Chapter 4 – Practical Circuits

Rectifier Circuits

Batteries and Chargers

Connectors

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Power Supplies

Power supplies provide the necessary power, voltage and current requirements for electronic devices.

- 13.8 V supplies for transceivers
- High Voltage supplies for amplifiers.
- Alternate power

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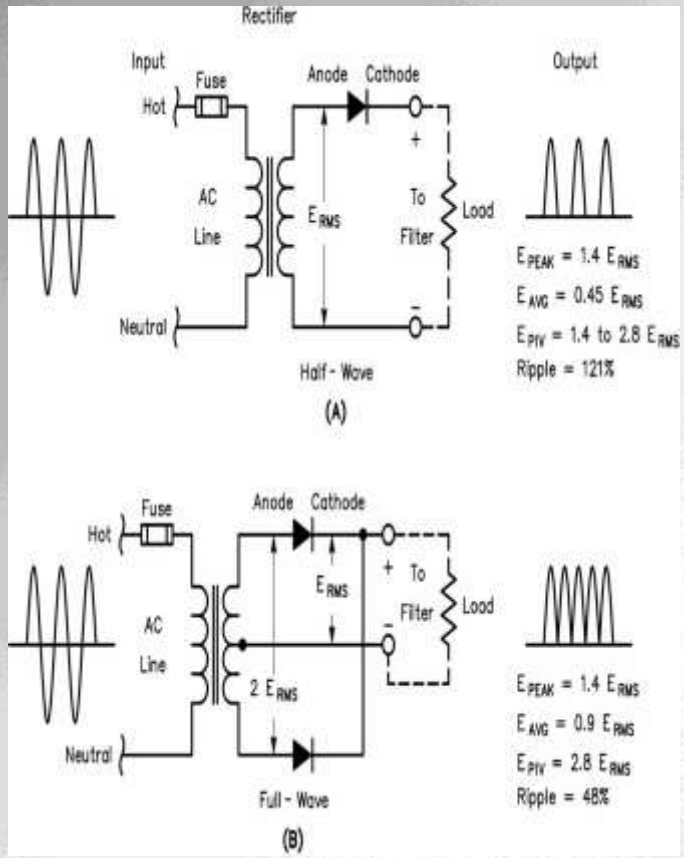
Power Supply Parts

- Transformer – steps AC voltage up or down.
- Rectifier Diodes – change AC to pulsating DC.
- Filter Network – includes capacitors and inductors to smooth out the pulses.
- Voltage Regulator – keeps the voltage constant.
- Protection –
  - Crowbar circuit for Overvoltage.
  - Voltage Foldback circuit for Overcurrent.

Rectifiers – Half Wave and Full Wave



- Diodes conduct only when anode is positive.
- Diode in Half Wave conducts for one half cycle – 180^{O}
- Diodes in Full Wave each conduct on alternate half cycles – 360^{O}
- Full Wave ripple frequency is twice the line frequency.
- Peak voltage across the diodes when not conducting is $2 * E_{Pk} = 2.828 * E_{RMS}$

