Wireless Communication Systems

HW2

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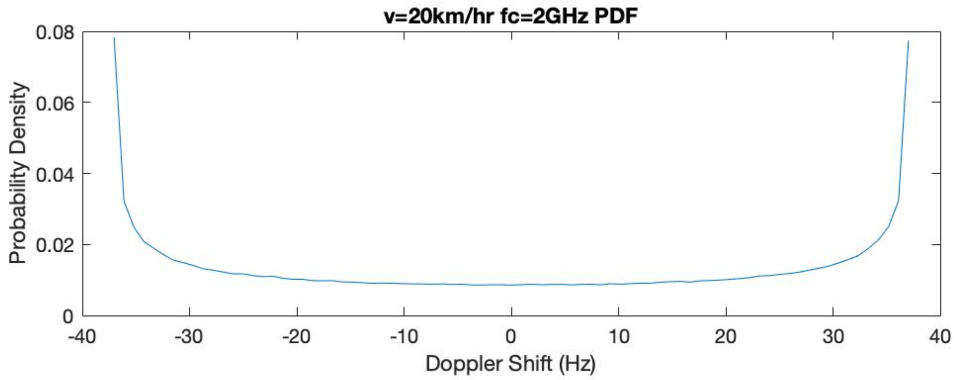
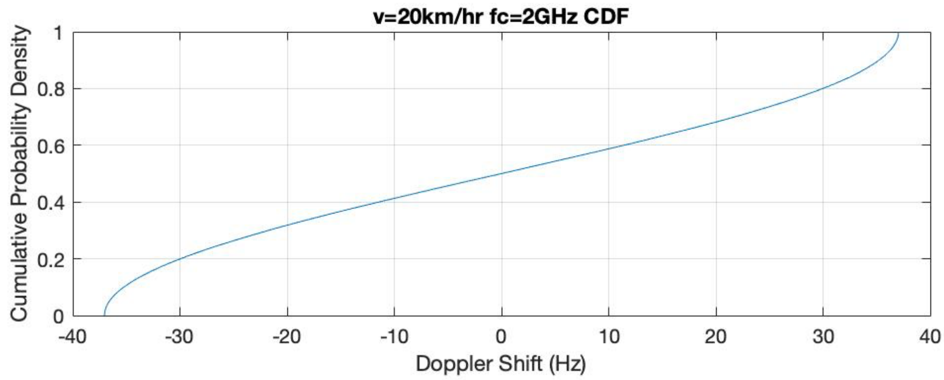
1.

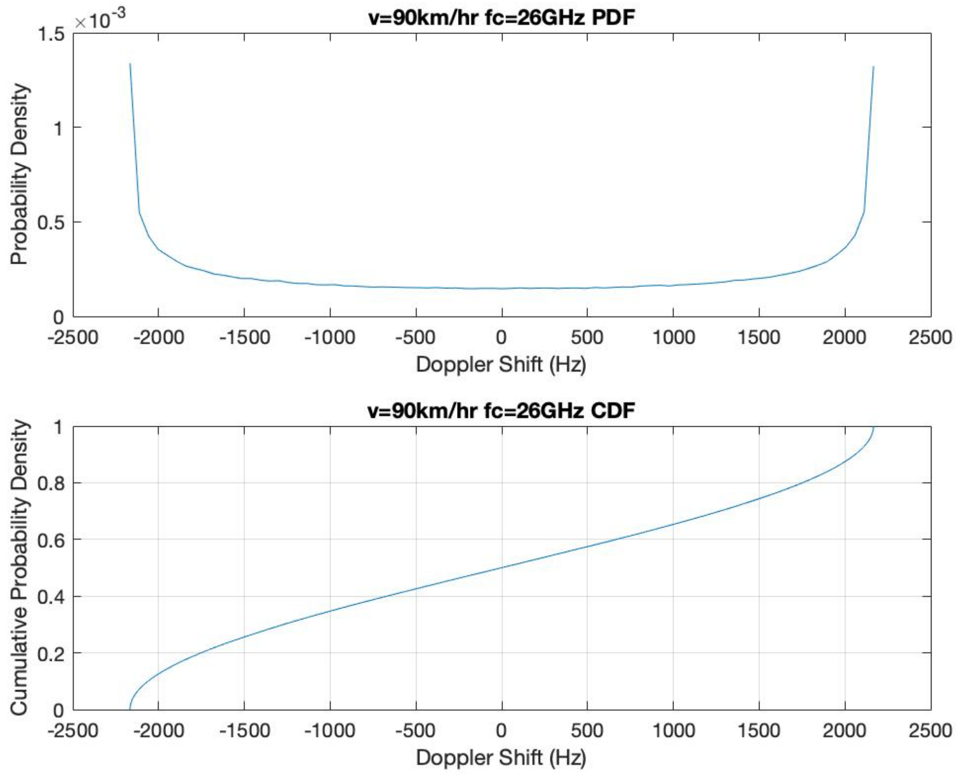
Doppler Shift is the change in frequency of a wave in relation to an observer who is moving relative to the wave source. From the formula, $f_d = f_m * cos\theta(t) = \frac{v}{\lambda_c} * cos\theta(t) = \frac{v * f_c}{c} * cos\theta(t)$, where f_d is doppler shift, v is the receiver velocity, c is the speed of light, and f_c is the carrier frequency of the signal, $\theta(t)$ is the angle between directions of the receiver velocity and the arrival signal. Assume that $\theta(t)$ is uniformly distributed between -π to π.

