Spacecraft Communication

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AST-402 Spacecraft Communication

- Ground Segment

https://uydu.turksat.com.tr/en

- Space Segment

https://uydu.turksat.com.tr/en/satellite-fleet/turksat-6a

Communication satellite orbits; LEO, GEO, MEO
Modulation/demodulation techniques
Channel coding
Carrier-to-noise ratio
Link budget
Frequency regulations

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Reason for adoption MATLAB Satellite Communication Toolbox

- Students can simulate satellite orbits on the secreen using TLE data
- Students can simulate ground stations on the desired geographic locations
- Students can see the advantages/disadvantages of the different modulation techniques
- Students can see the advantages/disadvantages of the different channel coding techniques
- Students can calculate link budgets using realistic scenarios, and compare their results with visualization-based tools
- Students learn fundamentals of the telemetry and telecommand regulations using MATLAB functions

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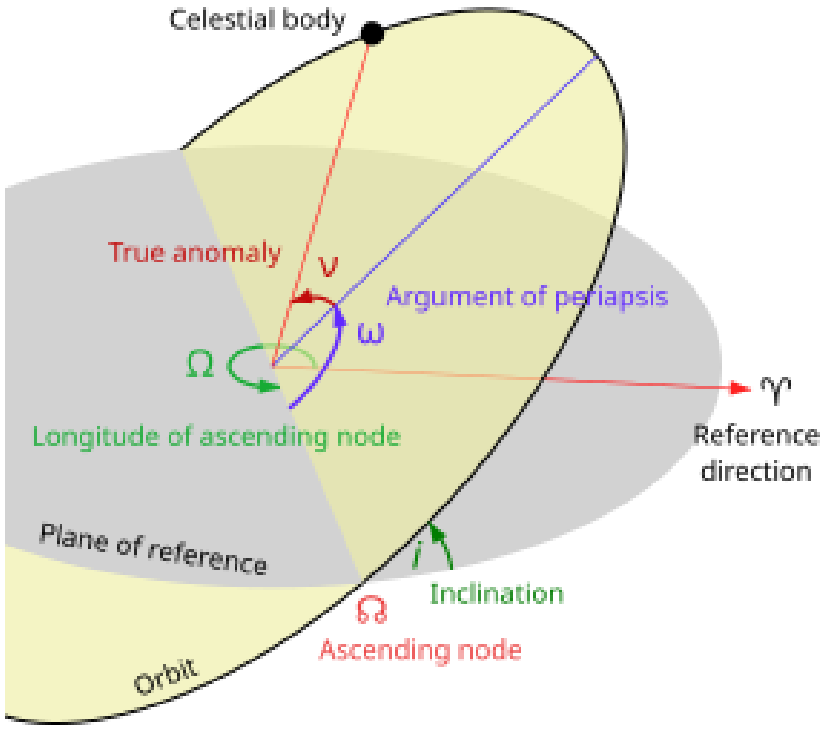
KilicSat TLE file reading and demonstrate orbital elements

KILICSAT

1 70305C 23054E 23105.32625438 -.00010461 00000+0 -47477-3 0 01

2 70305 97.4139 1.1728 0007826 257.6522 109.9853 15.20856378 12

a (semi major axis [km])=6881.39
e (eccentricity [deg])= 0.0008
i (inclination) [deg]= 97.4139
Ω (longitude of ascending node) [deg])= 1.1728
ω (argument of periapsis)[deg])= 257.6522
ν (true anomaly) [deg])=109.9860