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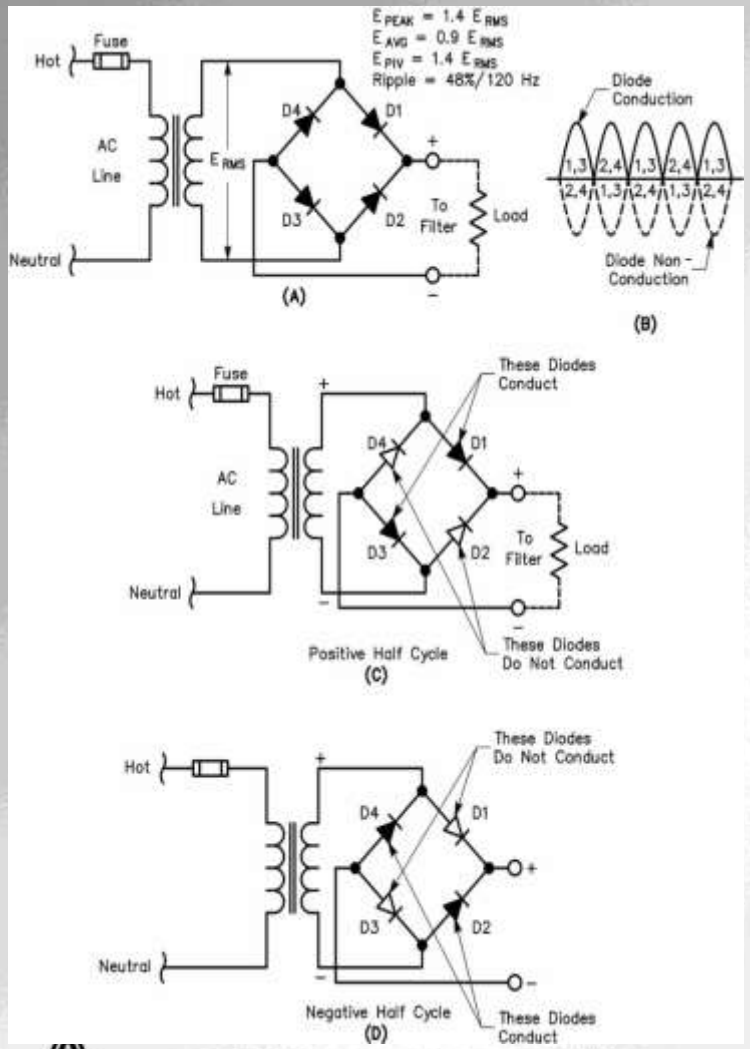
Rectifiers – Full Wave Bridge



- Two diodes conduct on each half cycle.
- Output ripple frequency is twice the line frequency.
- Peak voltage across the diodes when not conducting is $E_{Pk} = 1.414 * E_{RMS}$
- Compared to Full Wave for same voltage to Load:
  - Transformer secondary voltage is half as large.
  - Transformer secondary current is twice as large.
  - Diode Peak Inverse Voltage is half as large.
  - Load voltage is lower by one extra diode drop, ~1.4V vs. 0.5V

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Rectifier Ratings

Peak Inverse Voltage – PIV

- Voltage across the diode when not conducting
- 2 X E_{peak} minimum for half-wave and full-wave
- 1 X E_{peak} minimum for bridge.
- Increase voltage capacity by adding additional diodes with <u>parallel</u> *equalizing* resistors.

Average Forward Current

- Current through the diode when conducting. Highest in half-wave for the same power out.
- Increase current capacity by adding additional diodes with <u>series</u> *equalizing* resistors in parallel.

Power Supply Filtering

The ripple must be smoothed out to make DC.

- Ripple is removed with a filter network of
  - Large capacitors – capacitor input filter
  - Inductors and Capacitors – Choke input filter
- Capacitor charges to peak when diode conducts and discharges until next diode conducts.
- Voltage variation depends on load and size of capacitor.
- *Regulation* is the percent change from no-load to full-load.

Power Supply Filter Capacitors

Electrolytic capacitors are best for low voltage power supply filters – high capacitance in small volume compared to oil and paper.

- The AC current from charging and discharging causes losses in the capacitor due to the *Equivalent Series Resistance – ESR.*
- Capacitor voltage rating should be larger than the peak inverse voltage.
- Hum and noise on signals is often caused by open or failed filter capacitors.

Power Supply Safety

Grounding means connecting the metal case of the PS to the Electrical Ground. Connections must be made with UL approved connectors.

- Neutral and ground are connected together at one point. (By National Electric Code: **Only at the main load center**.)
- Ground Fault Circuit Interrupters: GFCI
- A switch and fuse should be provided to disconnect the AC power.

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High Voltage Power Supply Safety

A dangerous supply can be anything over 30 Volts or containing more than 5 Joules.

- Filter capacitors hold a charge a long time, and may be charged to the output voltage of the power supply.
- After turning off power, check the high voltage with a meter or discharge the high voltage with a shorting probe before working on the supply.
- Bleeder resistors across the filter capacitors “bleed off” charge when supply is turned off.

