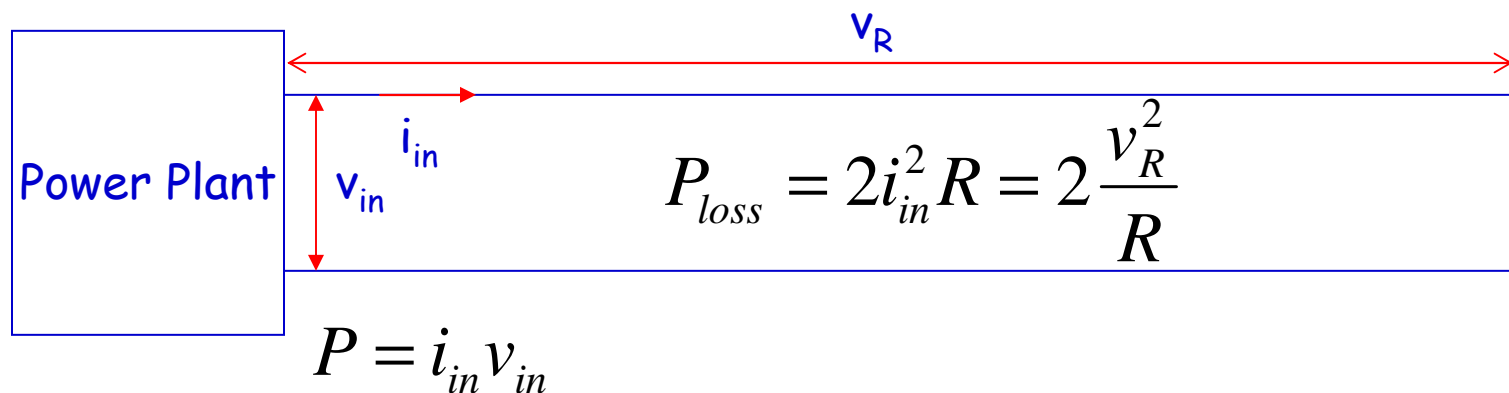


Electrical Consumption: why is ac important

- Consider a city such as Newark, DE. Assume that 30,000 citizens wish to dry their hair at the same time; that would require approximately 50 MW ($30,000 \times 1500\text{W} = 45,000,000\text{ W}$). (The actual Delmarva Power Fall 1995 figure was a peak demand of 2500 MW for 400,000 customers, yielding an average of more than 6000 W per user.)
- At 120 V, this power would require a current of $I = P / V = 50,000\text{ kW} / 120\text{ V} = 400\text{ kA}$. A 10-gauge wire (5 mm^2 cross-sectional area) can handle 30 A before overheating -- thus more than 13,000 such wires would be required *or* a wire of diameter 15 cm, both physically unreasonable!

Electrical Consumption: why is ac important

- To deliver a particular amount of power, the current may be decreased by increasing the voltage, since $P = I V$. For example, boosting the voltage to 80 kV results in a current of $(50,000\text{kW})/(80\text{kV})=600 \text{ A}$, a much more manageable value. The ratio of currents between 80 kV and 120 V is 670 -- the energy lost in the transmission lines would be that ratio squared, approximately one-half million, since the power dissipated by the transmission lines is proportional to the current squared.
- If a device exists that can raise or lower voltages while maintaining power, with very little loss of energy, then power can be transferred over greater distances with less loss. Electric power stations can thus be situated further from residential areas. Such a voltage conversion is difficult with *dc*; however, the conversion from one *ac* voltage to another is straightforward when the electrical component known as a **transformer** is used.



Transformer

Transformation of Voltage: $\frac{V_{out}}{V_{in}} = \frac{N_{out}}{N_{in}}$

$N_{out} > N_{in}$ step-up

$N_{out} < N_{in}$ step-down

Ideal Transformer:

