Isolation

- The **load** attached to the transformer is **not physically connected** to the **primary**, as the windings are insulated.
- Much consumer equipment is powered without transformers to keep costs down.
- As a result the **chassis is directly connected** to one side of the **AC line**, and must therefore be enclosed in an insulated cabinet for safety reasons.
- Amateur gear **must be capable of interconnection**, and so such construction is unacceptable for us.
- **Fuse** in the AC line **provides additional safety.**

Isolation Transformer



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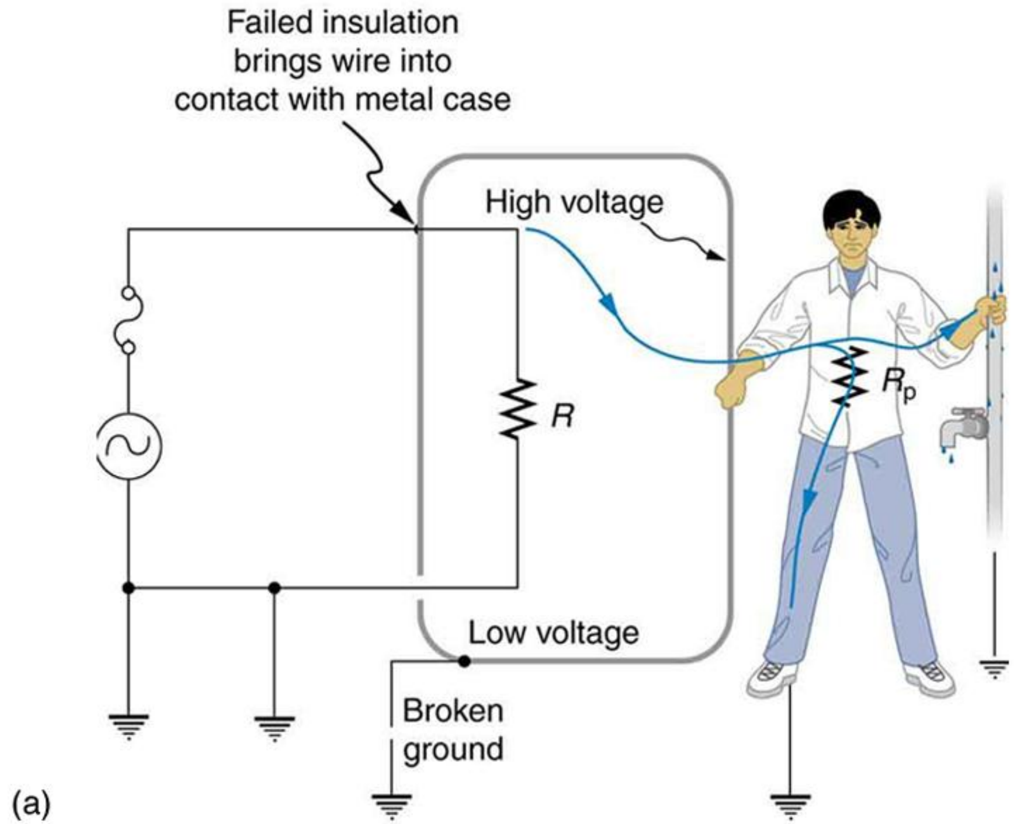
Without Isolation Transformer