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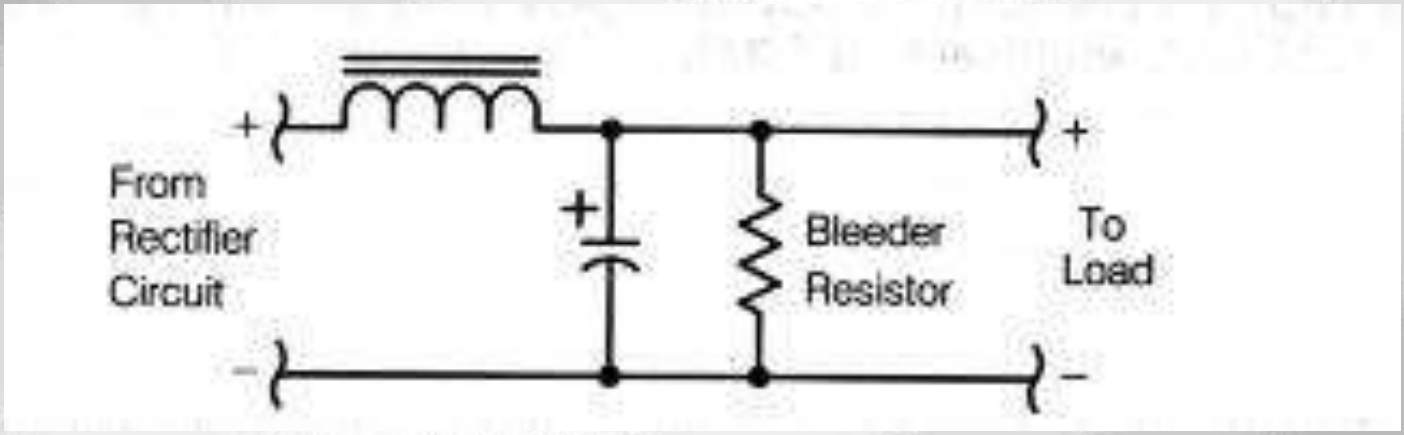
Bleeder Resistors

A bleeder resistor is installed across the filter capacitors as a safety feature to make sure that the capacitors are discharged.



Switching Power Supplies

Switchmode power supplies can be small and lightweight and very efficient. Almost all modern powers supplies, including those in PCs, are switching power supplies.

- Some disadvantages are complexity and RF interference.
- Because they operate at high frequencies, the transformers and capacitors can be smaller.
- Capacitors must have low ESR and also low Equivalent Series Inductance, ESL.

