

Electric Power and Energy Definition and Measurement

Lesson 20

EET 150



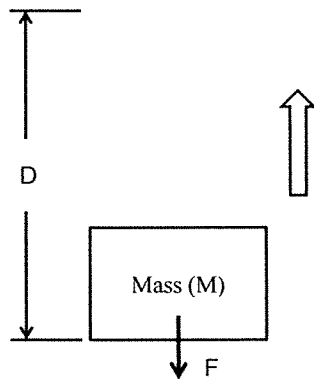
Learning Objectives

- ▣ In this lesson you will:
- ▣ see the definitions of work, energy and power
- ▣ learn to measure and compute power in simple dc circuits
- ▣ define power in Ac circuits
- ▣ see how power varies with time in Ac circuits
- ▣ learn how voltage and current relationships effect ac power
- ▣ define electric energy
- ▣ see the construction of a energy meter
- ▣ learn to read an energy meter



Work, Energy and Electric Power

Energy and work occur when a force acts on a mass



Force = (Mass)(Acceleration of gravity) = Weight

Lifting a weight requires work and dissipates energy

Work = (Force)(Distance)

W (Joules) = F (Newtons) X D (Meters)

Power is how fast work is done

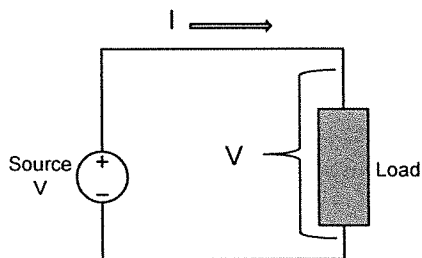
Rate of energy consumption

Power = Work/Time

P (Watts) = W (Joules)/ t (seconds)



Electric Power Dc Circuits



Power = Voltage X Current

P (Watts) = V (Volts) x I (Amps)

If load is a resistor then:

Know load current $P = I^2 \times R$

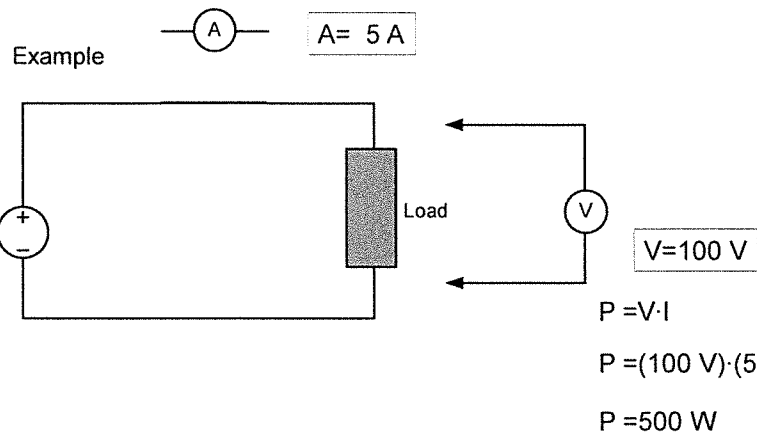
Know load voltage $P = \frac{V^2}{R}$

Where R is resistance in ohms (Ω)

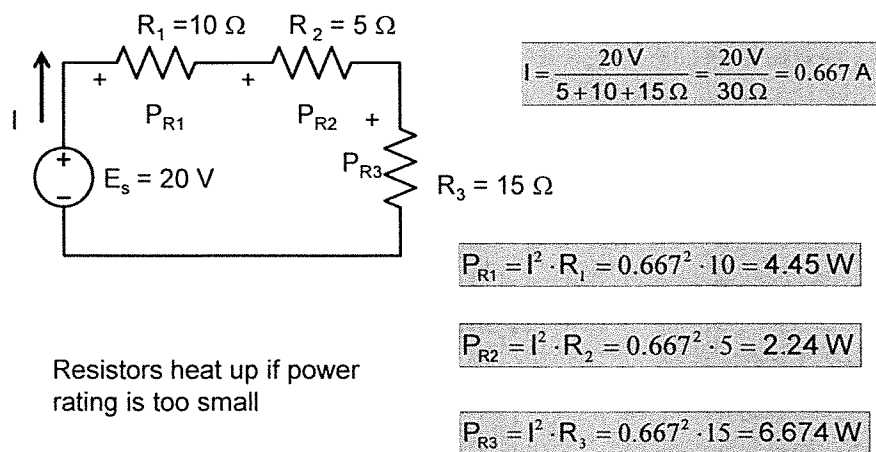


Measuring Dc Power

Both current and voltage measurements are necessary to measure power.



