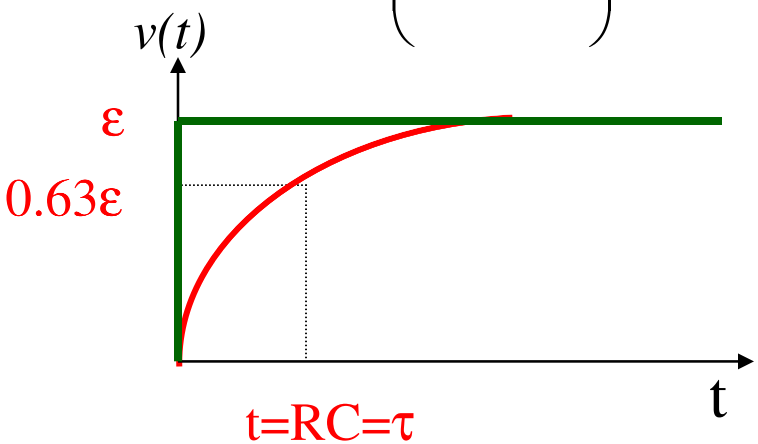
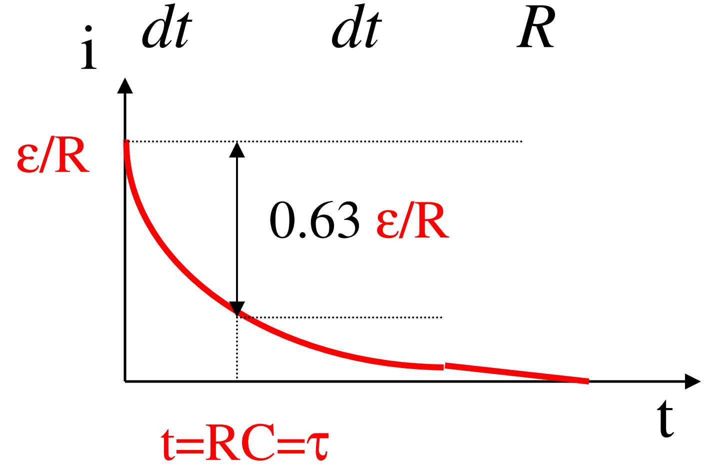
Charging a Capacitor

$$v(t) = \varepsilon\left(1 - e^{-\frac{t}{RC}}\right)$$



$$i = \frac{dq}{dt} = \frac{Cdv(t)}{dt} = \frac{\varepsilon}{R}e^{-\frac{t}{RC}}$$

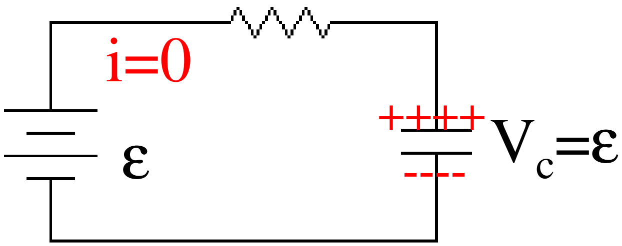


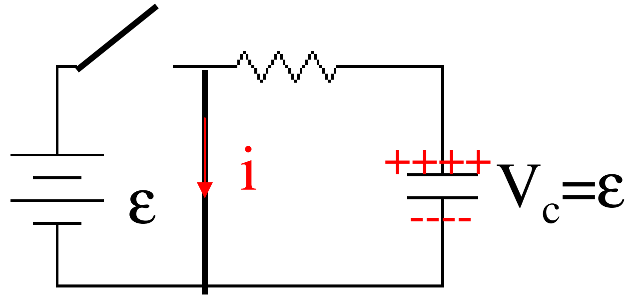
Time constant (τ): time needs to charge a capacitor to 63% of its full charge.

The larger the RC, the longer it takes to charge a capacitor.

The larger the R value, the smaller the current is in the circuit.
The larger the C value, the more the charge the capacitor can hold

Discharging a Capacitor

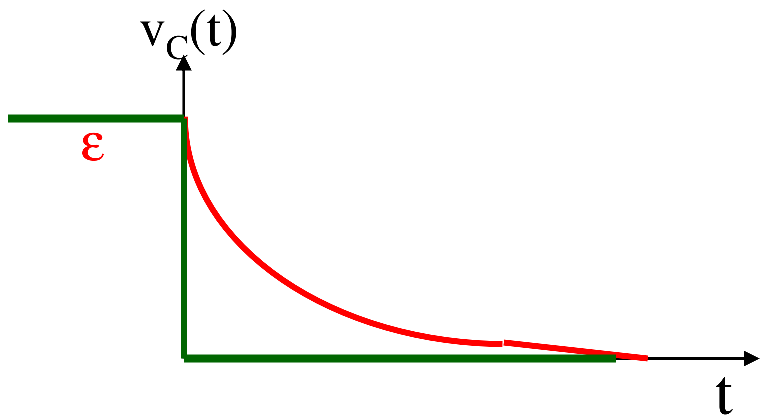




t = 0

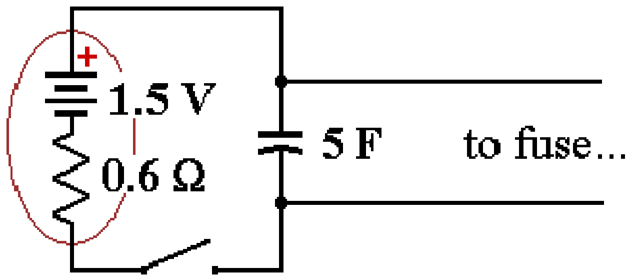
$$v(t) = \varepsilon e^{-\frac{t}{RC}}$$