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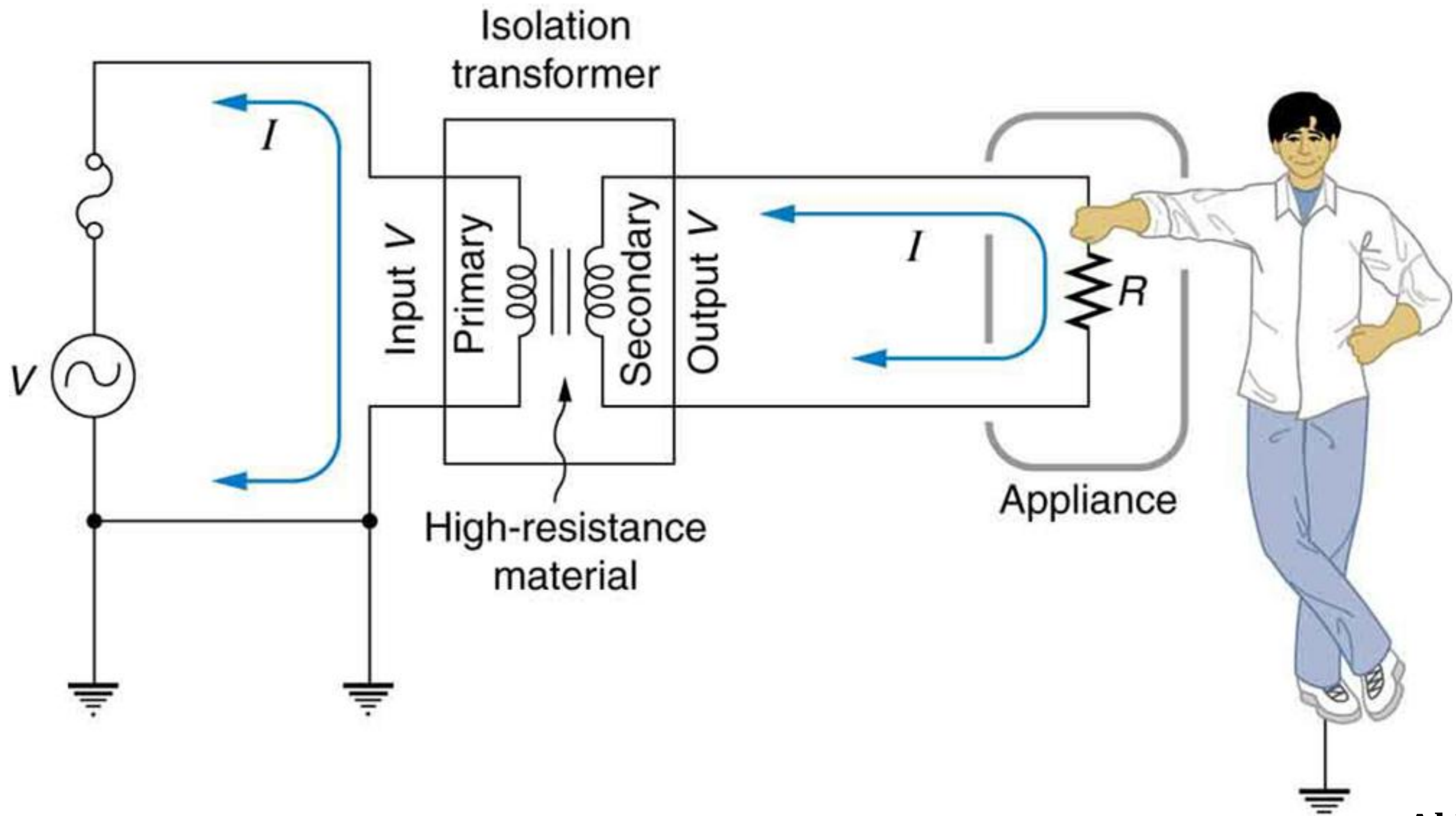
With Isolation Transformer