Calculating Power in Series Dc Circuit



Measuring Power in Series Dc Circuit

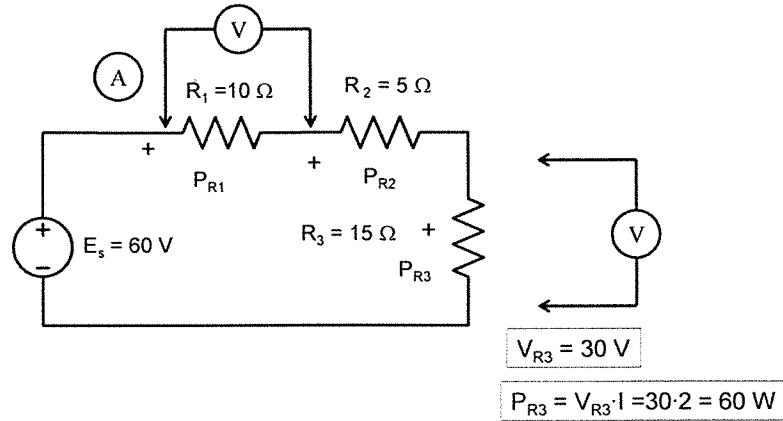
$I = 2 \text{ A}$

$P_{R1} = V_{R1} \cdot I = 20 \cdot 2 = 40 \text{ W}$

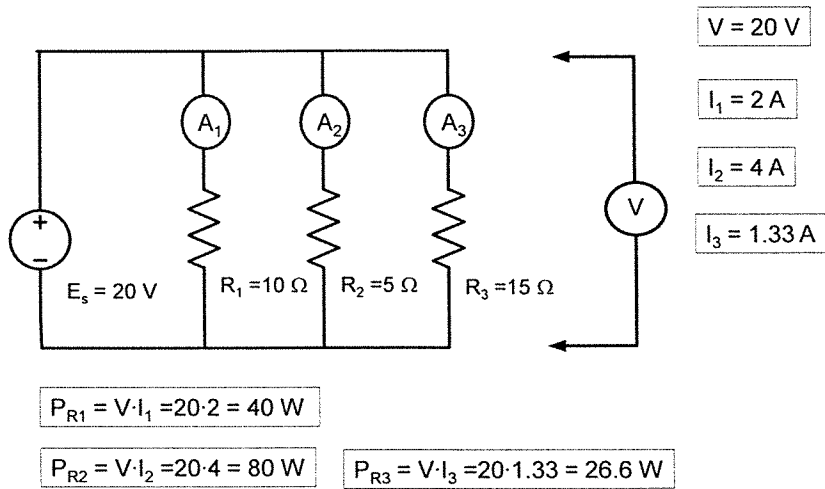
$P_{R2} = V_{R2} \cdot I = 10 \cdot 2 = 20 \text{ W}$

$V_{R1} = 20 \text{ V}$

$V_{R2} = 10 \text{ V}$



Measuring Power in Parallel Dc Circuits

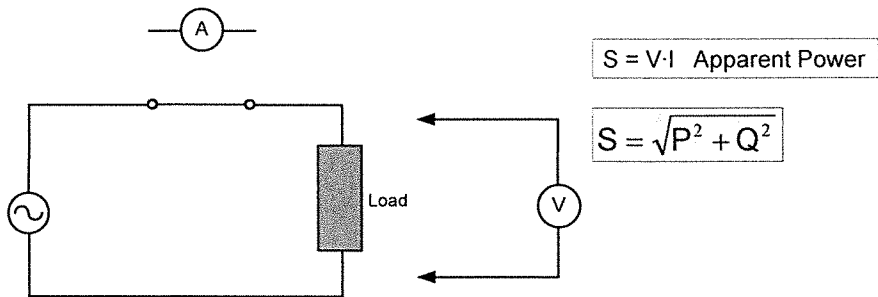


Power in Ac Circuits

Ac circuits dissipate some energy as light, heat, or motion. Other energy goes to charging and discharging capacitors and building magnetic fields in inductors

