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 Recommendation[1] 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 GMSK[2] and baseband filtered OQPSK[3] modulations have only a small performance degradation as compared with ideal unfiltered suppressed carrier systems;

(f) that since GMSK[2] 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 degradation[4];

(h) that recommended maximum values of phase noise is needed to ensure small end-to-end losses;

recommends

(1) that GMSK[2] or baseband filtered OQPSK[3] 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 [5/10]-200 coded Msymbol/s[5];

(2) that CCSDS agencies use a data randomizer as specified in CCSDS 131.0-B-3 (or latest edition);

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[1] See SFCG recommendation 32-2R2 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.

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

(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.

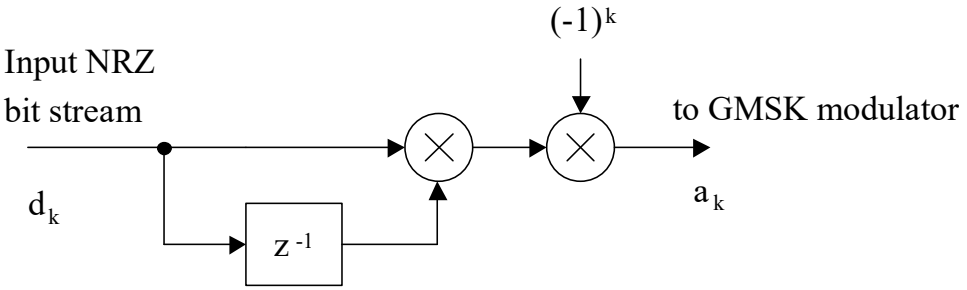

Figure 2.2.9-1: GMSK Precoder

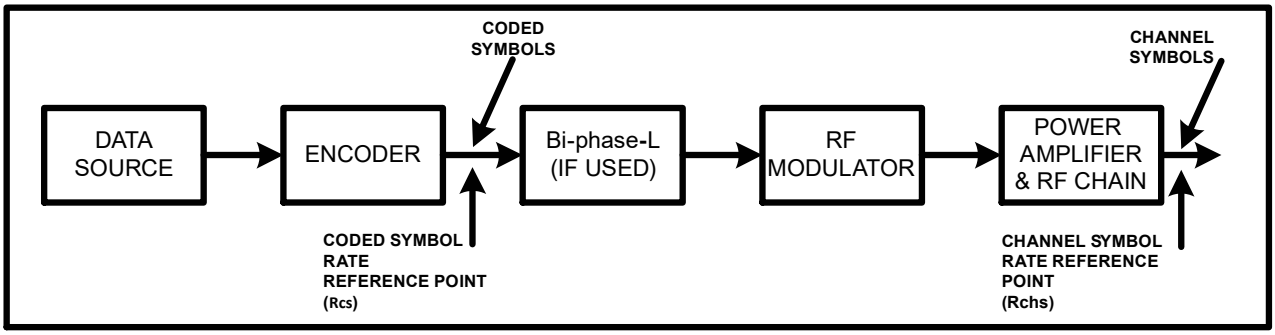

Figure 2.2.9-2: Telemetry Rates Definition

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.

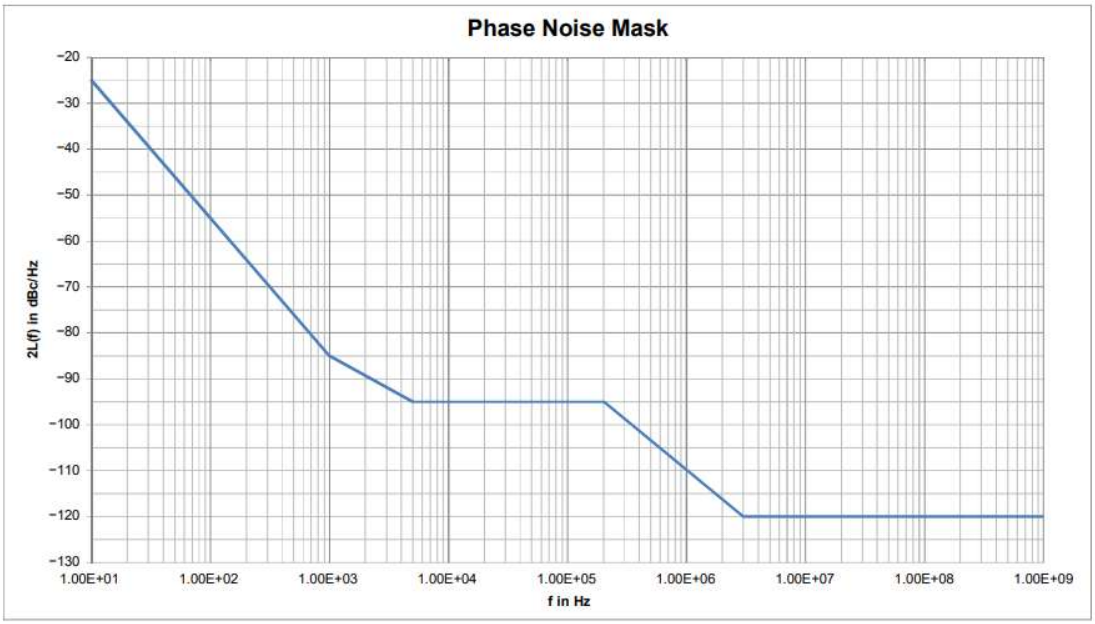

Figure 2.2.9-3: Phase noise mask recommendation