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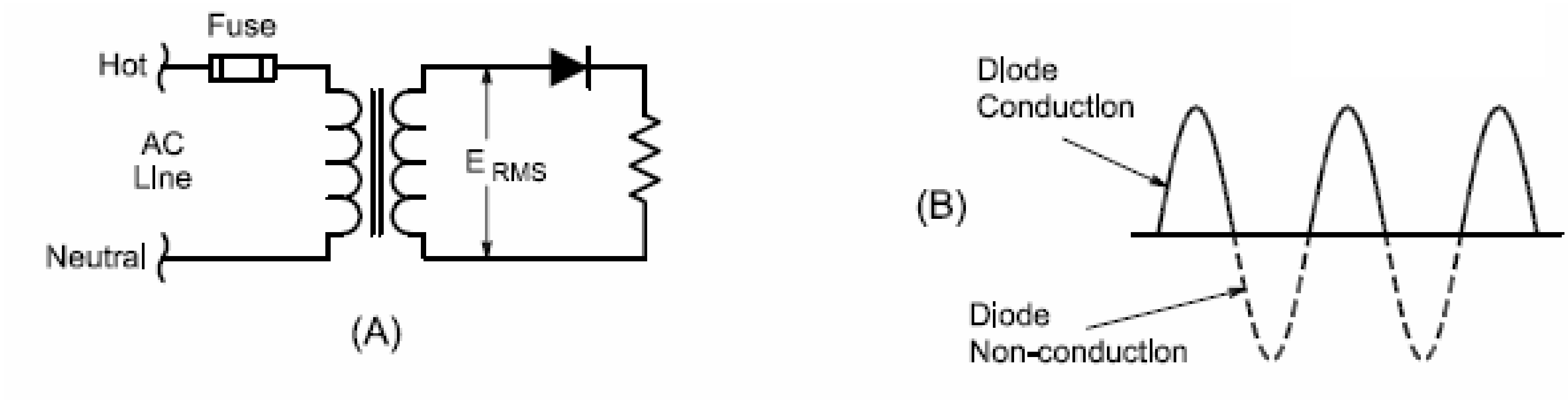
Rectification

- The process by which **AC is converted to DC** is called **Rectification.**
- Broadly classified as either:
  - **Half Wave:** rectify only the positive or negative half of each AC cycle; or
  - **Full Wave:** rectify both halves of the AC cycle.

Half Wave Rectification



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Half Wave Rectification

- Half Wave rectification only **passes half** of the energy thru to the output.
- Resulting DC is very **rough** and needs **heavy filtering.**
- If current requirements are small however, it provides a simple and low-cost solution.

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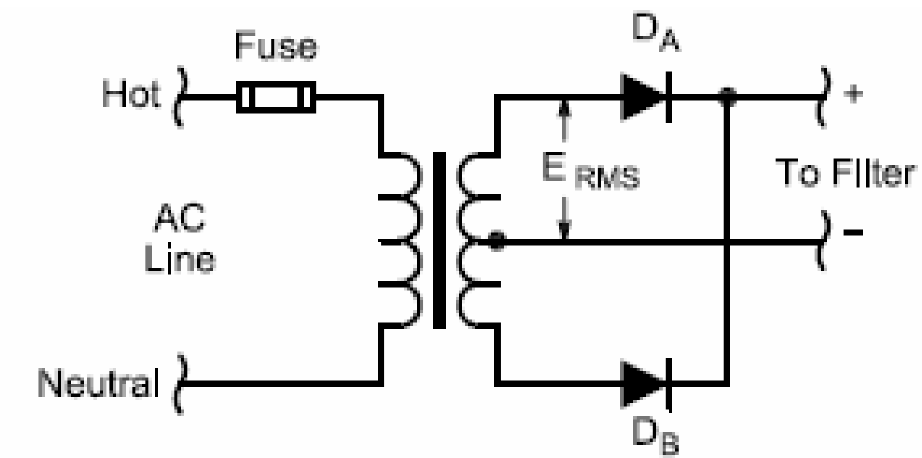
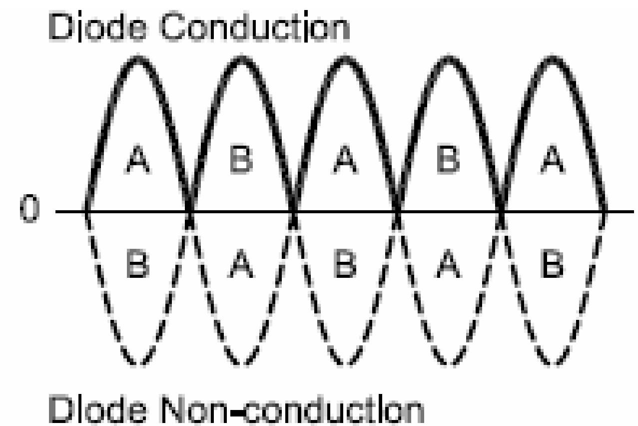
Full Wave Rectification
Center-Tap Transformer





