Ham 69 – License, Resonance

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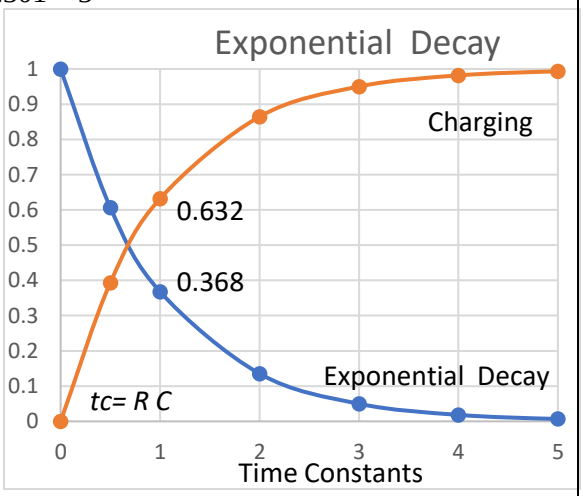
1. The previous article discussed impedance. Resonance is the frequency when inductive reactance 'X_L' equals capacitive reactance 'X_C'. Resonance is important to antennas and feedlines to minimize loss. What is the resonant frequency?
   a. The frequency depends on inductance and capacitance, but no resistance. $f_R = 1/[2\pi\sqrt{LC}]$.
   b. At resonance the impedance is only resistance, so impedance is minimum.
   c. In a series resonant circuit, voltages can be greater than applied and the current is maximum, because of lowest Z.
   d. In a parallel resonant circuit, maximum current *circulates* in the tank, but minimum current flows in and out.
   e. Parallel allows no power through, so it is called a trap.
   f. With only resistance, the voltage and current are in-phase, or maximum at the same time.
2. When out-of-resonance, voltage and current are out-of-phase. So, one or other will lead or be measured first.
   a. A ditty may help: *ELI the ICE man.*
   b. In a predominantly inductive (L) circuit, voltage (E) leads the current (I).
      In a predominantly capacitive (C) circuit, then current (I) leads the voltage (E).
3. Quality factor 'Q' of a resonant circuit is the ratio of resistance to reactance. Q is opposite of loss. Less loss = more Q.
   a. Resonant frequency directly relates to Q and bandwidth. $f_R = Q * bandwidth$
   b. Series circuit: $Q = X/R$
   c. Parallel circuit: $Q = R/X$
   d. High Q is less loss, so high circulating current and voltages.
4. Bandwidth is between the upper and lower cutoff frequency, where by definition the voltage has dropped to 0.707 of peak. At cutoff, the power has dropped by one-half. Cut-off frequencies are the -3dB points.
   a. Example: Voltage = 10V, resistor = 50Ω.
   b. Peak Power: $P_O = V^2 / R$, $P_O = 10^2 / 50 = 2W$
   c. Cut-off Power: $P_{.707} = 7.07^2 / 50 = 1W$
   d. Power ratio dB: $P_{dB} = 10 \log_{10} P_O / P_{.707}$, $P_{dB} = 10 \log_{10} 2 / 1 = 10 * .301 = 3$
5. Frequency is an oscillation that continues, without resistance.
   a. Resistance is opposition that dampens, causing a decay in response.
   b. Time constant is time required for a capacitor to discharge to 36.8% or to charge to 63.2% of its final value
   c. Time Constant (***tc***) depends on capacitor and resistance. $tc = R\,C$.



6. Capacitors store electrical energy. Inductors store magnetic energy. Store means potential energy, since it is not moving. Resistors convert to heat.
   a. As frequency increases, *skin effect* causes current to flow on the surface (skin) of the conductor.
   b. Frequency increases the reactance of inductors. Keep wires short.
   c. As we saw with ELI, there is a time delay or phase shift from an inductor. Short wires = less inductance = less phase shift.
   d. *Microstrip* is a printed circuit above a ground plane, which operates as a transmission line, cancelling inductance effect
7. An inductor with current flowing makes an electromagnet. The direction is determined by the *left-hand-rule.* Wrap your left hand around a wire with the thumb pointed in the direction of ELECTRON flow. Your fingers point in the direction of the magnetic field. CAUTION: Electron flow is the opposite direction from conventional current flow.
8. An inductor is a coil of wire. Metals inserted inside the coil change the *permeability* of the *core*. Iron-type (ferrite) has positive permeability and increases the inductance while brass has negative permeability which decreases inductance.
   a. *Saturation* occurs when the ability to store more magnetic energy is exceeded. The result is harmonics and distortion.
   b. *Self-resonance* occurs when the capacitance between the winding wires couples with the inductance of the coil.
9. The number of turns (N) required for an inductor can be calculated from desired inductance (L) and inductance index (A_L). $N = 100\sqrt{(L/A)}$
10. Core material limits use for inductors.
    a. Toroidal cores can be used for audio (20 Hz) through VHF (300 MHz).
    b. Powered-iron is used for high-current.
    c. Ferrite core requires fewer turns.
    d. Toroidal core concentrates magnetic field better than solenoidal (straight).
11. Life is good. Enjoy!