

Earth Stations and Spacecraft

2.4.25 MODULATION METHODS FOR HIGH CODED SYMBOL RATE TRANSMISSIONS IN 25.25–27.5 GHz BAND, INTER-SATELLITE SERVICE, SPACE RESEARCH, SPACE-TO-SPACE

The CCSDS,
considering

- (a) that the 25.25–27.5 GHz band is allocated on a primary basis to the inter-satellite service for space research and Earth exploration-satellite applications, and also for transmission of data originating from industrial and medical activities in space (ITU-RR-5.536);
- (b) that use of the 25.25-27.5 GHz band by the inter-satellite service includes high data rate space-to-space links for data relay satellites as well as for proximity communication links;
- (c) that the SFCG has recommended¹ that use of the 25.25-27.5 GHz band for proximity communication links be constrained to the sub-bands 25.25-25.6 GHz and 27.225-27.5 GHz;
- (d) that the SFCG has recommended² that lunar surface-to-lunar orbit links and lunar relay-to-relay crosslinks use the 27-27.5 GHz band;
- (e) that efficient use of RF spectrum resources is imperative with the increasing congestion of the frequency bands;
- (f) that GMSK³ and baseband filtered OQPSK⁴ are spectrally and power efficient modulations, and have been recommended by the CCSDS for high symbol rate space-to-space transmissions in the 22.55-23.15 GHz band as well as high symbol rate space-to-Earth transmissions in the 25.5-27 GHz band⁵;
- (g) that since GMSK modulation is inherently differential in nature, the use of GMSK with precoding is necessary to optimize bit error rate performance;
- (h) that GMSK³ and baseband filtered OQPSK⁴ modulations have only a small performance degradation as compared with ideal unfiltered suppressed carrier systems;
- (i) that the receiver tracking loops for GMSK $BT_s=0.5$ are able to track signals with higher Doppler rates compared to GMSK $BT_s=0.25$, assuming the same symbol SNR and data rate;
- (j) that GMSK $BT_s=0.25$ has better spectral efficiency (occupied bandwidth) compared to GMSK $BT_s=0.5$;

¹ See SFCG Recommendation 15-2R4 or latest version.

² SFCG Recommendation 32-2R4 or latest version.

³ Gaussian Minimum Shift Keying $BT_s=0.25$ or $BT_s=0.5$ with pre-coding as in Figure 2.4.25-1. B refers to the one-sided 3-dB bandwidth of the filter.

⁴ Filtered (Square Root Raised Cosine $\alpha = 0.5$) Offset QPSK; Butterworth 6 poles, $BT_s = 0.5$; agencies may also utilize filtered OQPSK modulation with other types of bandpass filters provided that the equivalent baseband BT_s is not greater than 0.5 and they ensure compliance with SFCG Recommendation 21-2R5 (or latest version) and interoperability with the cross-supporting networks. B refers to the one-sided 3-dB bandwidth of the filter.

⁵ CCSDS Recommendations 401 (2.2.10) B-1 and 401 (2.4.21A) B-1

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- (k) that some agencies channelize the frequency band and for this they prefer to use GMSK^3 $BT_s=0.25$ in order to maximize the total number of channels available;
- (l) that a modulator phase imbalance of less than 5 degrees and an amplitude imbalance of less than 0.5 dB should result in acceptable performance degradation⁶;
- (m) that recommended maximum values of phase noise is needed to ensure small end-to-end losses;

recommends

- (1) that, for space-to-space transmissions in the 25.25–27.5 GHz inter-satellite service band, GMSK^3 ($BT_s=0.25$ or $BT_s=0.5$) or baseband filtered OQPSK^4 should be used; and that when channelization of the band and/or better spectral efficiency is needed, GMSK^3 ($BT_s=0.25$) or baseband filtered OQPSK^4 should be used;
- (2) that, for space-to-space transmissions in the 25.25–27.5 GHz inter-satellite service band, the residual carrier modulation schemes of Recommendations 2.3.1 and 2.4.7 may be used when the coded symbol rate is less than 1 coded Msymbol/s⁷ and the suppressed carrier modulation schemes of Recommendation 2.3.2 may be used when the coded symbol rate is less than 10 coded Msymbol/s⁷;
- (3) that CCSDS agencies use a data randomizer as specified in CCSDS 131.0-B-3 (or latest version);
- (4) that the modulator’s phase imbalance shall not exceed 5 degrees, and the amplitude imbalance shall not exceed 0.5 dB between the constellation points;
- (5) that the phase noise for the oscillators in the communication link should be limited according to the mask in the Annex.