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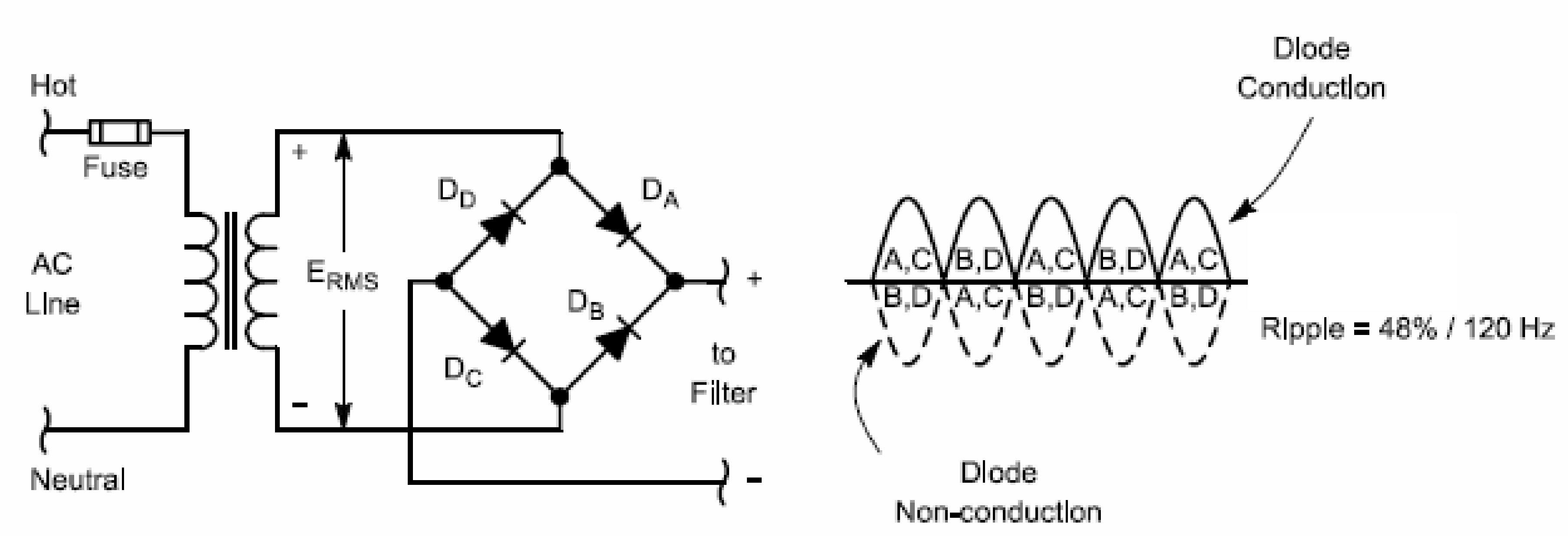
Full Wave Rectification
Center-Tap Transformer

- **Passes all the energy** thru to the output.
- This method **requires a center tap** however.
- The diodes work alternately, handling the full current load but only for half the time.
- Essentially this is **two half wave rectifiers** operating on **opposite polarities of the AC cycle.**
- An advantage of this method is that the resulting DC **ripple frequency** is 120 Hz (twice 60 Hz), making it **easier to filter.**