(a) When v=20km/hr=20*10^3/(60*60), f_c=2GHz

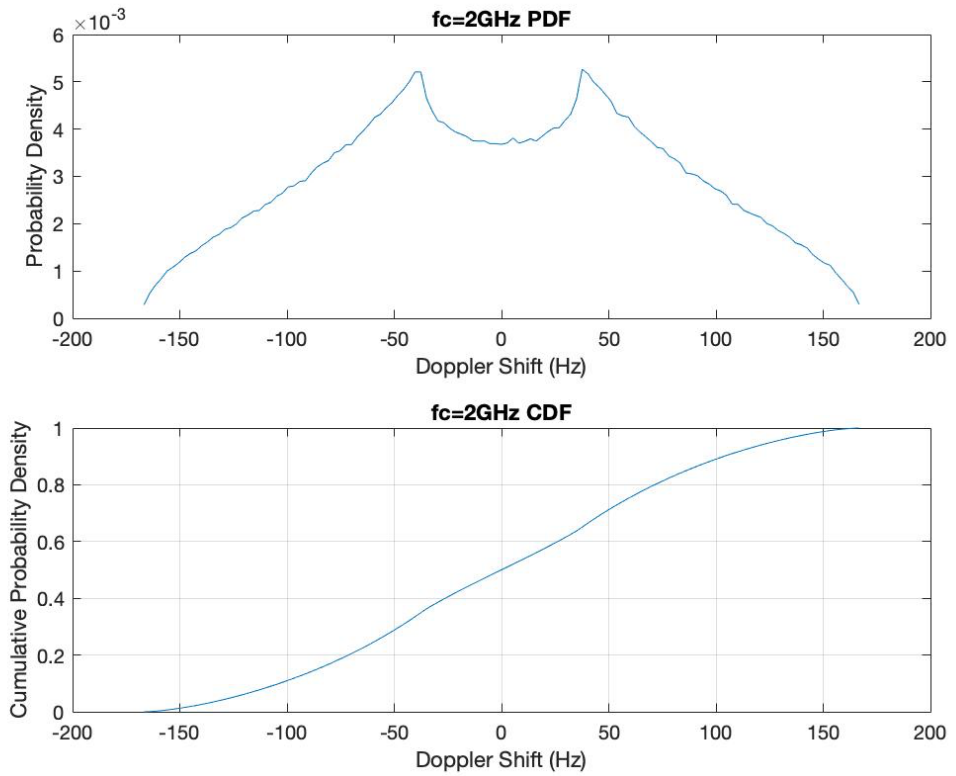




(b)When v=90km/hr=90*10^3/(60*60), f_c=2GHz



(c) When f_c=2GHz and v is uniformly distributed between 20~90km/hr



(d) Let $\theta \sim U([-\pi, \pi])$. To find the distribution of the random variable Y = cos θ.

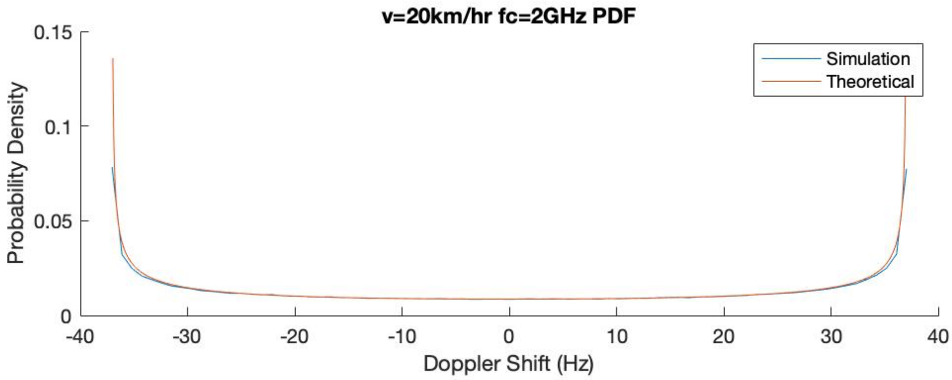
The pdf of θ is $f_\theta(\theta) = \frac{1}{2\pi}$ for $\theta \in [-\pi, \pi]$ and the cdf of θ is $F_\theta(\theta) = \frac{\theta}{2\pi} + \frac{1}{2}$.