$$i = \left(\frac{\varepsilon}{R}\right) e^{-\frac{t}{RC}}$$

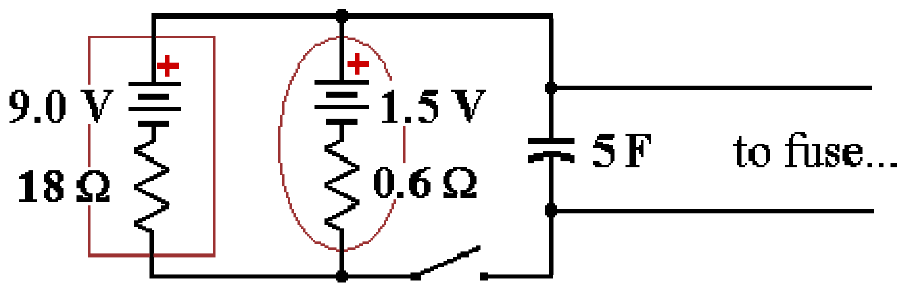


Example

a) A young MacGyver enthusiast is attempting to design a simple switched RC circuit to use as a fuse timer. The child has a 5 F capacitor and one AAA cell with an emf of 1.5 V and an internal resistance of 0.6 ohm. If the fuse will ignite when the capacitor is charged to a voltage of 1.0 V, how much time does the youngster have to vacate the premises?



b). With a never ending enthusiasm for adding batteries to a circuit, the youngster connects a fresh 9 V lithium battery as shown. Now how much time expires after switch closure until the fuse is ignited?



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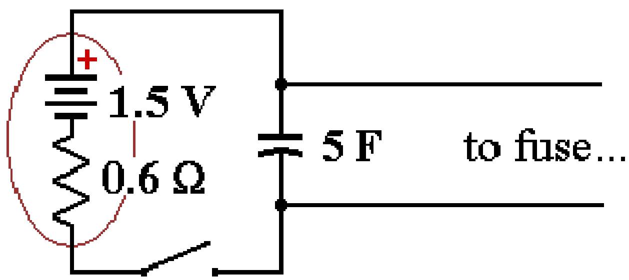


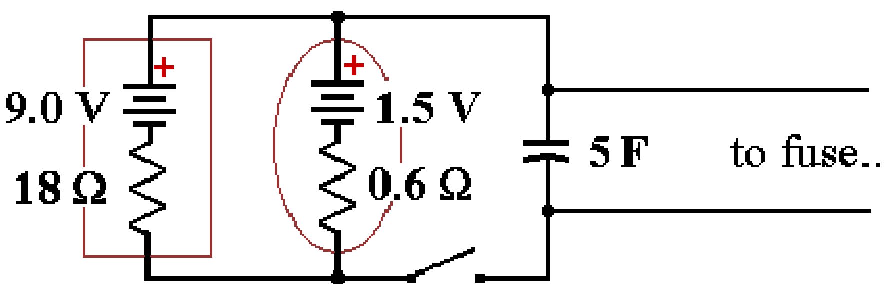
$$V_C = V_S\left(1 - e^{-\frac{t}{RC}}\right)$$

$$t = -RC\ln\left(1 - \frac{V_C}{V_S}\right)$$

$$= -0.6 \times 5\ln\left(1 - \frac{1.0}{1.5}\right)$$

$$= 3.3\,\mathrm{sec}$$

b). With a never ending enthusiasm for adding batteries to a circuit, the youngster connects a fresh 9 V lithium battery as shown. Now how much time expires after switch closure until the fuse is ignited?