Full Wave Rectification Without a Center Tap Transformer



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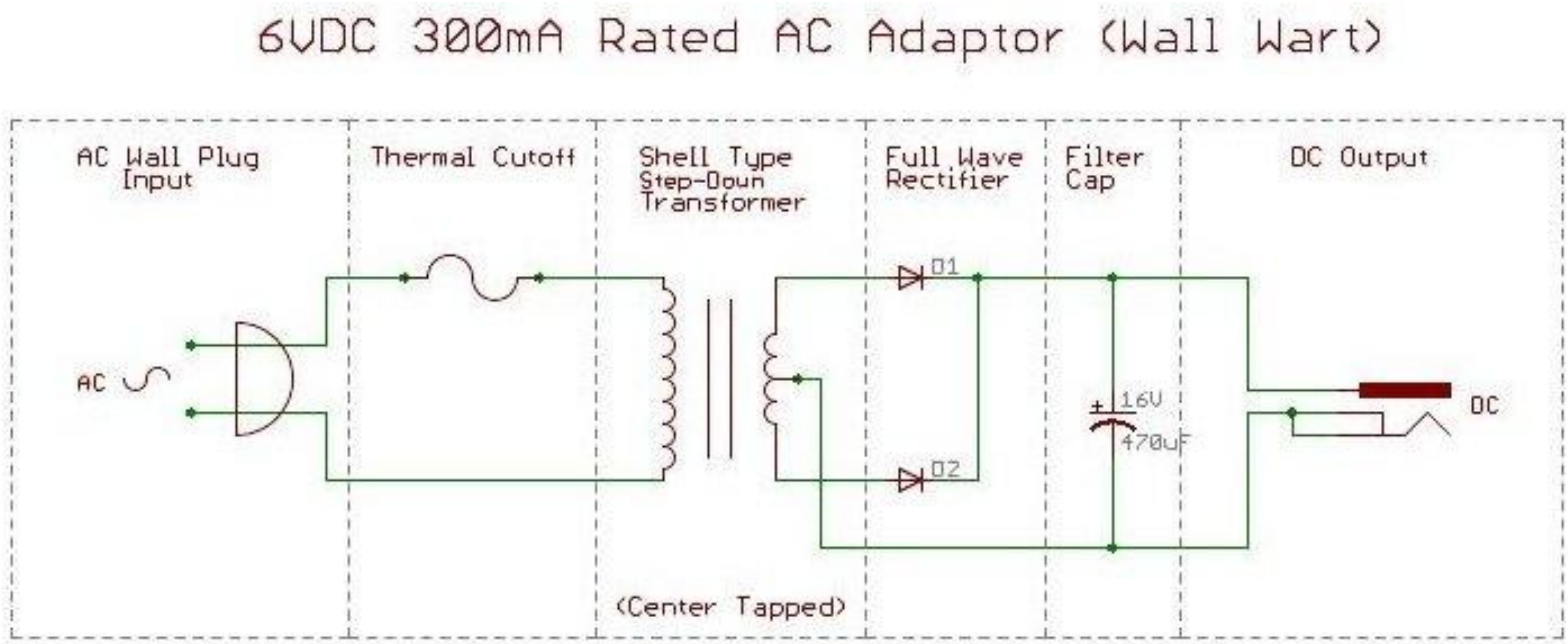
Full Wave Rectification Without a Center Tap Transformer

- This method **eliminates** the requirement for a **center tap transformer.**
- It uses a **Full Wave Bridge Rectifier.**
- Note the polarity of the diodes – two will conduct and two will not conduct on each half-cycle.

Filtering the DC

- Straight out of the rectifier stage, the **DC pulsates,** causing severe hum on transmitted and received signals, as well as a host of other problems.
- This **fluctuating DC** must be “smoothed out” by a **filter.**
- The most effective way to do this is by **using a capacitor** across the output of the power supply.

