

Proposed Transponder Turnaround Ratios for 23.15-23.55 GHz and 27.0-27.5 GHz Bands

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I. Introduction

Action item AI_19-03 was issued at the CCSDS Spring 2019 RFM meeting to propose a transponder turnaround ratio for Inter-Satellite Service (ISS) links operating in the 23.15-23.55 GHz (forward) and 27.0-27.5 GHz (return) bands. The pairing of these bands is of interest because the SFCG has recommended these two bands for lunar orbit-to-surface and lunar surface-to-orbit links, respectively [1]. In addition, some elements of the Lunar Gateway program plan on using these Ka-band frequencies for high rate proximity links around the Moon.

II. Transponder Turnaround Frequency Ratio (TTFR) Selection

For these ISS frequency bands, the allocated bandwidth on the Ka forward link is 400 MHz and the allocated bandwidth on the Ka return link is 500 MHz. Thus it is only possible for a single TTFR to cover about 467 MHz of the return link band. Two TTFRs would be needed to cover the entire 27.0-27.5 GHz range. However, not every proximity link will require frequency coherency between the forward and return links. Also it should be noted that it is less important for the TTFRs to cover the edges of the band, since the carrier frequency cannot be too close to the band edge in order to avoid having the modulation sidebands extend outside the allocation. This is particularly true for high data rate applications envisioned for use in the Ka-band intersatellite links.

Since a single turnaround ratio can cover > 90% of the 27-27.5 GHz frequency range, the decision was made for this study to select a single turnaround ratio rather than having two turnaround ratios. This has an advantage of simplifying the recommendation, as well as making cross-support easier. There are examples of other turnaround ratio recommendations in the 401 Blue Book which do not cover the entire band; one such example is the S-up/X-down TTFR in Recommendation 2.6.5B.

One option for selecting the TTFR is to reuse one of the turnaround ratios for the 22/26 GHz bands in Recommendation (401) 2.6.14, which was approved by the RFM working group and is currently under agency review. The advantage of this option would be the potential reuse of transponder hardware. For example, one could envision a mission employing a single transponder that could be used to support Ka-band uplinks and downlinks with Earth in the 22 and 26 GHz bands, while also supporting intersatellite links in the 23 and 27 GHz bands. Of the three turnaround ratios in Recommendation 2.6.14, the 2407/2816 turnaround ratio would cover about 416 MHz of the ISS return link band. However with this TTFR, the lower 84 MHz of the 27.0-27.5 GHz band cannot be used for coherent ISS communications.

Using the same criteria used to select the 22/26 GHz TTFRs in [2], other candidate TTFRs are shown in Table 1. Of particular interest is the 2407/2808 turnaround ratio,

which would maximize coverage of the return link band. It provides the maximum coherent frequency range coverage of the return link (about 467 MHz), and is fairly well centered in the band. It also has other properties desirable for a turnaround ratio, and was a candidate for the 22/26 GHz turnaround ratio recommendation.

Objectively, the 2407/2808 turnaround ratio is better than the 2407/2816 TTFR if the hardware re-use factor is not taken into account. In the current Lunar Gateway architecture, there is no requirement for the Ka-band transponder to also serve as the Ka-band proximity radio. Another possibility would be to revise Recommendation 2.6.14 so that the 2407/2808 TTFR is used instead of 2407/2816.

Table 1. Candidate TTFRs for the 23/27 GHz Inter-Satellite Service (ISS) bands

Downlink Frequency Multiplier	Candidate TTFR	Coherent Forward Frequency Range (MHz)	Coherent Return Frequency Range (MHz)	Downlink Divisor Prime Factors
2800	2407/2800	23150 – 23550	27000 – 27395.098	2,2,2,2,5,5,7
2808	2407/2808	23150 – 23550	27006.730 – 27473.369	2,2,2,3,3,3,13
2816	2407/2816	23150 – 23550	27083.673 – 27500	2,2,2,2,2,2,2,11

III. Summary

The selection of a TTFR for intersatellite links in the 23.15-23.55 GHz and 27-27.5 GHz bands is discussed in this paper. A single TTFR which covers the vast majority of the return link band is preferred for the sake of simplicity.

The value of the numerator in the TTFR was chosen to be 2407 in order to match that used in the 22/26 GHz TTFR recommendation. The corresponding denominator in the TTFR can either be 2808 or 2816. The former value has the advantage that it maximizes the coherent frequency range in the return link, while the latter value would provide hardware re-use possibilities between the long-haul and proximity Ka-band radios.

Perhaps the best solution would be to use the 2407/2808 turnaround ratio for ISS links, and modify Recommendation 2.4.16 by replacing the 2407/2816 TTFR with 2407/2808. This would allow for maximum coherent frequency coverage of the 27.0-27.5 GHz ISS band, while also allowing possible hardware sharing between the long-haul and proximity Ka-band radios.

A draft version of the proposed 23/27 GHz turnaround ratio recommendation for intersatellite links is shown below.

References

- [1] Recommendation SFCG 32-2R2, Communication Frequency Allocations and Sharing in the Lunar Region, July 8, 2019.
- [2] D. Lee, “Proposed Revision to Draft Recommendation on 22/26 GHz Transponder Turnaround Ratios”, SLS-RFM_19-11, May 5-9, 2019.

**2.6.15 TRANSPONDER TURNAROUND FREQUENCY RATIOS FOR THE 23.15
– 23.55 GHz AND 27.0 – 27.5 GHz BANDS, INTERSATELLITE SERVICE**

The CCSDS,

considering

- (a) that the 23.15 – 23.55 GHz and 27.0 – 27.5 GHz frequency bands are allocated for use by the intersatellite service;
- (b) that some space agencies have expressed interest in pairing forward links in the 23.15 - 23.55 GHz band with return links in the 27.0 – 27.5 GHz band, particularly for proximity communications in the lunar region;
- (c) that the SFCG has recommended¹ the use of the 23.15 – 23.55 GHz and 27.0 – 27.5 GHz bands for lunar orbit-to-surface and lunar surface-to-orbit communications, respectively;
- (d) that some intersatellite links may require coherency between the forward and return frequencies for ranging and Doppler measurements;
- (e) that for space missions which require coherency, Transponder Turnaround Frequency Ratios (TTFRs) must be defined;
- (f) that for forward links in the 23.15 – 23.55 GHz band, a single TTFR can cover more than 93% of the frequency range in the 27.0 – 27.5 GHz band;
- (g) that for reasons of simplicity and cross-support, a single turnaround ratio is preferable;

recommends

that CCSDS agencies use the 2407/2808 turnaround ratio for intersatellite links requiring frequency coherency between forward links in the 23.15 – 23.55 GHz band and return links in the 27.0 – 27.5 GHz band²

¹ Recommendation SFCG 32-2

² The 2407/2808 TTFR provides frequency coherency for return link frequencies between 27006.730 MHz and 27473.369 MHz.