



**Recommendation SFCG 21-2R4**

**EFFICIENT SPECTRUM UTILISATION FOR SPACE RESEARCH SERVICE  
(CATEGORY A) AND EARTH EXPLORATION-SATELLITE SERVICE ON  
SPACE-TO-EARTH LINKS**

The SFCG,

CONSIDERING

- a) that frequency bands allocated to the space science services (SRS and EESS) are becoming more congested as space missions multiply, data rates increase and other services enter these bands;
- b) that usage of spectrum beyond what is actually required increases the potential for interference to other users and at the same time may result in a higher susceptibility to interference from other users of the band;
- c) that notified bandwidth requirements beyond the amount of spectrum actually required generally increases the coordination burden;
- d) that the use of PCM/PM/Bi-phase or PCM/PM/NRZ modulation is only justified when a distinct carrier component is required and for symbol rates below 2 Ms/s<sup>1</sup>;
- e) that in some exceptional cases, such as data relay satellite inter-orbit links, PFD limits laid down in RR No. 21.16 cannot be met with efficient modulation schemes;
- f) that some frequency bands of the space science services are allocated with a secondary status resulting in very difficult sharing conditions, which may require the use of spread spectrum-type modulations;
- g) that quaternary or higher order filtered modulation schemes have bandwidth characteristics which generally reduce coordination burdens and that spectrum shaping can be used to significantly reduce the occupied bandwidth;
- h) that a common residual carrier modulation system in use is PCM/PSK/PM;
- i) that the use of sub-carriers shall be limited, as stipulated by REC SFCG 21-3;

- j) that trellis-coded modulators act as an encoder and a modulator<sup>2</sup>;
- k) that telemetry is sometimes transmitted simultaneously with a ranging signal;

## RECOMMENDS

1. that space agencies use the most bandwidth efficient modulation schemes practicable for their missions;
2. that, PCM/PM/Bi-phase or PCM/PM/NRZ modulation only be used when a carrier component is technically necessary and for symbol rates below 2 Ms/s.
3. that the emitted spectrum<sup>3,4</sup> for all Space Science Services projects that will utilize space-to-Earth link frequency assignments in the bands 2200–2290 MHz, 8025–8400 MHz and 8450–8500 MHz, adhere to the low rate spectral emission mask of Figure 1 for symbol rates below 2 Ms/s and to the high rate spectral emission mask of Figure 1 for symbol rates equal or above 2 Ms/s;
4. that the emitted spectrum<sup>3</sup> for all Space Science Services projects designed for launch after 2020 that will utilize space-to-Earth link frequency assignments in the 25.5-27.0 GHz band and for channel symbol rates<sup>5</sup> equal or above 10 Ms/s, adhere to the high rate spectral emission mask of Figure 1;
5. that transmissions that include a ranging signal be exempt from the spectrum masks in Fig 1;
6. that PCM/PSK/PM transmissions in accordance with REC SFCG 21-3 be exempt from the spectrum masks in Fig 1.

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<sup>1</sup> For non spectrum modifying modulation, the symbol rate is defined as the baseband single line bit rate following error correcting coding (if applicable) and Bi-phase encoding (if used) at the input of the RF modulator. This definition makes this recommendation more stringent for lower order modulations. See Figure 2.

<sup>2</sup> For trellis-coded modulation, the symbol rate is defined as the baseband single bit rate at the input of an equivalent M-PSK modulator. This definition makes this recommendation more stringent for lower order modulations. See Figure 3

<sup>3</sup> Measured relative to the peak of the telemetry spectrum and excluding the residual carrier as well as all spurious emissions.

<sup>4</sup> PCM/PM/Bi-phase emissions with symbol rates up to 300 ks/s may deviate from the low rate mask by up to 5 dB in the slope region and up to 10 dB in the plateau region, and in the transition between the two regions.

<sup>5</sup> For all bands where such modulations as (O)QPSK, 8PSK, 16-APSK, 32-APSK or 64-APSK are used, the channel symbol rate (R<sub>c</sub>) is equal to the symbol rate (R<sub>s</sub>) (see figure 3) divided by log<sub>2</sub>(M) where M is 4 for (O)QPSK, 8 for 8PSK, 16 for 16-APSK, 32 for 32-APSK and 64 for 64-APSK.