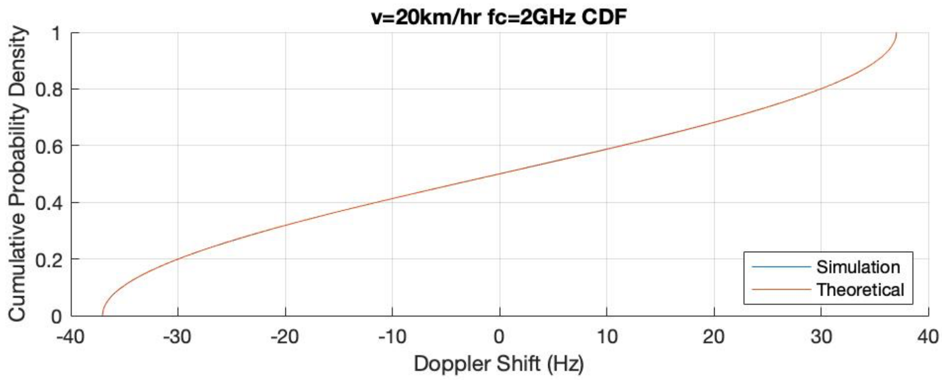
PDF of Y:

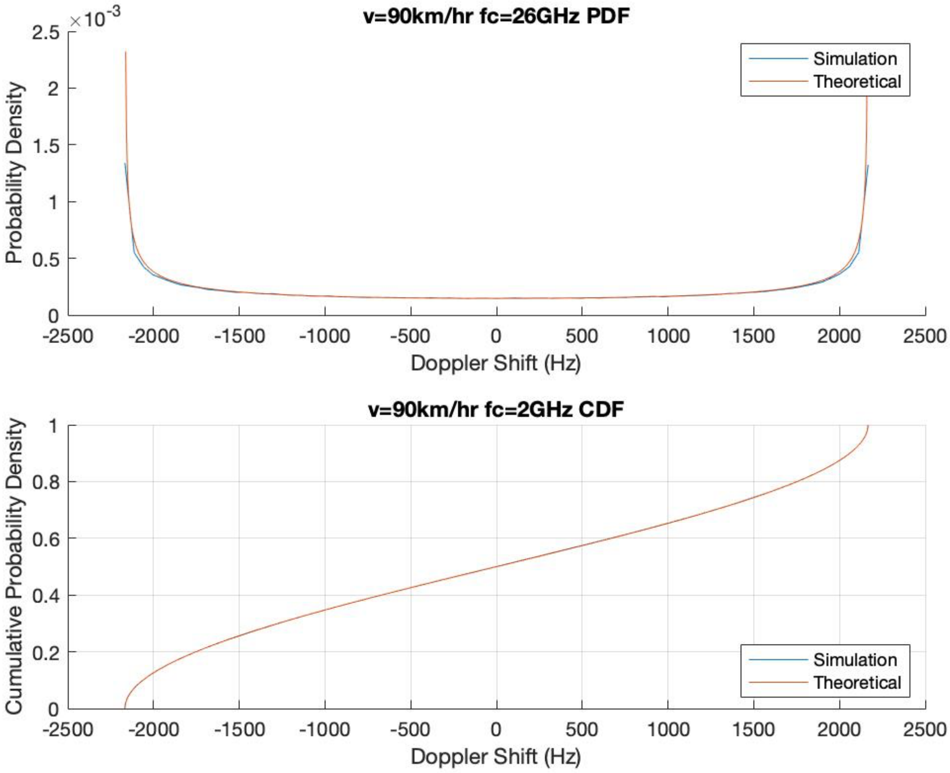
$$f_Y(y) = f_\theta(cos^{-1}y) * \left|\frac{dy}{d\theta}\right| = f_\theta(cos^{-1}y) * \left|\frac{1}{-\sin(cos^{-1}y)}\right| = \frac{1}{\pi \sin(cos^{-1}y)} = \frac{1}{\pi\sqrt{1-y^2}}$$

CDF of Y:

$$F_Y(y) = P(Y \leq y) = P(cosX \leq y) = P(X \leq -cos^{-1}y) + P(X \geq cos^{-1}y) = 1 + \frac{cos^{-1}y}{\pi}.$$







v=90km/hr fc=26GHz PDF
×10^-3
Probability Density
Doppler Shift (Hz)
Simulation
Theoretical
v=90km/hr fc=2GHz CDF
Cumulative Probability Density
Doppler Shift (Hz)
Simulation
Theoretical