

Earth Stations and Spacecraft

2.2.9 USE OF SUPPRESSED CARRIER MODULATIONS FOR HIGH RATE EARTH-TO-SPACE LINKS, SPACE RESEARCH, AT 22.55-23.15 GHZ

The CCSDS,

considering

- (a) that the frequency band 22.55-23.15 GHz is allocated to Earth-to-space links of Space Research Service missions;
- (b) that Lunar missions in the near future will require high-rate Earth-to-space links, up to 200 coded Msymbol/s, for functions other than telecommand;
- (c) that the SFCG has approved a Recommendation¹ specifying that links from Earth to Lunar orbit or to Lunar surface shall use the frequency allocation 22.55-23.15 GHz;
- (d) that it is important to limit the occupied bandwidth at high rates to reduce out-of-band interference;
- (e) that GMSK² and baseband filtered OQPSK³ modulations have only a small or negligible performance degradation as compared with ideal unfiltered suppressed carrier systems;
- (f) that since GMSK² modulation is inherently differential in nature, the use of GMSK with precoding is necessary to optimize bit error rate performance;
- (g) that a phase imbalance of less than 5 degrees and an amplitude imbalance of less than 0.5 dB should result in acceptable performance degradation⁴;
- (h) that recommended maximum values of phase noise is needed to ensure small end-to-end losses;

recommends

- (1) that GMSK² or baseband filtered OQPSK³ modulations be used for high rate Earth-to-space links in the frequency band 22.55-23.15 GHz with coded symbol rates in the range 2-200 coded Msymbol/s⁵;
- (2) that CCSDS agencies use a data randomizer as specified in CCSDS 131.0-B-4 (or latest edition);

¹ See SFCG Recommendation 32-2R4 or latest version.

² Gaussian Minimum Shift Keying ($BT_s = 0.25$), with pre-coding as in Figure 2.2.9-1 (see CCSDS 413.0-G-3). B refers to the one-sided 3-dB bandwidth of the filter.

³ 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 interoperability with the cross-supporting networks. B refers to the one-sided 3-dB bandwidth of the filter.

⁴ See CCSDS Recommendation 401 (2.4.12A) B-5

⁵ For the purpose of this Recommendation, the coded symbol rate is defined in Figure 2.2.9-2.

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- (3) 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;
- (4) that the phase noise for the oscillators in the communication link should be limited according to the mask in the Annex.

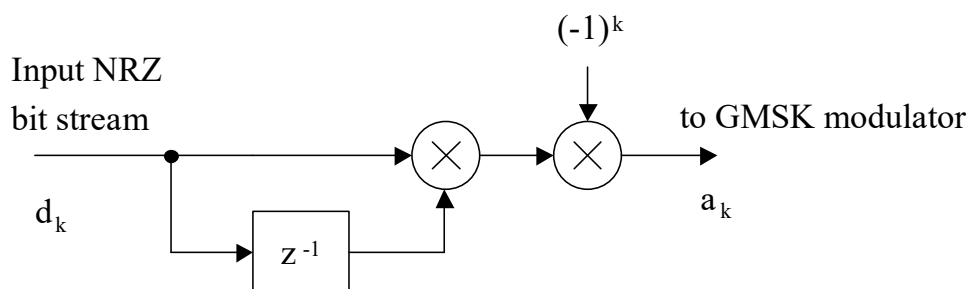


Figure 2.2.9-1: GMSK Precoder

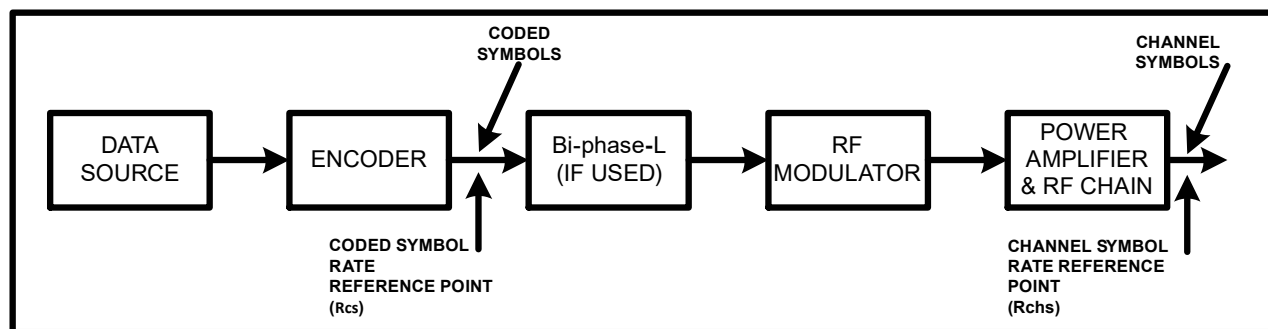


Figure 2.2.9-2: Telemetry Rates Definition

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**2.2.9 USE OF SUPPRESSED CARRIER MODULATIONS FOR HIGH RATE EARTH-TO-SPACE LINKS, SPACE RESEARCH, AT 22.55-23.15 GHZ
(Continued)****ANNEX****PHASE NOISE****(Normative)**

The phase noise for the oscillators of the communication chain shall be limited according to the mask given in Figure 2.2.9-3.

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

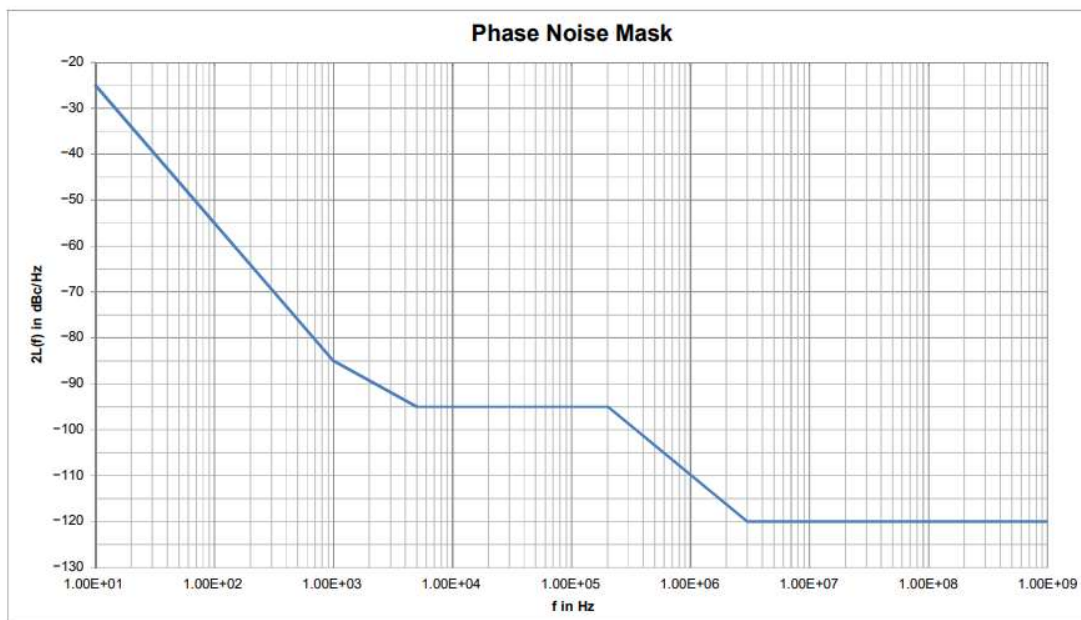


Figure 2.2.9-3: Phase noise mask recommendation