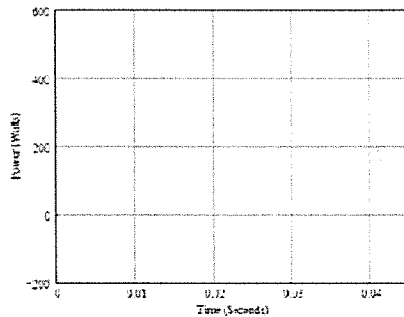
P = active power (light, heat, motion)

Q = Reactive power (Charging capacitors, inductor magnetic fields)



Ac Power

Ac power changes with time. For Ac sources and resistor loads, this graph plots the power.

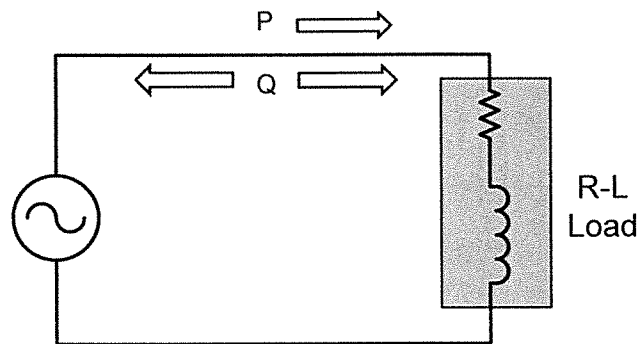


Power wave never negative

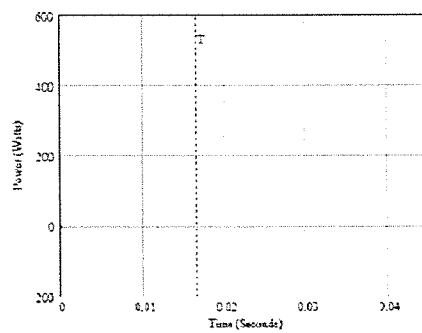
Power wave is zero twice in a period.

Ac Reactive Power

Reactive power flows back and forth between the source and the load



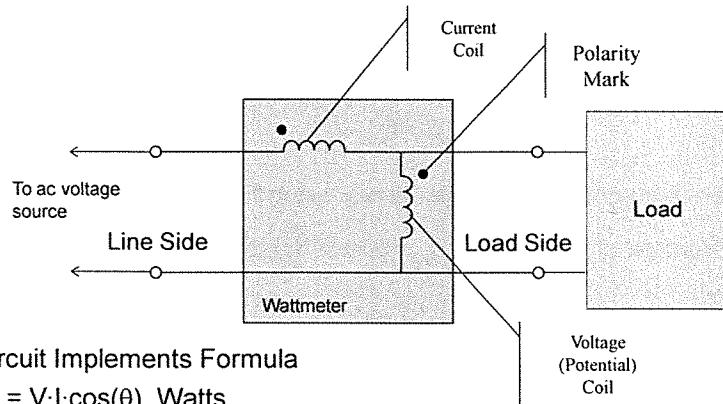
Ac Power-Active and Reactive



Power wave goes negative showing power returned to source

Measuring Ac Power Using the Wattmeter

The Wattmeter has internal voltage and current measuring elements and displays Watts (W)

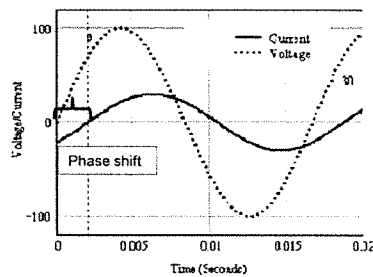


Circuit Implements Formula

$$P = V \cdot I \cdot \cos(\theta) \text{ Watts}$$

V = Rms value of voltage waveform θ = phase angle between V and I waves
 I = Rms value of current waveform

