Pre-Work for Knowledge Integration 4
Spring 2020

(Due Feb. 19, 2020 at 11am)

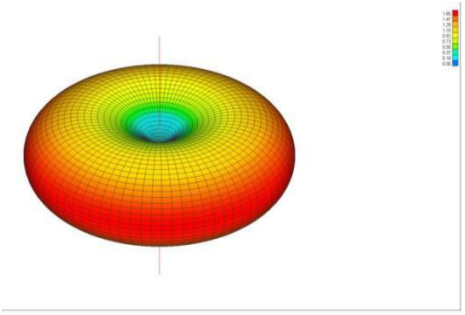
Here is a list of pre-work question for Knowledge Integration 4. Please submit your written answers to the questions individually using the dropbox in the BC-infill by 10pm on 2/13.

1. Baseband amplifiers in a radio system often perform the function of transforming a low-frequency small input signal to an output signal of the same frequency with enough swing to drive a given load. Some of the key design features include DC gain, output swing, power consumption and linearity. If you were to use a simple MOSFET common source amplifier for this purpose, identify at least three relationships to show how some of the component characteristics in the schematic (R_D, Ids, W/L, Vsat, Vdd, V_{out_DC}) affect the amplifier features (DC gain, output swing, power consumption, and linearity).

2. A mixer multiplies two input signals, giving the output as $y(t) = x_1(t)x_2(t)$. Assume the baseband voice signal is $x_1(t)$ and the carrier signal is given as $x_2(t) = \cos(\omega_0 t)$ (i.e., a pure sinusoidal signal at the carrier frequency ω_0). Compute Y(s) in terms of $X_1(s)$ (here you may assume all signals are causal and use the one-sided Laplace Transform). Assume the Fourier Transform exists and compute $Y(j\omega)$.

3. Use Matlab to generate Bode plots of $H(s) = \frac{1}{(1+sT)^n}$ with T=0.1 seconds and n=1, 2, and 3 (Type *help tf* and *help bode* in Matlab for information). Explain why this is a Low Pass filter (LPF). How does the filter order (n) affect the filter cutoff slope? Approximately where is the filter cutoff frequency (the -3dB point)? How does this change if you choose T=0.01 seconds?

4. Different antenna configurations will generate different radiation patterns. For example, the figure below represents the radiation pattern corresponding to a dipole antenna oriented in the vertical direction. If you use a dipole antenna in the emitter, how would you align a dipole antenna in the receiver? How would you position a small loop antenna used as a receiver? Explain based on Faraday's law of electromagnetic induction applied to a receiving dipole and a receiving loop, respectively. Review different antenna configurations that will generate different radiation patterns and discuss the possible applications of these antennas. Discuss the typical size (order of magnitude) that an antenna must have for different carrier frequencies, ranging from 100 kHz to 100 MHz.



5. A simplified block diagram for a radio system, such as a cell phone, is shown below. The signal transmission part of the system is enclosed by the red box in the diagram. PA stands for Power Amplifier, which amplifies an input signal to drive the antenna. You can think of it as linear amplifier for signals within a specific narrow band of frequencies. Describe the chain of events starting from the input analog voice signal (marked A in the diagram) to the output signal at the antenna in terms of how signals

are transformed at the output of each major functional block inside the transmitter. Draw signals or their spectrum shape at the output of each functional block inside the red-boxed area to illustrate how signals are transformed in the process.