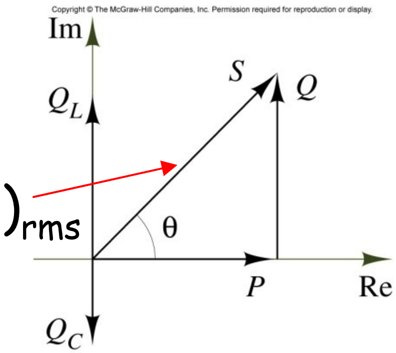


Chapter 7: Complex Power Recap

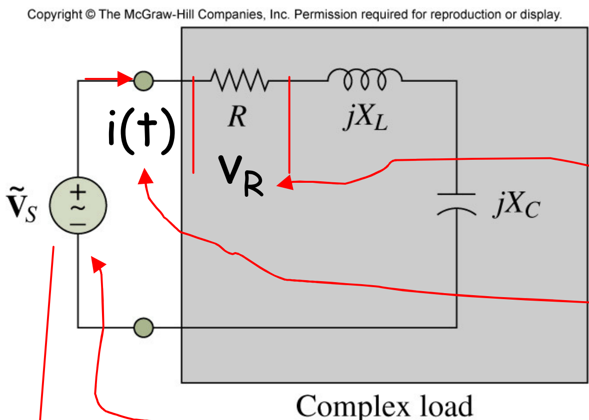
- Why do we use
  - It a fictitious power for simplification
  - But its absolute value can be measured

rms!

$$S = \tilde{V}\tilde{I}^* = P_{av} + jQ \qquad |S| = (I)_{rms}(V_S)_{rms}$$



Note: $S = P_R + jQ_C + jQ_L$



Calculation of P_{av}: power dissipated on R (heating the toast, dry your hair, washing your cloth…useful work!)

Method 1: $P_{av}=(I_R)_{rms}(V_R)_{rms}$, $(I_R)_{rms}=(V_R)_{rms}/R$

Method 2: $P_{av}=(I_R)_{rms}(V_S)_{rms}\cos\theta$

$$v_s(t) = V_p \cos(\omega t) = V_p\angle 0$$

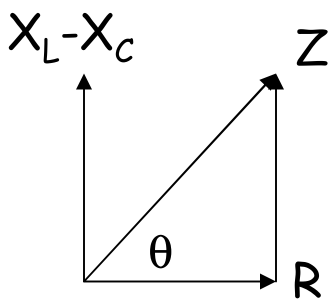
$$i(t) = I_p \cos(\omega t - \theta) = I_p\angle -\theta$$

$$I_p = \frac{V_p}{|Z|}$$

$$I_{rms} = I_p/\sqrt{2}$$

$$V_{rms} = V_p/\sqrt{2}$$

Calculate θ



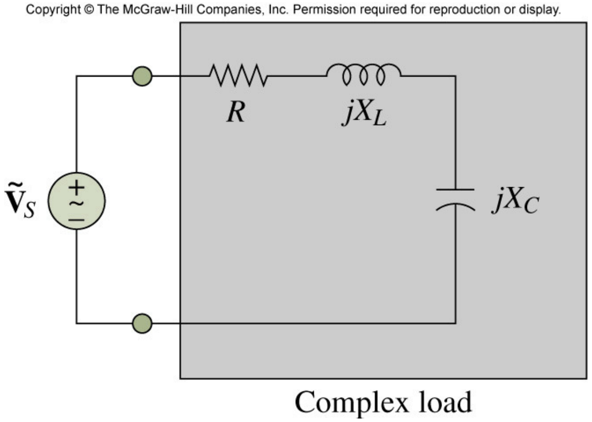
Calculation of Q: total power stored in L and C, not used, exchanged between L & C and source. Would like to minimize so no extra power requirement on the source.

Method 1: $Q_L=(I_L)_{rms}(V_L)_{rms}$, $(I_L)_{rms}=(V_L)_{rms}/\omega L$

$Q_C=(I_C)_{rms}(V_C)_{rms}$, $(I_C)_{rms}=(V_C)_{rms}\omega C$

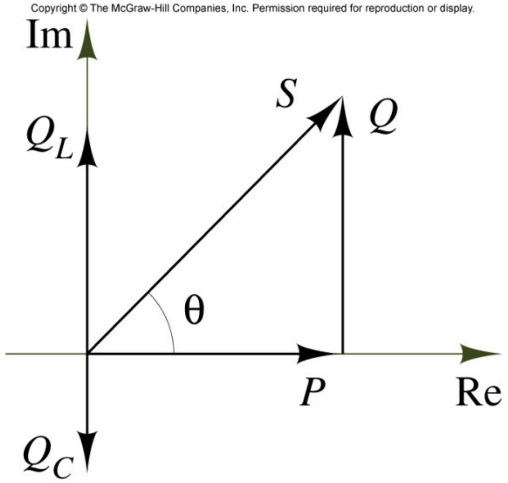
Method 2: $Q=Q_L+Q_C=(I)_{rms}(V_S)_{rms}\sin\theta$

Review cont.: Complex Power



Instantaneous power p(t)

$$S = \tilde{V}\tilde{I}^* = \tilde{I}^2 Z^* = \tilde{V}^2 / Z^*$$
$$= P_{av} + jQ$$



Pay attention to complex conjugate

Note: $S = P_R + jQ_C + jQ_L$

- real power P_{av}: power absorbed by the load resistance.
- Q (volt-amperes reactive, VAR): exchange of energy between the source and the reactive part of the load. No net power is gained or lost during the process.
- $|S|$: compute by measuring the rms load voltage and currents without regard for the phase angle.
- if Q<0, the load is capacitive, Q>0, the load is inductive