Figure 1: Spectral Emission Masks

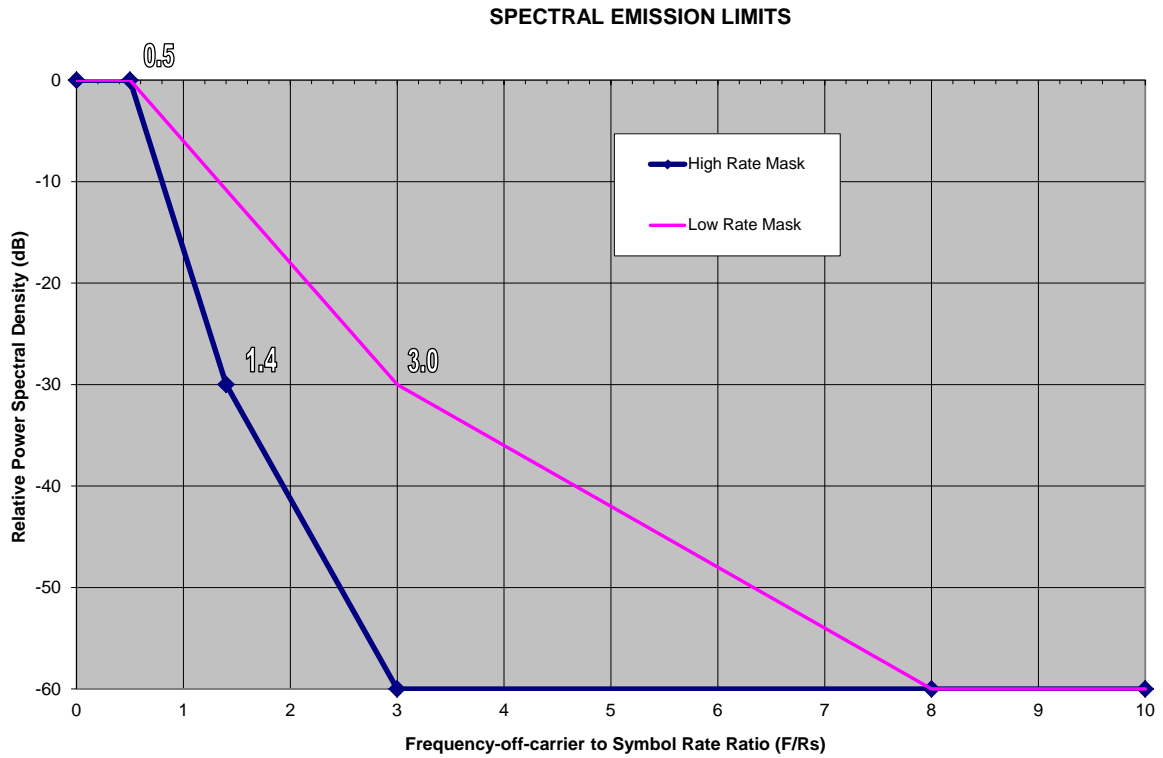


Figure 2: Non Spectrum Modifying Modulation Definitions

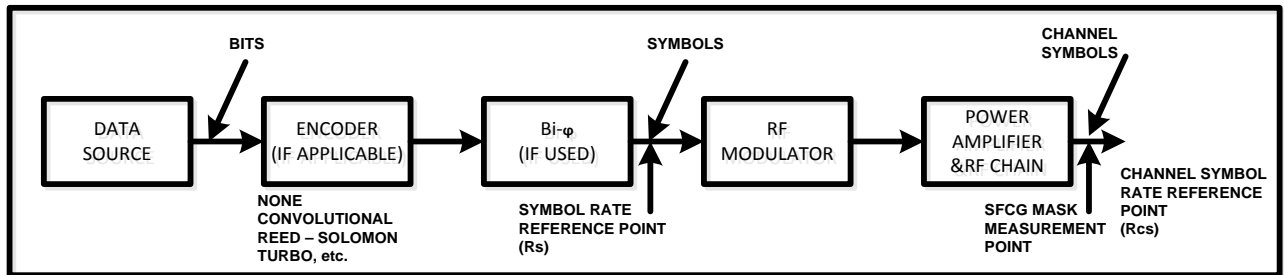


Figure 3: Trellis-Coded Modulation Definitions

