EE480

Self Test: week eleven

1)

A small source of 250 Hz harmonic spherical waves (outwardly propagating) in air is observed from a distance of 4 meters.

a) What is the magnitude and phase of the *specific acoustic impedance* at this location?

Assume $\rho_0 c$=415 Pa s/m, k=4.58 m^{-1}, r=4 m, and kr = 18.3:

$$\tilde{z} = \rho_0 c \left(\frac{(kr)^2}{1+(kr)^2} + j\frac{kr}{1+(kr)^2} \right)$$

Magnitude = 414.4 Pa s/m
Phase = 0.545 rad = 3.12 degrees

b) If the SPL re 20 µPa at this location is 45dB, what is the corresponding particle *speed amplitude* at this location?

At 4 meters:
P_{rms} = 20 μPa $10^{(45/20)}$ = 0.0036 Pa
P = sqrt(2) P_{rms} = 0.005 Pa

U = P/z = 0.005 / 414.4 = 12.1 μm/s

c) If the observation point is now moved to 2 meters from the source, what is the percent change in particle speed amplitude between the two locations?

Moving to 2 meters: P doubles and z becomes 412.5

$U_2 = U_4 \cdot 2/(412.5/414.4)$

$$U_2 = U_4 \left(\frac{2}{412.5/414.4} \right) = U_4 \cdot 2.009$$

so the speed amplitude is increased by 200.9 % .

2)

An amplifier with output impedance of 600 Ω is attached to a 600 Ω load. Under these conditions the load power level is measured to be +4 dBm.

If the 600 load is now replaced with a 10 kΩ load, what is the expected load level in dBV?

+4 dBm in a matched 600Ω load means the load voltage is 1.2277 volts rms, and the source voltage must be twice this, or 2.455 volts rms.

With a 10kΩ load, assuming no change to the source voltage, the load voltage is given by the voltage divider V_{source} **10k/(10k+600) =* V_{load} *= 2.316 volts rms.*

Finally, the level is dBV is 20 $\log_{10}(V_{load})$ *= 7.296 dBV.*

3)

A room has volume=2000 m^3, and total surface area=1000 m^2. The reverberation time is found to be 2.25 seconds at 125 Hz.

(a) What is the average Sabine absorptivity for the room?

(See eqn 12.3.4 and 12.3.7)

$$\bar{a} = \frac{0.161V}{S \cdot T_{60}} = \frac{0.161 \cdot 2000}{1000 \cdot 2.25} = 0.1431$$

(b) If the average Sabine absorptivity is doubled for 400 m^2 of the surface area while the remaining 600 m^2 is left unchanged, what is the expected Sabine T_{60} after this modification?

$$T_{60,\text{modified}} = \frac{0.161V}{S\bar{a} + S_{\text{modified}}(\bar{a})} = 1.61\,\text{seconds}$$

4)

A large plane circular piston with radius= 0.5 meters radiates into air (1 atm, 20° C) at a frequency of 4 kHz.

(a) Determine how many far field null angles are present between Θ = 0° and 90°.

For this piston, ka = 36.6366

There are 11 zeros of the Bessel function of the first kind, order 1.

(b) Determine the null angle(s) in degrees.

Using Matlab:
6.00°
11.04°
16.12°
21.32°
26.71°
32.37°
38.41°
44.99°
52.45°
61.47°
74.66°