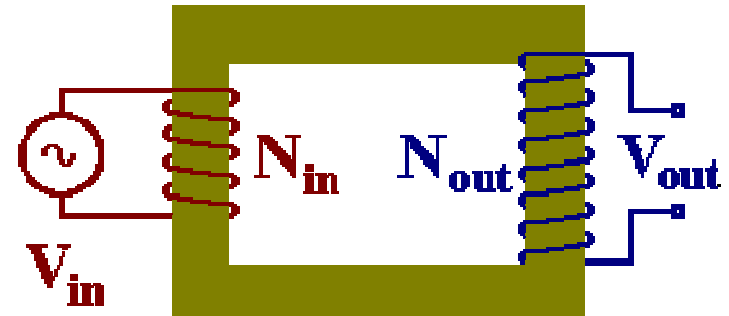
$$P_{out} = P_{in}$$

$$(IV)_{out} = (IV)_{in}$$

$$\frac{V_{out}}{V_{in}} = \frac{I_{in}}{I_{out}}$$

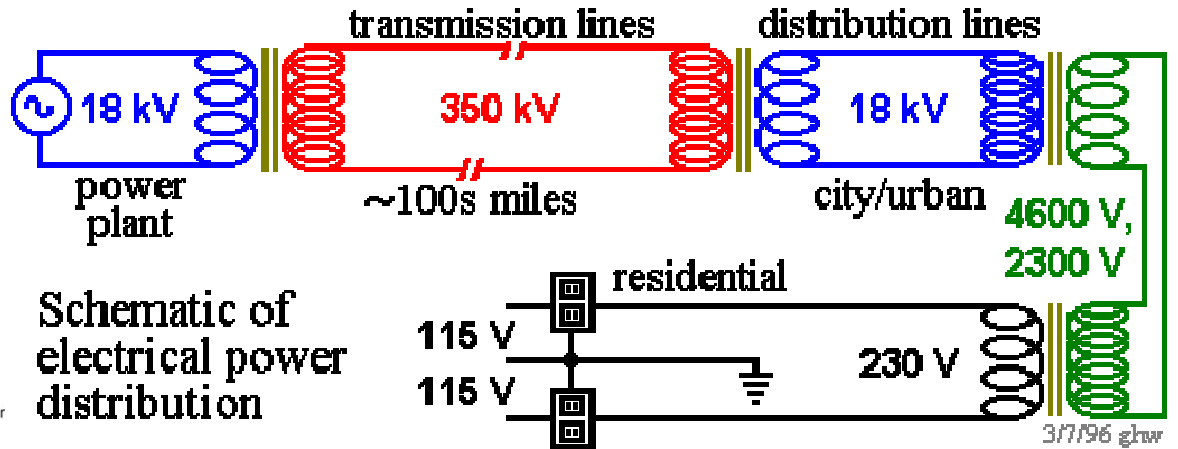
Transformation of Resistance: $R_{eq} = \left(\frac{N_p}{N_s}\right)^2 R_{load}$

Model of Transformer



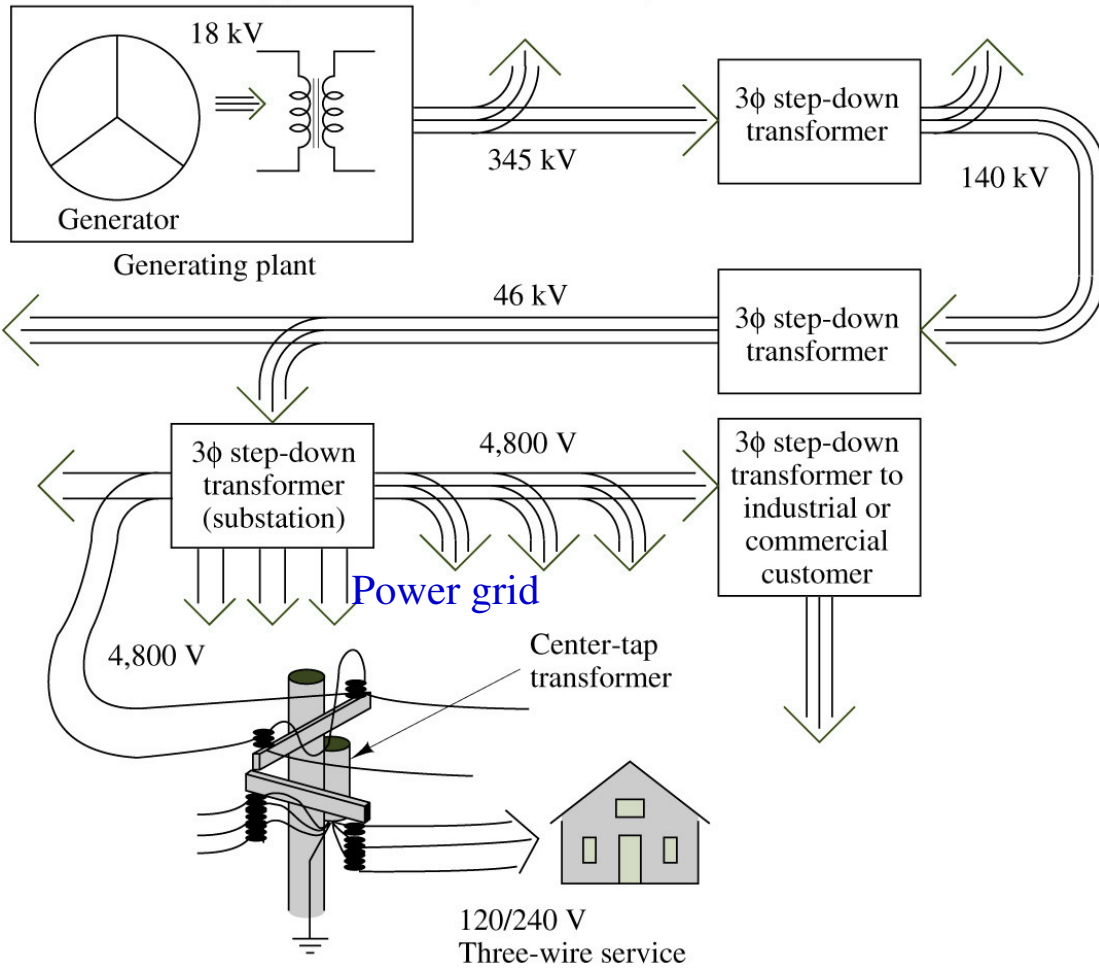
Transformers may also be used to transform impedances; *e.g.* coupling the output of a stereo amplifier ($R_{out} \sim 1 \text{ kohm}$) to a speaker of 4 or 8 ohm impedance for maximum power transfer. Refer to pg. 794 of *HRW* for impedance matching applications.

