

DYNAMIC CHANNEL MODELING AND PERFORMANCE ANALYSIS FOR UAV COMMUNICATIONS

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Abstract. A stepwise dynamic channel model for UAV communications is developed, integrating AWGN, Rayleigh fading, distance-dependent path loss, and velocity-dependent Doppler shift. BPSK and QPSK performances are compared under LOS/NLOS scenarios. Results show BER increases with distance and velocity, with QPSK more sensitive. Modulation switching thresholds are identified, and an interactive GUI is presented.

Keywords. UAV channels, AWGN, OFDM.

The increasing use of UAVs demands reliable air-to-ground links, but UAV channels are highly dynamic. This work builds a comprehensive model: UAV flies at 100 m altitude, 20 m/s, from (0,0,100) to (1000,0,100). Ground station at origin. Free-space path loss:

$$PL(d)=20\log_{10}(d)+20\log_{10}(f_c)-147, 55, f_c=2.4 \text{ GHz.}$$

Doppler shift:

$$f_d(t) = \frac{v_r(t)}{\lambda}, v_r(t) = \frac{x(t)v}{d(t)}.$$

NLOS adds flat Rayleigh fading $h_{ray}(t) = \frac{1}{\sqrt{2}}(N(0,1) + jN(0,1))$, BPSK/QPSK evaluated.

Simulation in MATLAB follows AWGN → Rayleigh → dynamic PL+Doppler → combined model. Table 1 lists parameters. GUI (Figure 1) allows real-time adjustment. Figure 2 shows BER vs. distance: QPSK degrades faster. Figure 3 shows BER vs. velocity: threshold ~30 m/s. Figure 4 compares modulations: in LOS, BPSK needs ~7 dB for BER=10⁻³, QPSK ~10 dB; in NLOS both worsen ~12 dB. Recommendations: SNR<10 dB → BPSK, 10–22 dB → QPSK, >22 dB → higher-order.

Table 1 – Simulation parameters

| Parameter | Value |
|-------------------------|------------|
| Carrier frequency f_c | 2.4 GHz |
| UAV velocity v | 20 m/s |
| UAV altitude | 100 m |
| Flight distance range | 0 – 1000 m |
| Symbol rate R_s | 1 kHz |
| Reference distance | 100 m |
| Reference SNR range | 0 – 30 dB |
| Number of symbols | 50,000 |

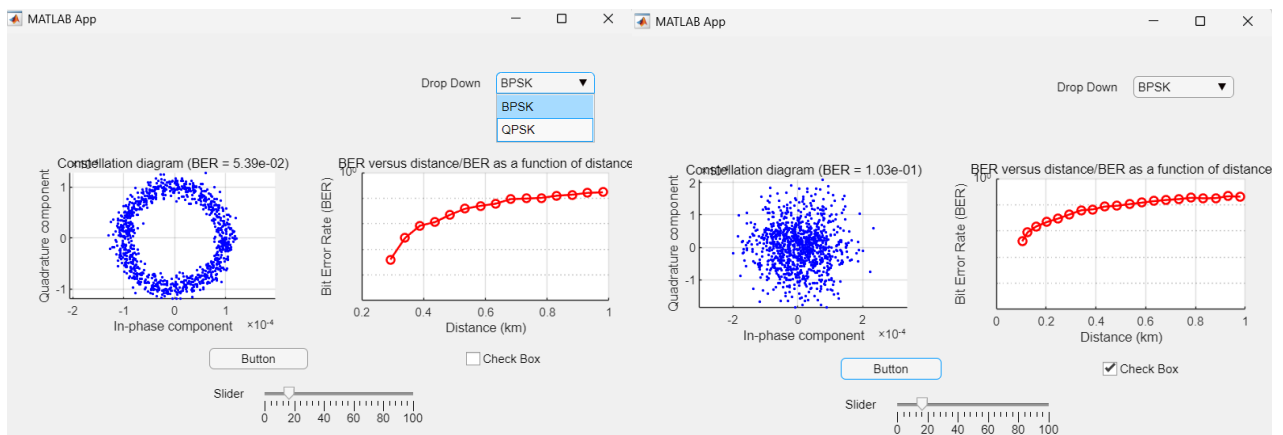


Figure 1 – GUI for UAV channel simulation (insert screenshot)

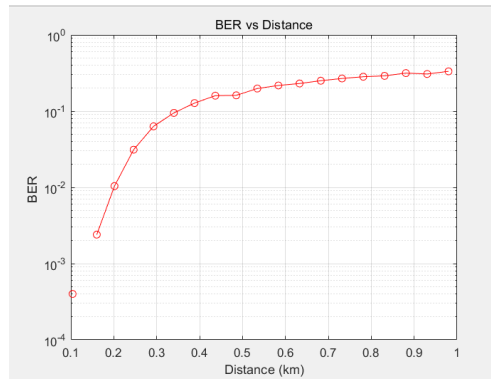


Figure 2 – BER vs. distance (BPSK & QPSK, LOS, SNR_{ref}=30 dB)

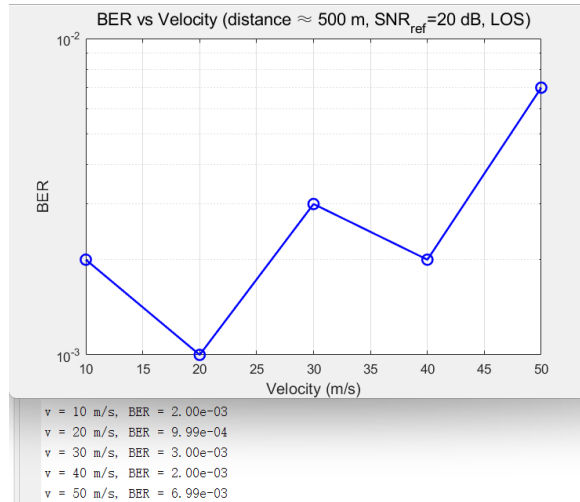


Figure 3 – BER vs. velocity (BPSK, fixed distance ≈500 m, SNR_{ref}=20 dB, LOS)

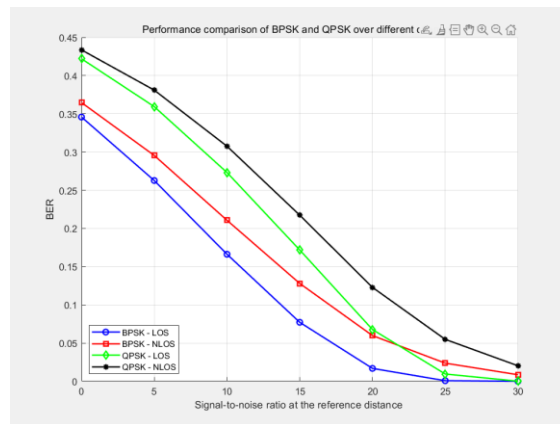


Figure 4 – BER vs. reference SNR (BPSK & QPSK, LOS & NLOS)

This work provides a dynamic channel model, quantifies distance/velocity impacts, gives modulation guidelines, and offers an interactive GUI. Future work includes urban scenarios and OFDM.

References:

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