

Earth Stations and Spacecraft

**2.2.10 USE OF SUPPRESSED CARRIER MODULATIONS FOR HIGH RATE SPACE-TO-SPACE LINKS, SPACE RESEARCH AND INTER-SATELLITE, AT 22.55-23.55 GHZ**

The CCSDS,  
considering

- (a) that the frequency band 22.55-23.15 GHz is allocated to the Space Research Service (Earth-to-space) and the band 22.55-23.55 GHz is allocated to the Inter-Satellite Service;
- (b) that lunar missions in the near future will require high-rate space-to-space links, up to 200 coded Msymbol/s, for functions other than telecommand;
- (c) that the SFCG has recommended<sup>1</sup> 23.15-23.55 GHz as one of the frequency bands to be used for intersatellite links between lunar orbiters and for communications from the lunar orbit to the lunar surface;
- (d) that it is important to limit the occupied bandwidth of high rate transmissions to reduce out-of-band interference;
- (e) that since GMSK<sup>2</sup> modulation is inherently differential in nature, the use of GMSK with precoding is necessary to optimize bit error rate performance;
- (f) that GMSK<sup>2</sup> and baseband filtered OQPSK<sup>3</sup> modulations have only a small or negligible performance degradation as compared with ideal unfiltered suppressed carrier systems;
- (g) 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;
- (h) that GMSK  $BT_s=0.25$  has better spectral efficiency (occupied bandwidth) compared to GMSK  $BT_s=0.5$ ;
- (i) that some agencies channelize the frequency band and for this they use GMSK<sup>3</sup>  $BT_s=0.25$  in order to maximize the total number of channels available;
- (j) that a phase imbalance of less than 5 degrees and an amplitude imbalance of less than 0.5 dB should result in acceptable performance degradation<sup>4</sup>;
- (k) that recommended maximum values of phase noise is needed to ensure small end-to-end losses;

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<sup>1</sup> See SFCG Recommendation 32-2R4 or latest version.

<sup>2</sup> Gaussian Minimum Shift Keying ( $BT_s = 0.25$  or  $0.5$ ), with pre-coding as in Figure 2.2.10-1. B refers to the one-sided 3-dB bandwidth of the filter.

<sup>3</sup> 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.

<sup>4</sup> See CCSDS Recommendation 401 (2.4.12A) B-5

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recommends

- (1) that, for space-to-space transmissions in the 22.55–23.55 GHz inter-satellite service band, GMSK<sup>2</sup> ( $BT_s=0.25$  or  $BT_s=0.5$ ) or baseband filtered OQPSK<sup>3</sup> modulations should be used; and that when channelization of the band and/or better spectral efficiency is needed, GMSK<sup>2</sup> ( $BT_s=0.25$ ) or baseband filtered OQPSK<sup>3</sup> should be used;
- (2) that, for space-to-space transmissions in the 22.55-23.55 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/s<sup>5</sup> 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/s<sup>5</sup>;
- (3) that CCSDS agencies use a data randomizer as specified in CCSDS 131.0-B-4 (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 oscillators in the communication link should be limited according to the mask in the Annex.

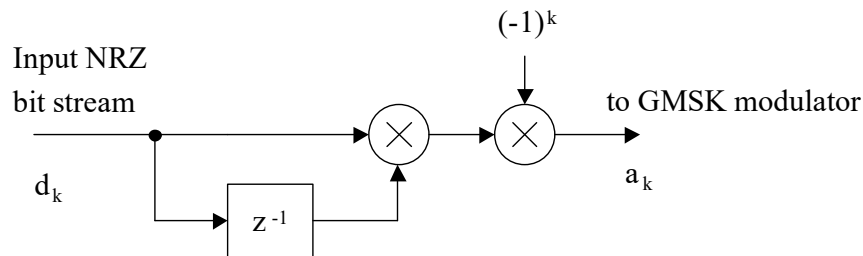


Figure 2.2.10-1: GMSK Precoder

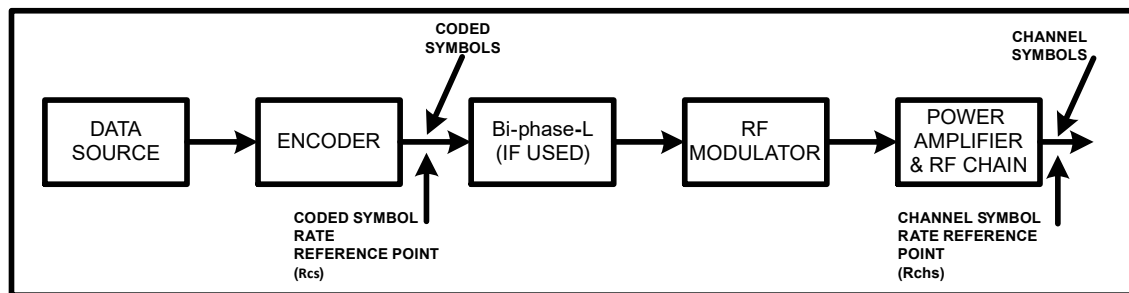


Figure 2.2.10-2: Telemetry Rates Definition

<sup>5</sup> For the purpose of this Recommendation, the coded symbol rate is defined in Figure 2.2.10-2

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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 2.2.10-3.

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

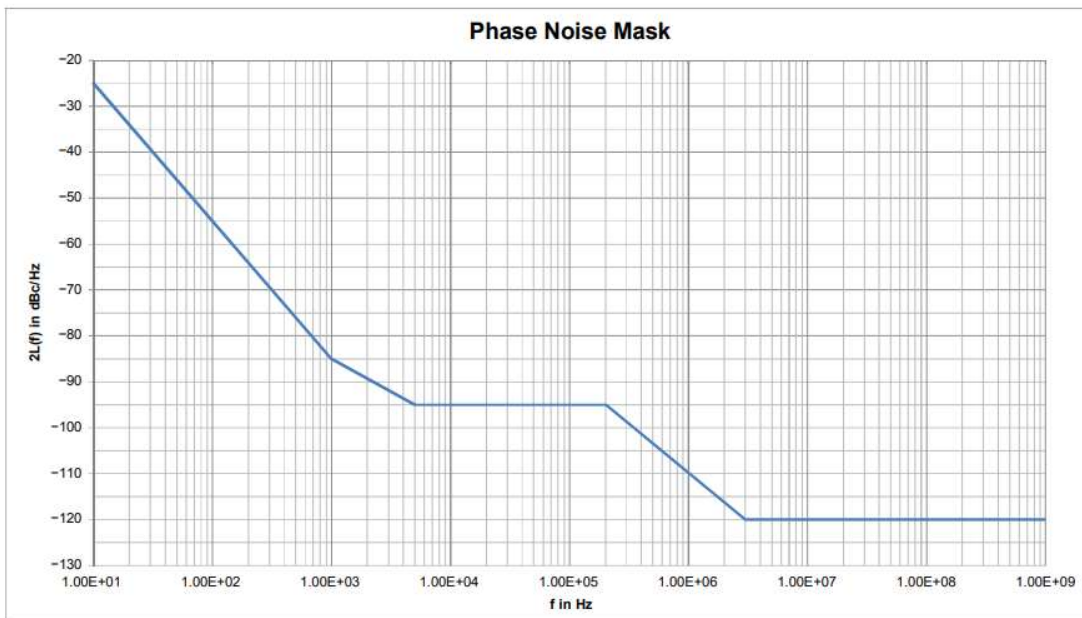


Figure 2.2.10-3: Phase noise mask recommendation