Switching Power Supplies

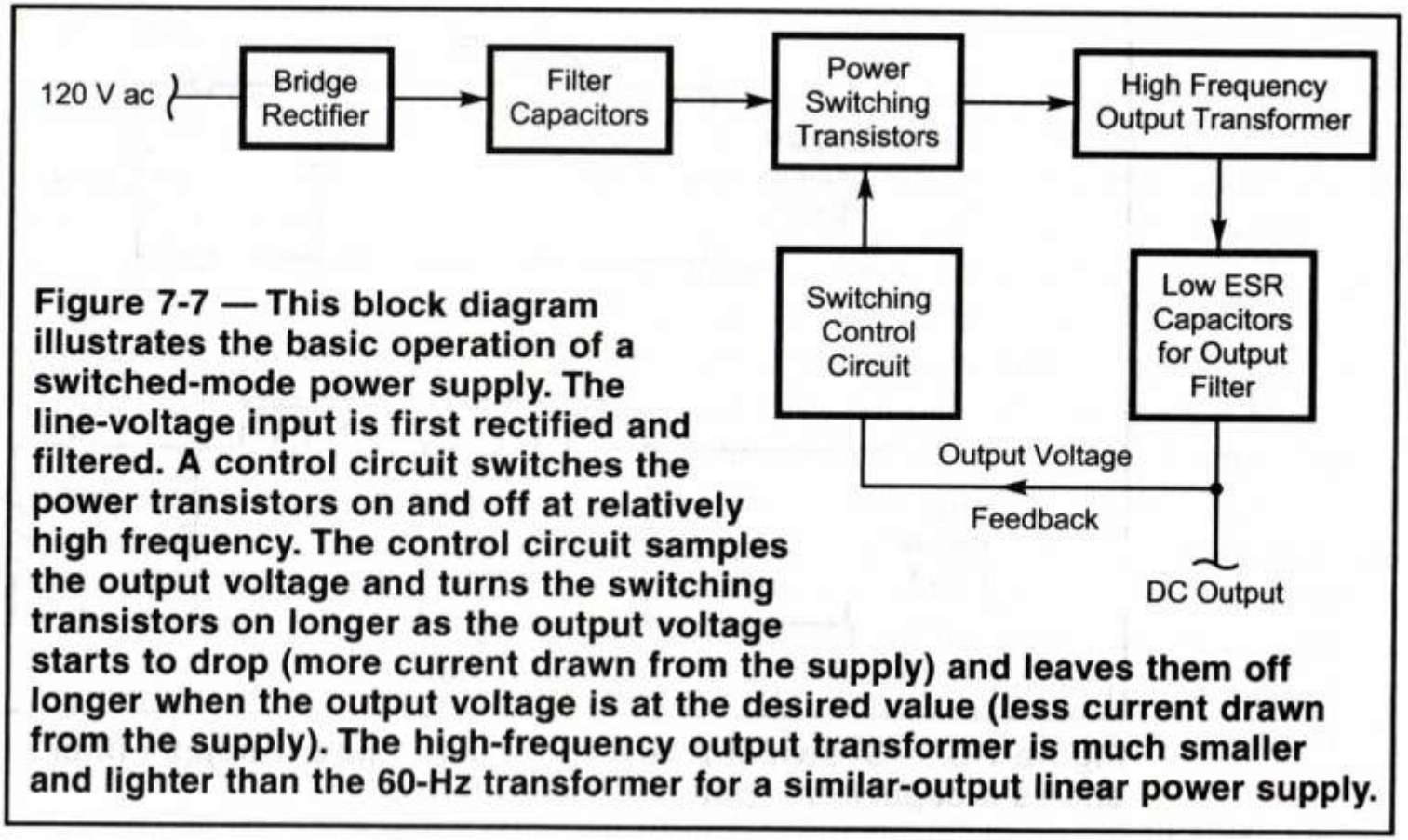


Figure 7-7 — This block diagram illustrates the basic operation of a switched-mode power supply. The line-voltage input is first rectified and filtered. A control circuit switches the power transistors on and off at relatively high frequency. The control circuit samples the output voltage and turns the switching transistors on longer as the output voltage starts to drop (more current drawn from the supply) and leaves them off longer when the output voltage is at the desired value (less current drawn from the supply). The high-frequency output transformer is much smaller and lighter than the 60-Hz transformer for a similar-output linear power supply.

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Batteries

Two basic types:

- *Primary* or Non-rechargeable.
- *Secondary* or Rechargeable.

- Rechargeable battery types based on battery chemistry
  - NiCd, NiMH – Low internal resistance, high discharge
  - Li-Ion – Large energy density makes for small size
  - Lead Acid – *Storage Batteries*
    - 2.3 Volts per cell
    - 13.6 Volt battery useful down to 10.5 Volts
    - Over-discharging will reduce battery life.

Battery Charging

Batteries should be charged at the rate and method recommended by the manufacturer.

- Use a charger designed for the type of battery.
- NEVER attempt to charge primary batteries such as carbon-zinc, alkaline, or silver-nickel.
- Lead-Acid storage batteries may generate hydrogen gas while charging. Do it in a well ventilated area.

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Alternative Power Sources for Off-Grid

Solar power is *Photovoltaic Conversion* using large PN junction cells.

- Photons give electrons energy to cross the PN
- Current from the cell makes an open-circuit voltage of 0.5Volts.
- Cells are connected in series-parallel
- Efficiency is about 20% but sunlight can be up to 1000 watts per square meter.

A storage battery is necessary for night time.

- A series diode keeps the cell from discharging the battery.