Electrical Power Distribution



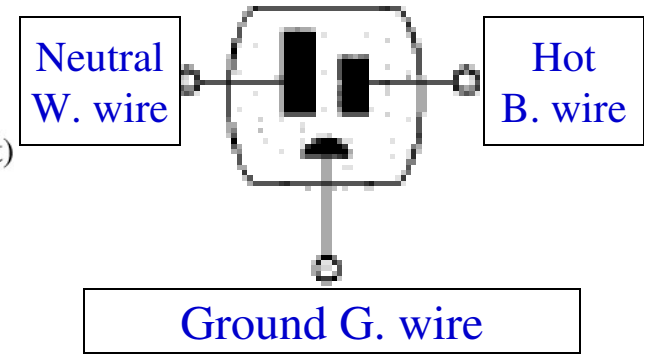
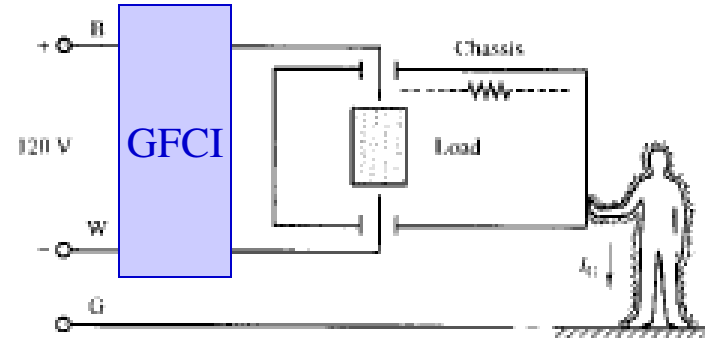
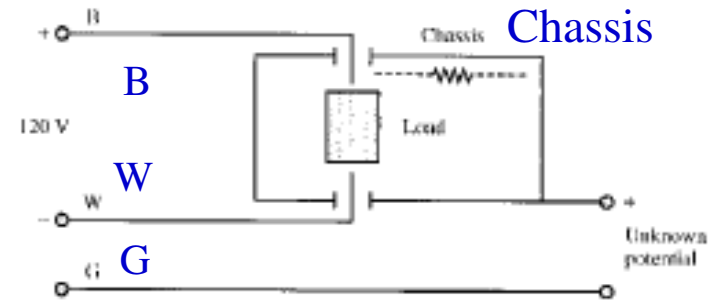
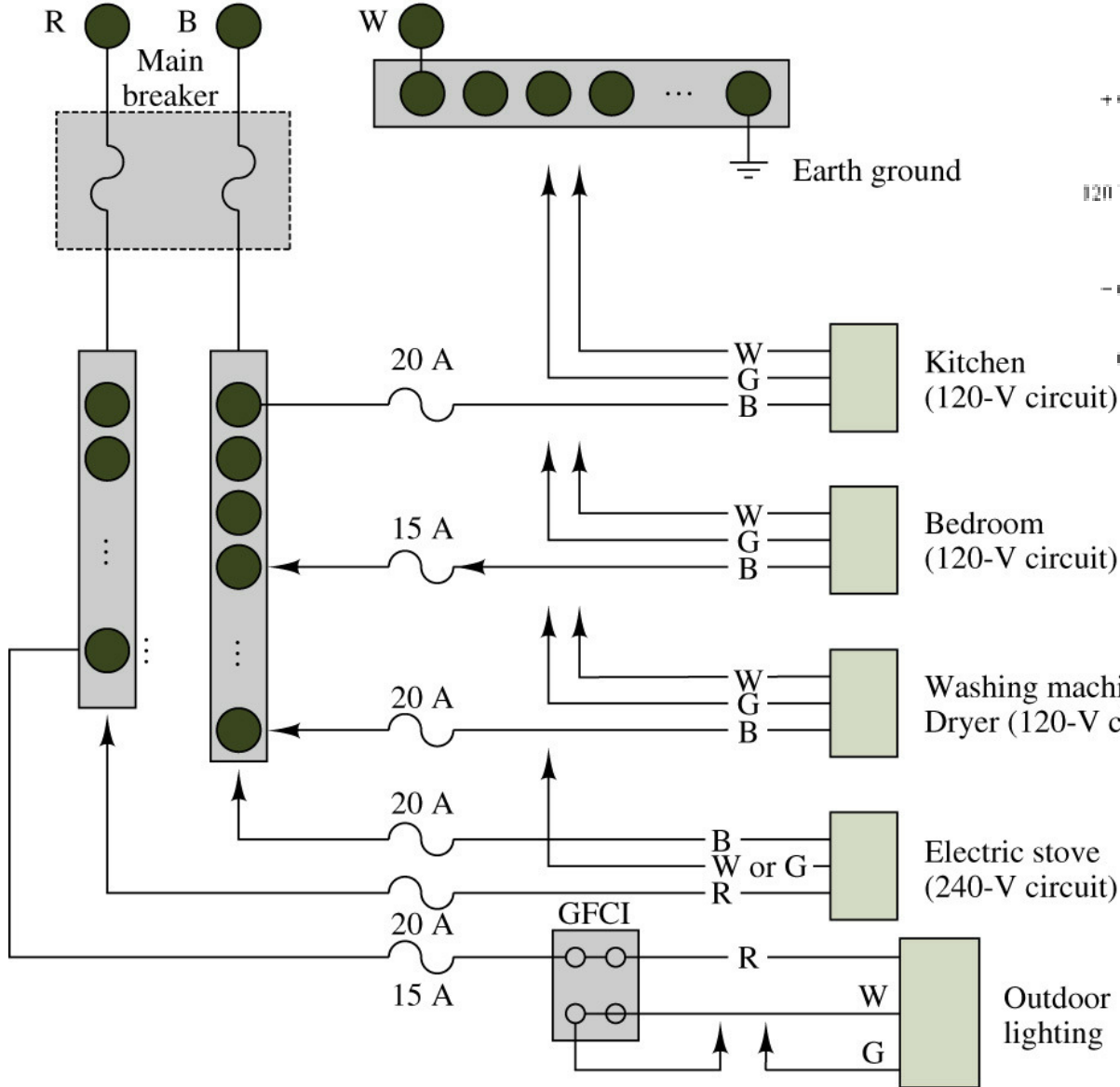
Schematic of electrical power distribution