Simple Full Wave Power Supply



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Voltage Output

Straight from Rectifier stage

After filtering by the Capacitor

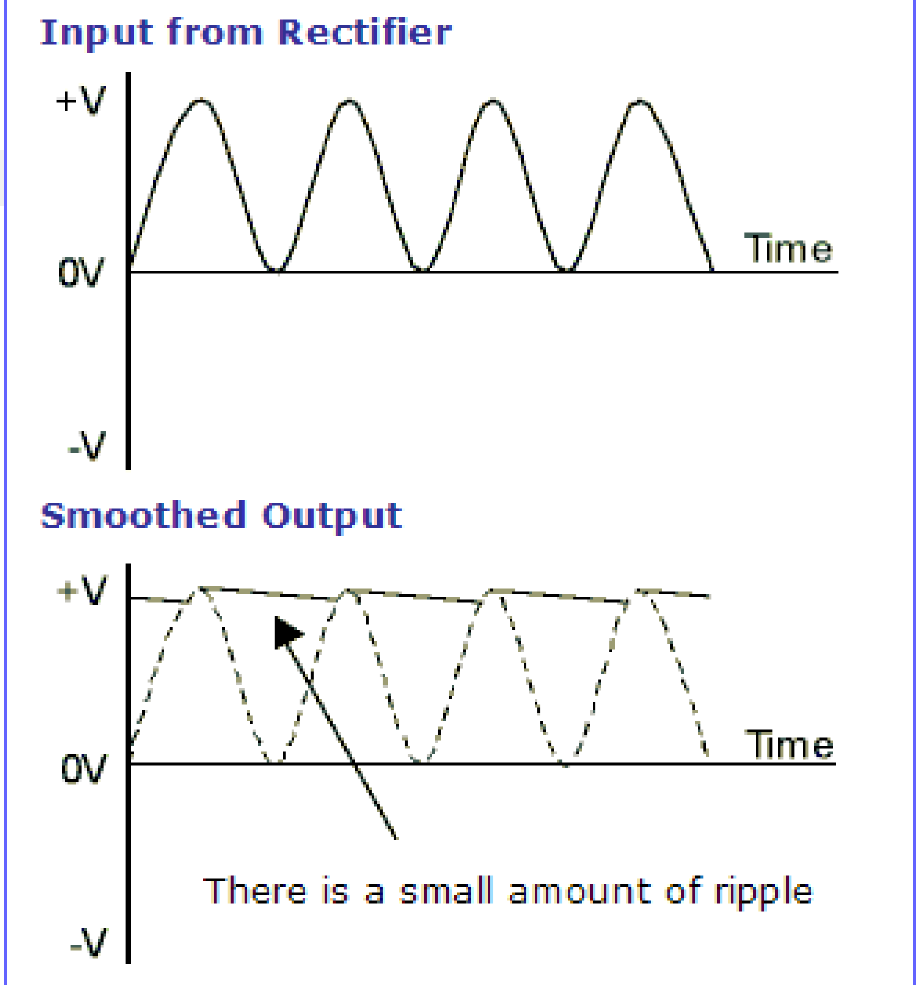

Figure 2: Smoothing

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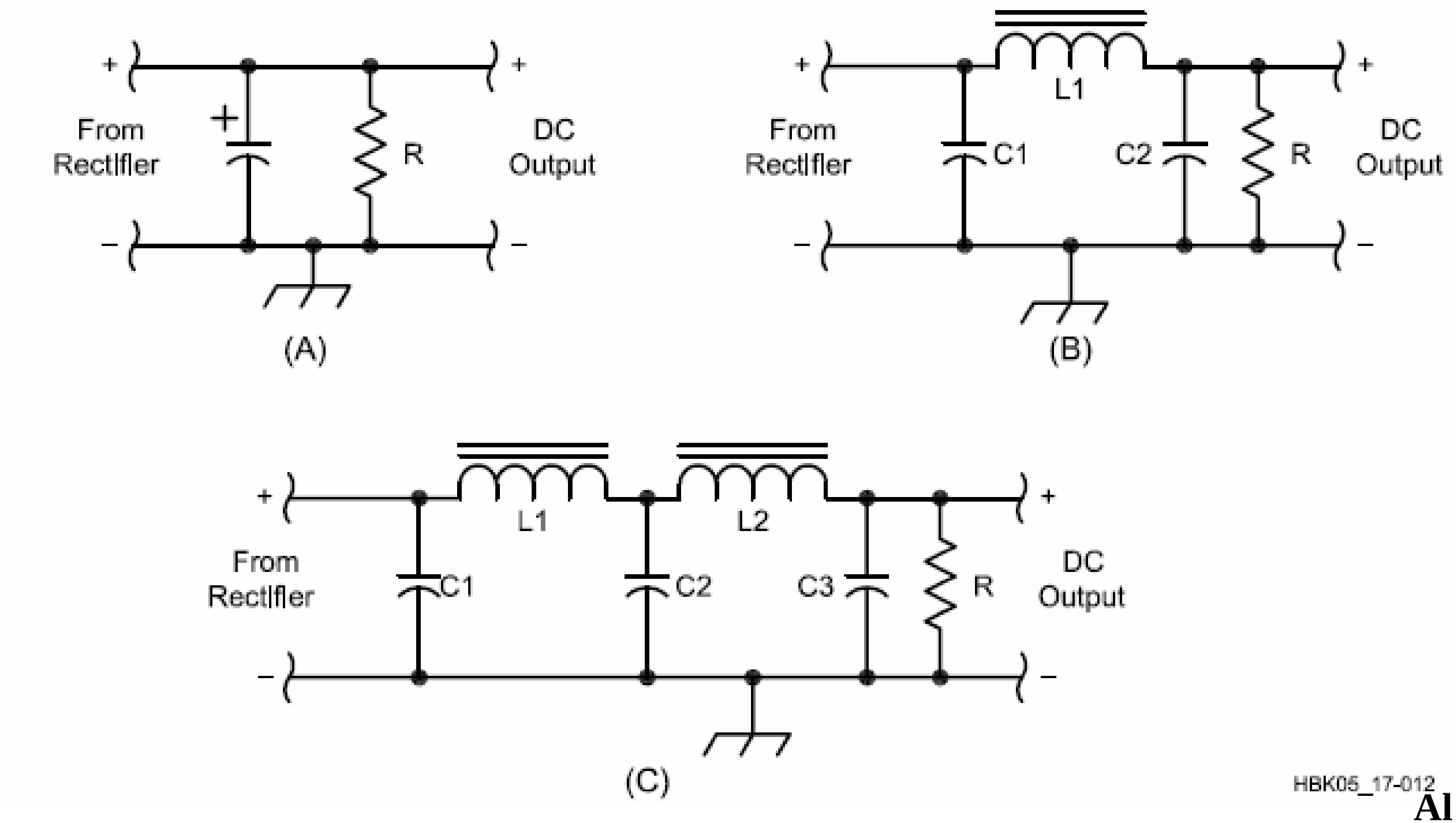
Filtering