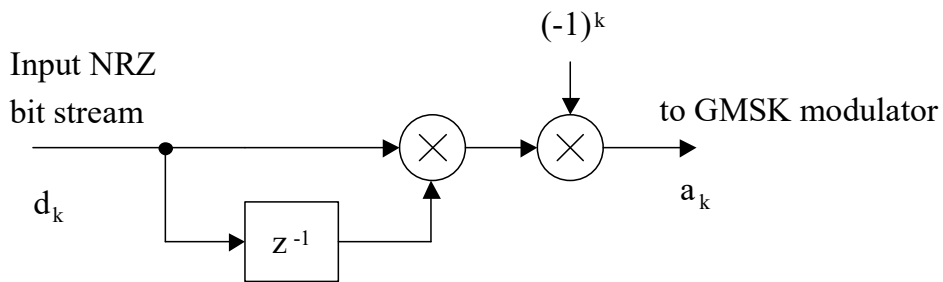


Figure 2.4.25-1: GMSK Precoder

⁶ See CCSDS Recommendation 401 (2.4.12A) B-5

⁷ For the purpose of this Recommendation, the coded symbol rate is defined in Figure 2.4.25-1.

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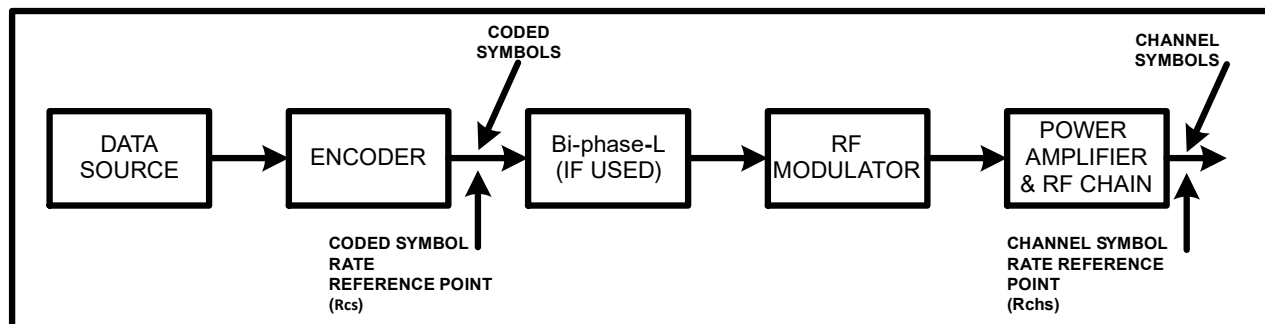


Figure 2.4.25-1: Telemetry Rates Definition

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ANNEX

PHASE NOISE

(Normative)

The phase noise for the oscillators of the communication chain shall be limited according to the mask given in Figure 2.4.25-1.

NOTE – The figure shows the double-sided phase noise mask $2L(f)$ in dBc/Hz versus frequency in Hz.

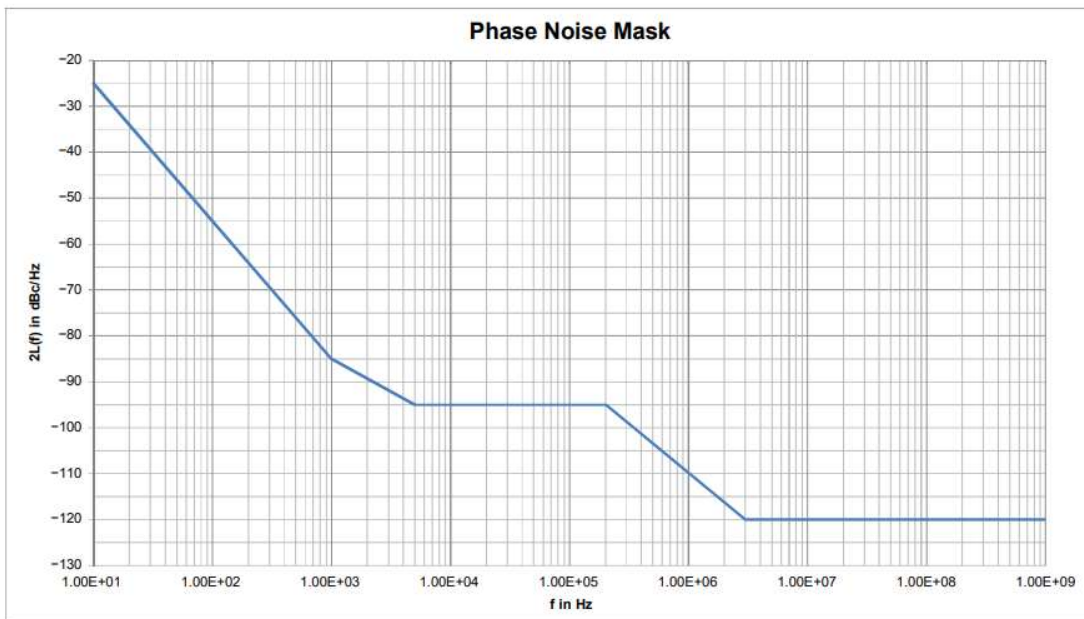


Figure 2.4.25-1: Phase noise mask recommendation