Phase Shift and Ac Power

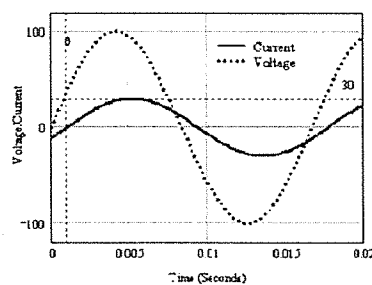


$$V_{rms} = 100(0.707) = 70.7 \text{ V}$$

$$I_{rms} = 30(0.707) = 21.21 \text{ A}$$

$$\theta = 45 \text{ degrees}$$

$$P = (70.7)(21.21)\cos(45 \text{ deg}) = 1060 \text{ W}$$



$$V_{rms} = 100(0.707) = 70.7 \text{ V}$$

$$I_{rms} = 30(0.707) = 21.21 \text{ A}$$

$$\theta = 23.5 \text{ degrees}$$

$$P = (70.7)(21.21)\cos(23.5 \text{ deg}) = 1375 \text{ W}$$

Electric Energy Measurement

ENERGY = (instantaneous power) x (time)

$W = p \times t$ where W = energy
 p = instantaneous power
 t = time

kWh meters sum power over time interval using a rotating disk.

Number of revolutions, n , proportional to energy

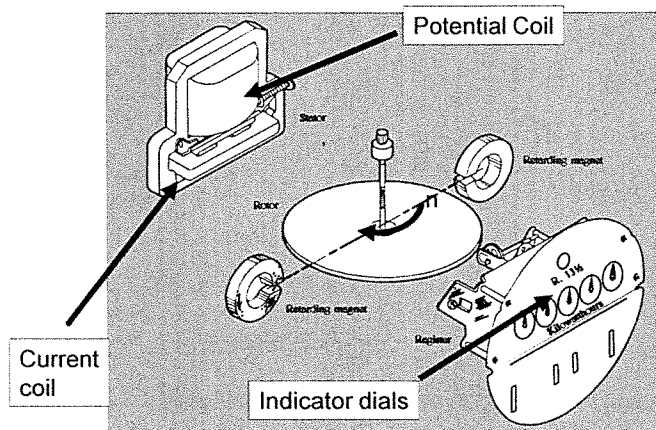
so $n = C_p \times P \times t$


C_p = meter energy constant
 (units kWh/rev)



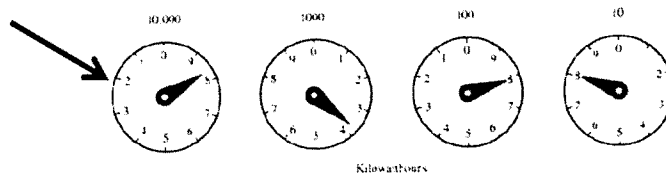
Energy Meter Construction

kWh meter measures the electric energy we all consume in our homes and businesses



n = number of disk (rotor) revolutions 

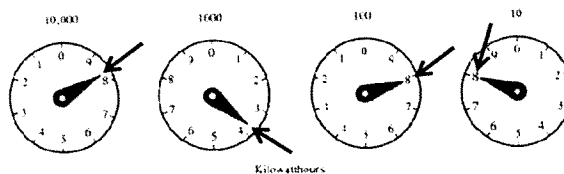
How to Read an Energy Meter



- 1.) Start from left-most Dial (10,000)
- 2.) Record value just past by pointer
- 3.) Record value of each dial
- 4.) Subtract present reading from last meter reading
- 5.) Difference is the usage in kWh for period



Reading an Energy Meter



Example Compute the usage for the last 30 days if the last meter reading was 7129 and the current meter reading is shown above

Note direction of rotation of the meter dials and read the last integer that the pointer has past.

Reading

8	3	8	8
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 Energy usage is the difference between the two readings

$$8388 - 7129 = 1259 \text{ kWh}$$



Electric Power and Energy Definition and
Measurement

END LESSON 20

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**COMING NEXT: MORE ELECTRONIC CIRCUIT
CONSTRUCTION TECHNIQUES**

