## 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[1] 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[2] modulation is inherently differential in nature, the use of GMSK with precoding is necessary to optimize bit error rate performance;

(f) that GMSK[2] and baseband filtered OQPSK[3] modulations have only a small 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 prefer to use GMSK[3] $BT_s$=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[4];

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

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

[2] 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.

[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 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.

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

## 2.2.10 USE OF SUPPRESSED CARRIER MODULATIONS FOR HIGH RATE SPACE-TO-SPACE LINKS, SPACE RESEARCH AND INTER-SATELLITE, AT 22.55-23.15 GHZ (Continued)

**recommends**

(1) that, for space-to-space transmissions in the 22.55–23.55 GHz inter-satellite service band, GMSK[2] ($BT_s$=0.25 or $BT_s$=0.5) or baseband filtered OQPSK[3] modulations should be used; and that when channelization of the band and/or better spectral efficiency is needed, GMSK[2] ($BT_s$=0.25) or baseband filtered OQPSK[3] 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/s[5] 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;

(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 oscillators in the communication link should be limited according to the mask in the Annex.

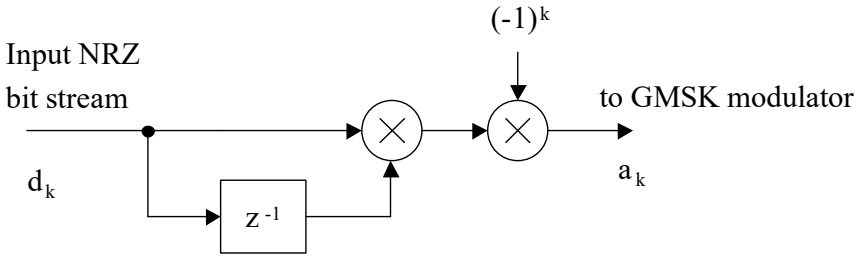


**Figure 2.2.10-1: GMSK Precoder**

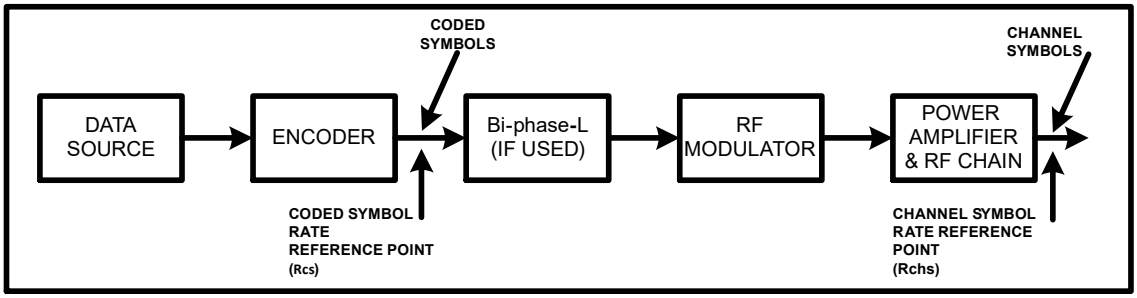


**Figure 2.2.10-2: Telemetry Rates Definition**

[5] For the purpose of this Recommendation, the coded symbol rate is defined in Figure 2.2.10-2

## 2.2.9 USE OF SUPPRESSED CARRIER MODULATIONS FOR HIGH RATE SPACE-TO-SPACE LINKS, SPACE RESEARCH AND INTER-SATELLITE, AT 22.55-23.55 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 2.2.10-3.

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

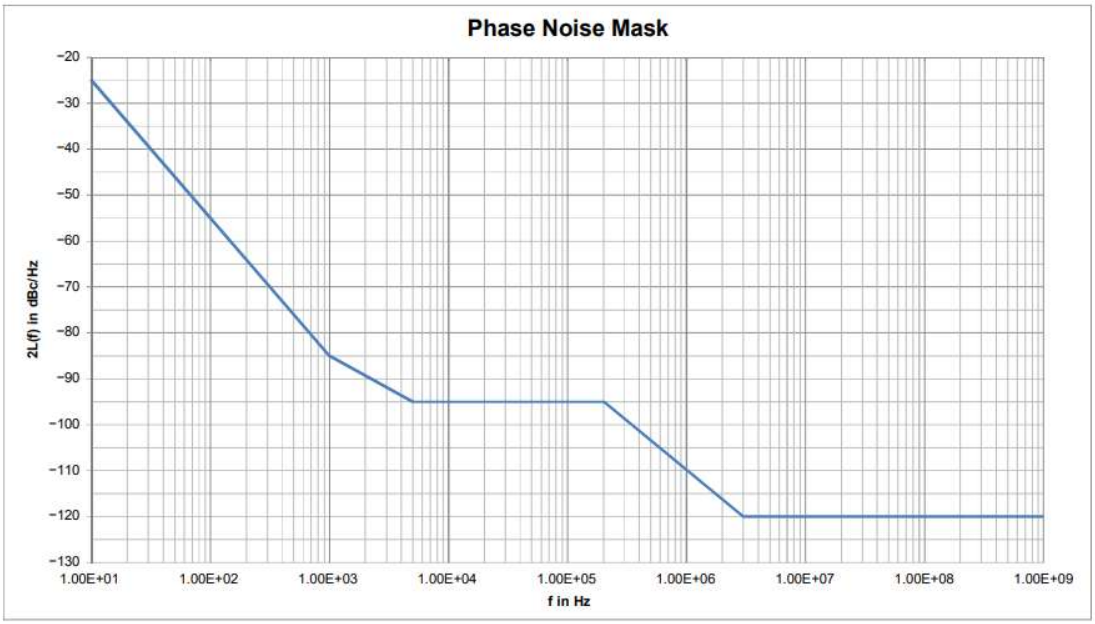


**Figure 2.2.10-3: Phase noise mask recommendation**