Orbital elements - Wikipedia

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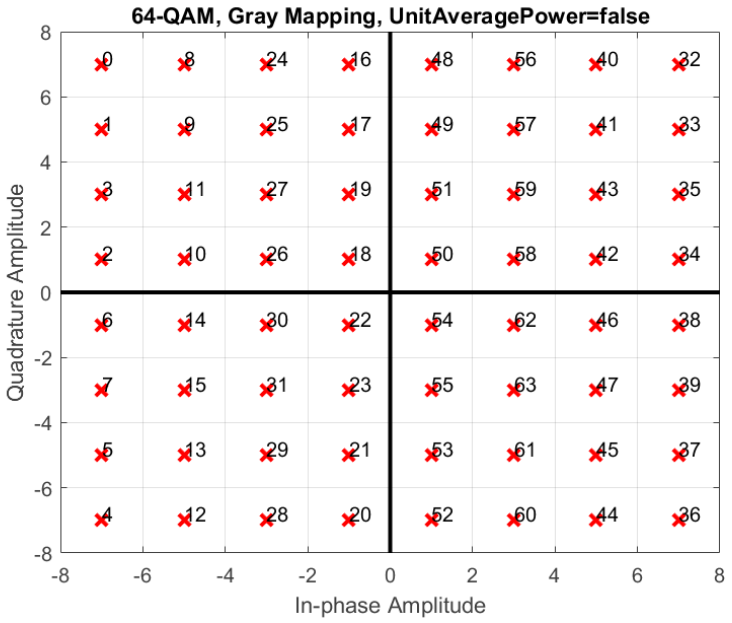
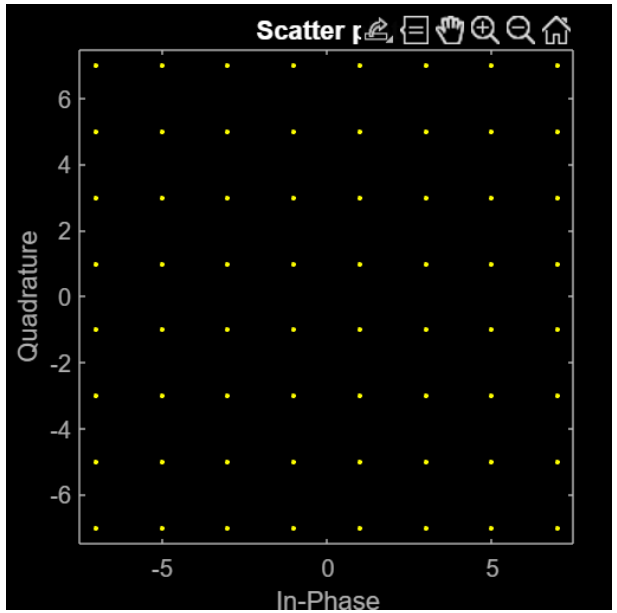
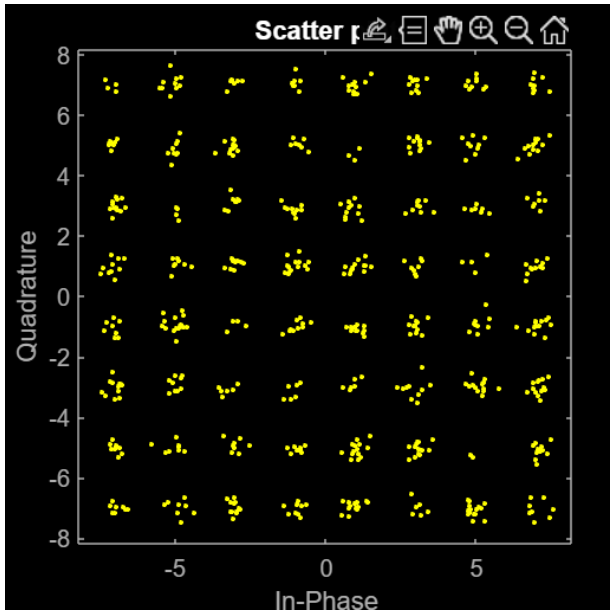
64-Quadrature Amplitude Modulation (QAM)