- The **capacitor stores energy** when the pulsating DC is high, and **delivers it to the load** when the DC voltage falls.
- Ensure that the capacitor has a working voltage of at least **1.5 times** that of the power supply.
- **"AC hum"** is a sign that the filter capacitor is failing.
- A **"bleeder resistor"** should be placed across the terminals of the capacitor to safely discharge it when the supply is turned off.
- When extra filtering is required, additional capacitors and inductors are used.

Filtering



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Regulating Voltage and Current

- The **output voltage** will tend to **drop** when a **load is applied.**
- A **regulator circuit** will ensure that the **voltage stays constant** when a heavy demand is placed on the supply.
- It works by acting as an **electronically variable resistor** between the filter and the output. As DC output voltage rises, resistance increases, and vice versa.
- Do not try to exceed the maximum output of the power supply!

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Zener Diodes

- A **Zener Diode** is a type of diode that permits current in the forward direction like a normal diode, but **also in the reverse direction** if the voltage is larger than the breakdown voltage known as the **"Zener voltage".**
- Important components of voltage regulation circuits.
- When **connected in parallel** with a variable voltage source so that it is **reverse biased**, a Zener diode **conducts** when the voltage reaches the diode's **reverse breakdown voltage.** From that point on, the relatively low impedance of the diode keeps the **voltage across the diode at that value.**