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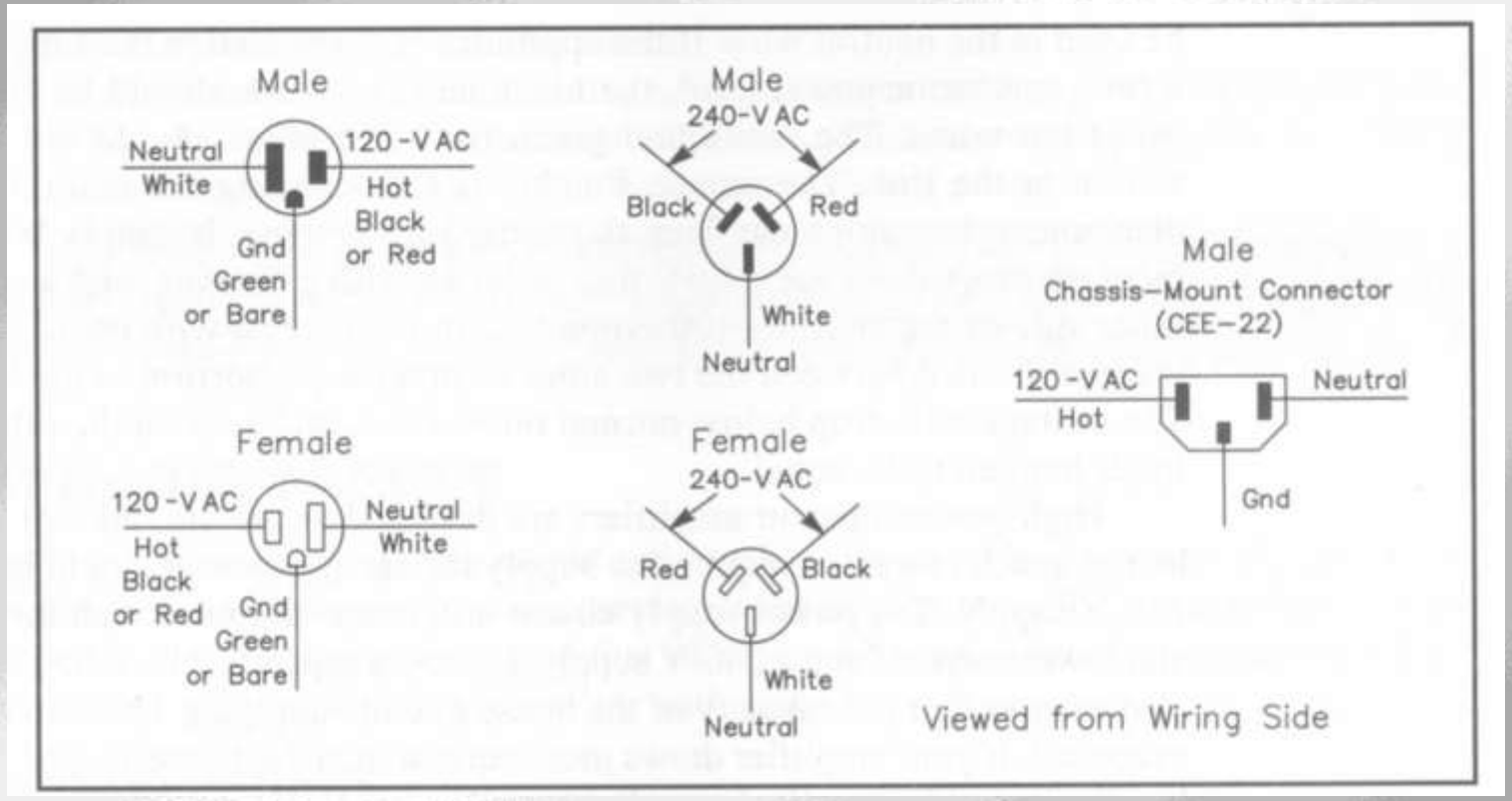
AC Power Connectors



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DC Power Connectors

- Molex – White nylon multi-conductor
- Coaxial – Common on “wall warts”
- PowerPoles – Sexless single conductor units can be combined into multi-conductor
- Binding Posts – for terminals or bare wires
- Automotive crimped terminals
- Terminals should be crimped with proper tool.
- Don’t use solder for high current without a crimped or mechanical connection.

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Signal Connectors

Connectors for audio and control signals need reliable contact at low currents.

- Plugs are on cables, Jacks are on equipment.
- Mating connectors should have an index key.
- Placing similar connectors close together can result in mixed up connections.
- RCA Phono plugs and jacks
- DIN and Mini-DIN multi-conductor
- Microphones: 8-Pin Round; RJ-45

RF Connectors

RF connectors can cause losses and reflections at higher frequencies. The connector must be rated for the voltage, current, and frequency.

- Common types: UHF, N, C, BNC, SMA
- UHF connector – PL259, SO239 – is OK For HF (and VHF) at amateur power levels.
- For UHF, type N is useable to 10GHz.
- Connectors used outside must be waterproof or sealed.

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Data Connectors

Several connector families commonly used in computing equipment and newer amateur equipment.

- D-Type – commonly called DB-25, DB-9, etc. P or S suffix denotes Pins or Sockets, i.e., DB-9P, used for PC COM serial ports.
- USB – Becoming common for radio⇔computer.
- USB⇔RS232 adapters
- Ethernet RJ-45

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