64-QAM constellation



Modulated signal without noise



Modulated signal with noise

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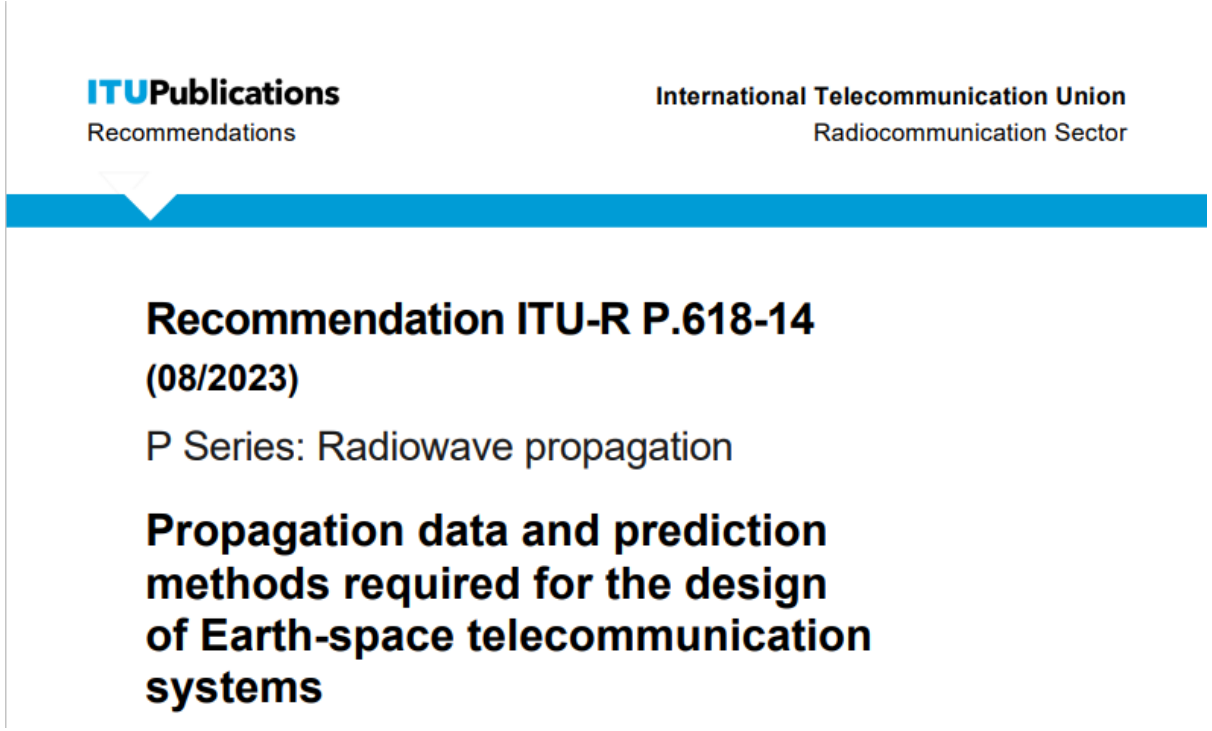
Propagation Losses using ITU-R P.618 Propagation Loss Model

- Frequency = $25\ \mathrm{GHz}$
- Elevation Angle = 45^0
- Latitude = 30^0
- Longitude = 120^0
- Antenna Efficiency = 0.65


ITUPublications
Recommendations

International Telecommunication Union
Radiocommunication Sector

Recommendation ITU-R P.618-14

(08/2023)

P Series: Radiowave propagation

Propagation data and prediction methods required for the design of Earth-space telecommunication systems

- Ag: Gaseous attenuation (in dB)=1.6393
- Ac: Cloud and fog attenuation (in dB)=1.2010
- Ar: Rain attenuation (in dB)=0.0811
- As: Attenuation due to tropospheric scintillation (in dB)=0.3010
- At: Total atmospheric attenuation (in dB)=6.6514

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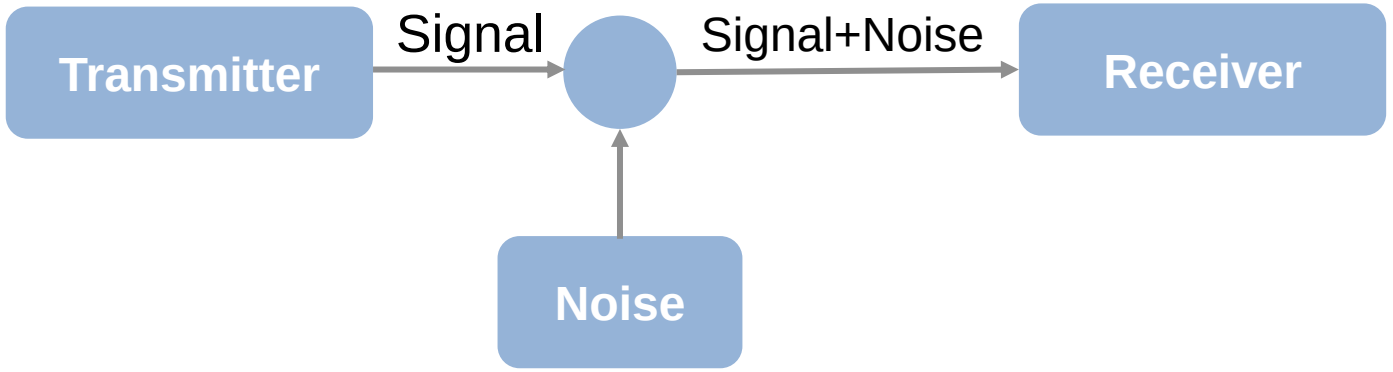
Encode a random bit vector using 2-D turbo product coding (TPC)

- Specify (N,K) code pairs for TPC encoding.
  - N = [32;64]
  - K = [21;57] Message Length (21x57 bits)
- Modulate message with 4-QAM
- First case S/N=6.5
  - BER=0
- Second case S/N=2.5
  - BER=0.0794

$$BER = \frac{Number\ of\ error\ bites\ in\ message}{Number\ of\ total\ bits\ in\ message}$$



Thank you

Q&A – 5min

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