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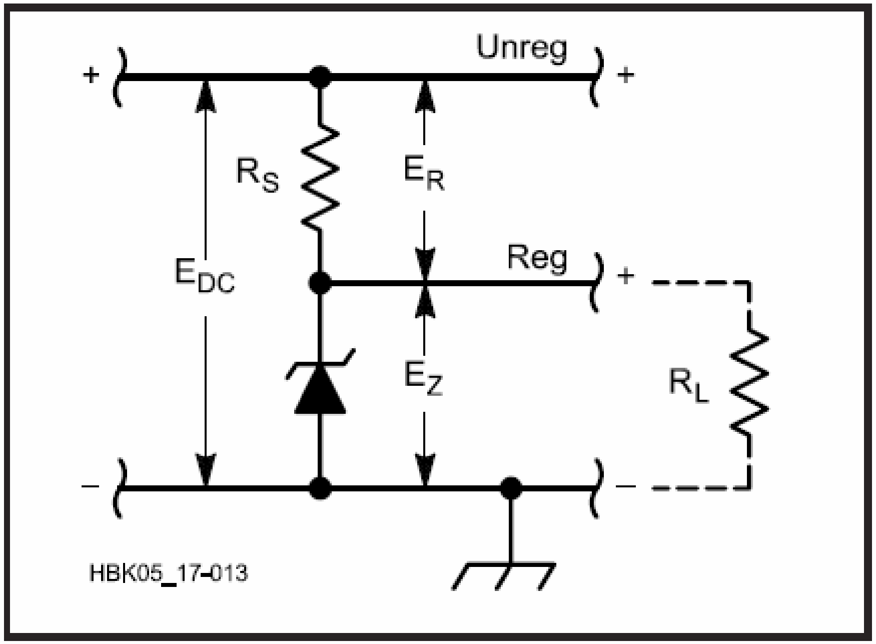
Zener Diodes



Zener-diode voltage regulation. The voltage from a negative supply may be regulated by reversing the power-supply connections and the diode polarity.

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Chirp

- A **poorly regulated power supply** can cause the transmitter **frequency to vary** as the radio is keyed.
- When this happens with a CW signal, the resulting frequency change is called a **chirp.**
- Check the **regulation of your power supply** if you receive a report of chirp.

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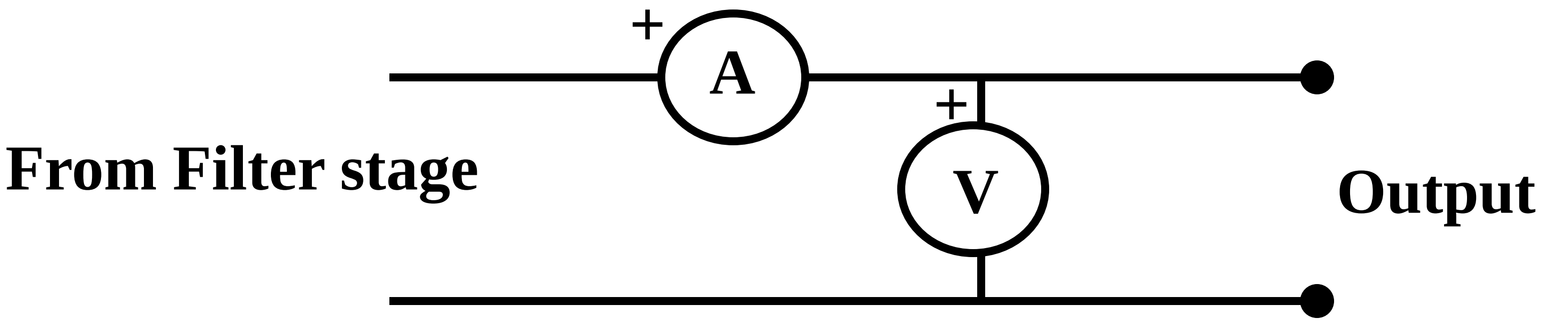
Monitoring the Output

- Good commercial power supplies include a **voltmeter** and **ammeter** to monitor voltage and current.
- Homebrew power supplies should also incorporate voltmeters and ammeters.

Monitoring the Output

- **Voltmeters** are connected **in parallel** with (ie: across) the output of the power supply. Ensure that the meter's polarity is correct.
- **Ammeters** are usually placed **in series** with the positive output terminal, but can also be placed in the negative return line.



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Switching Power Supplies

- **Switching** Power Supplies **switch a power transistor** between **saturation** (full on) and **cutoff** (completely off) with a variable duty cycle whose **average** is the **desired output voltage.**
- **Switching rate** is in the range of **tens to hundreds of kHz,** which can cause **electronic "noise"** on receivers.
- **Advantage** is that they are much **lighter** and **smaller** than conventional power supplies, but they are **more complex.**
- In **widespread use** nowadays.

Questions?

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