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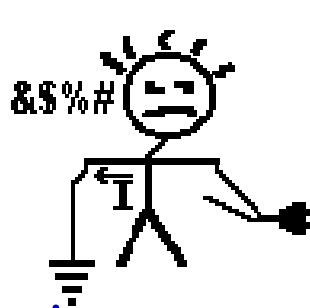


Residential Wiring

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Electrical Safety



CURRENT KILLS (not voltage)

Current effects on human body, current through chest (A, amps)

<0.01 tingling or imperceptible

0.02 painful, cannot let go

0.03 breathing disturbed

0.07 breathing very difficult

0.10 death due to fibrillation

>0.20 no fibrillation, but severe burning, no breathing

- **Dry** skin resistance is typically ~500,000 ohms.
- **Wet** skin resistance falls to ~1000 ohms.
- Internal resistance of body is only 100 to 500 ohms.
- Most household electrical injuries occur in the bathroom as a consequence.
- Our skin, when dry, normally protects us from electrocution if we make inadvertent contact with 115V household voltages. Not so when wet...

Fibrillation and resuscitation

- Fibrillation is the fine, rapid, erratic, movements that replace the normal contraction of the ventricular muscle of the heart
- Fibrillation can be stopped by application of another *controlled* electrical shock, known as defibrillation, often seen in movies and on TV...
- A stopped heart can often be resuscitated with CPR techniques (cardiopulmonary resuscitation), but seldom a fibrillating heart.

Dielectric breakdown and sparking

- Air suffers dielectric breakdown at $\sim 3,000,000$ volt per meter.
-- Demonstration of Tesla coil
- 115 V source (wall socket) will not "reach" for you with a spark, **but** a 50,000 V power line *will* spark over before you actually contact (touch) it.
- Contacting voltages higher than ~ 230 V often results in current puncturing skin, compromising the protection offered by its dry resistance.
- Sometime a person contacts a wire that has sufficient current to contract hand muscles onto wire. The resulting current through the body may not be lethal initially, but skin resistance may drop with time, under these conditions, until a lethal current level is achieved. Remove person as soon as possible **without endangering self!**