Advanced Amateur Radio Licence

Rupert Brooks

April 25, 2013

Outline

Units

- Farad: Capacitance,$1F = 1C/V = 1s^4 \cdot A^2/m^2 \cdot kg$
- Henry: Inductance, $1H = 1Wb/A = 1V \cdot s/A = 1\Omega \cdot s$
- Hertz: Frequency, f, also angular frequency ω in rad/s
- $1Hz = 2\pi rad/s; f = 2\pi\omega$

Concepts

- Skin Effect: RF current in a conductor flows along the outside

Time Constant

- Time constant:
  - RC time required for voltage to reach 63.2% of equilibrium
  - RL time required for current to reach 63.2% of equilibrium
- Why 63.2%? Because it is an exponential function.

$$v(t) = v_e e^{-t/RC} \qquad I(t) = I_e e^{-tL/R}$$

Note: These are both for decay. For rise, use $1 - e^{-t/RC}$

Time Constant

Time constants	e^{-t}	$1 - e^{-t}$
0	1.000	0.000
1	0.368	0.632
2	0.135	0.865
3	0.050	0.950
4	0.018	0.982
5	0.007	0.993

- Circuitlab RC `https://www.circuitlab.com/circuit/ga5y34/simple-rc/`
- Circuitlab RL `https://www.circuitlab.com/circuit/veg4ma/simple-rl/`

Reactance

- In a pure resistance, current is in phase with voltage.
- In a pure capacitance, current leads voltage by 90°
- In a pure inductance, voltage leads current by 90°
- Reactance and resistance can be viewed as a complex number. Impedance is the magnitude of this number.

Capacitive Reactance

$X_c = \frac{-j}{2\pi f C}$

Inductive Reactance

$X_i = j2\pi f L$

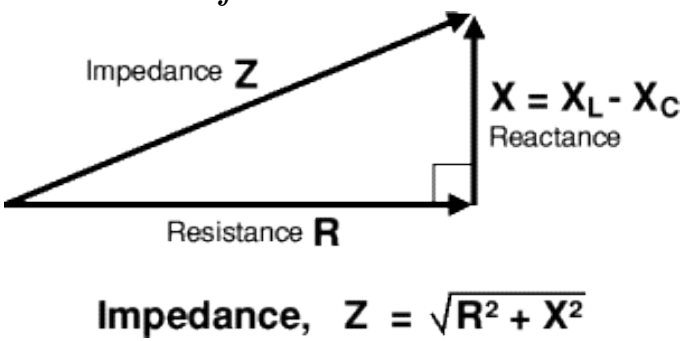
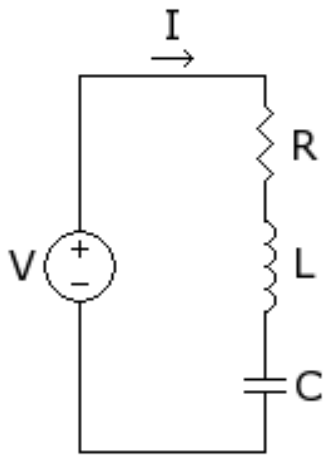


Image taken from

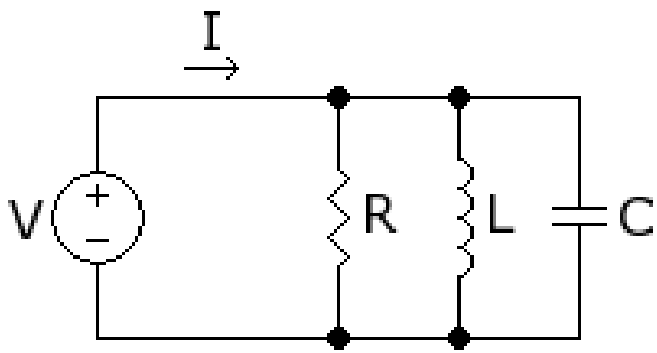
`http://electronicsclub.info/impedance.htm`

Resonance

- Capacitive and Inductive reactances oppose.
- The frequency at which they exactly cancel is the resonant frequency.
- $f = \frac{1}{2\pi\sqrt{LC}}$
- The resonant frequency can be altered by resistance in some configurations, but not in pure series or pure parallel.



Attrib: http://en.wikipedia.org/wiki/File:RLC_series_circuit.png



Attrib: http://en.wikipedia.org/wiki/File:RLC_parallel_circuit.png

Q factor

- Indication of 'quality' of a resonator.
- High Q indicates small bandwidth, and low damping.
- $Q = \frac{1}{F_b}$
- Series $Q = \frac{X}{R}$, Parallel $Q = \frac{R}{X}$
- F_b is width between the -3dB points

Examples on circuitlab

- https://www.circuitlab.com/circuit/5xp69v/series-rlc/
- https://www.circuitlab.com/circuit/tgbk77/parallel-rlc/

Rectifiers

- Half Wave
- Full Wave
- Bridge

Note that the full wave is two diodes, one from each side of a center tapped transformer. Thus the full wave has half the output voltage of a bridge (4 diodes).
Also, dont be tricked by the ripple frequency - its double the supply frequency for full and bridge rectifiers.
Diodes should be rated with a PIV of 2.8 times the transformer secondary. Just memorize it.
They state you may put bypass resistors and capacitors around the rectifiers to guard against voltage spikes. I have not seen this.

Filters

Supply filters are classified by the first component after the rectifer.

- Choke input
- Capacitor input

Capacitor input has higher output voltage, but choke input can handle higher loads.
The questions state that choke input can give better regulation.

Terms and concepts

- *Bleeder Resistors* - maintain a minimum current draw, often necessary on choke input filtered systems
- *Linear* vs *Switching* supplies
- *Zener diodes* - often used as voltage reference
- *Remote sensing.* It may be necessary to take feedback from near the load, if the voltage may be drawn down over long supply leads.
- *dynamic regulation* Managing short term changes in load resistance.
- *static regulation* Managing long term changes in load resistance.

Linear regulators

- May be configured as series (series with load) or shunt (parallel with load) configuration.
- Often packaged as a *three terminal regulator*.
- Internally, this contains
  - voltage reference
  - error amplifier
  - sensing resistors and transistors
  - pass element
- and is characterized by
  - min / max input voltage
  - max output current and max output voltage.