

Update of Deep Space Frequency Channels in Recommendation 3.1.6B

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I. Introduction

CCSDS Recommendation (401) 3.1.6B provides the channel frequency plan for the 2, 7, 8, 32, and 34 GHz deep space research bands. The channel center frequencies in Recommendation 3.1.6B follow those given in Recommendation SFCG 7-1. At the SFCG meeting in July 2019, Recommendation SFCG 7-1 was updated to correct some minor frequency errors in the deep space channel plan. This document proposes an update to CCSDS Recommendation (401) 3.1.6B to mirror the changes in Recommendation SFCG 7-1R6.

II. Deep Space Channel Plan

It was noticed by one of the NASA deep space missions that the X-band uplink and Ka-band downlink frequencies for their channel assignment in Recommendation SFCG 7-1R5 did not match the X-up/Ka-down turnaround ratio (749/3328). In fact the Ka-band downlink frequency for Channel 21 in both the SFCG and CCSDS Recommendations differed by 2 Hz from the downlink frequency computed from the ideal turnaround ratio.

The specific channel in this case was deep space Channel 21. Per CCSDS Recommendation 3.1.6B and SFCG Recommendation 7-1R5, the Ka-band downlink center frequency for this channel is 31859.950622 MHz. However if the uplink frequency for this channel (7170.403550 MHz) is multiplied by the inverse of the turnaround ratio, $3328/749$, the corresponding downlink frequency is actually 31859.950620 MHz, which is 2 Hz less than what is given in the CCSDS and SFCG recommendations. Note that some deep space missions use transponders that can generate coherent downlink frequencies to within a fraction of a millihertz needed for precision Doppler measurements and radio science; for these missions a 2 Hz error in the coherent downlink frequency would be quite significant. Further examination of the channel center frequencies in Recommendation SFCG 7-1R5 and CCSDS Recommendation 3.1.6B showed that in addition to Channel 21, there were a number of other channels with frequency errors on the order of 1 to 2 Hz.

After further investigation, it was discovered that these errors are due to rounding in the method used to generate the channel center frequencies. The uplink and downlink frequencies for X- and Ka-band channels are generated separately, first by multiplying the S-band uplink channel frequency by the appropriate factor and then rounding the result to the nearest hertz. Since the S-band uplink frequency is always used as the reference, this results in S-up/S-down, S-up/X-down, and S-up/Ka-down frequency channel pairs that correctly follow the ideal turnaround ratio. However, frequency pairs that do not include the S-band uplink (e.g., X-up/X-down and X-up/Ka-band pairs) can deviate from the ideal turnaround ratio due to separate rounding of the uplink and downlink frequencies after multiplication of the S-band reference.

One solution that would avoid such rounding errors and correct all frequencies was presented in [1]. However this approach introduced somewhat large changes in the center frequency of some

channels. Since current deep space missions would still be using the old channel frequencies and introducing a new set might cause confusion, the decision was made to go with another solution that would only modify the channel center frequencies by a few hertz. This solution involved referencing all channels to the X-band uplink rather than the S-band uplink. The rationale for this approach is that deep space mission have been migrating away from using the 2110-2120 MHz uplink S-band, and most current deep space missions now rely on an X-band uplink in the 7145 – 7190 MHz band. By referencing the X-band downlink and Ka-band downlinks to the X-band uplink, the X-up/X-down and X-up/Ka-down coherent channel frequency pairs will comply with the ideal turnaround ratio. In addition, this approach will also not create any rounding errors in the S-up/S-down frequencies.

This approach has the advantage that changes to the channel center frequencies are generally quite small (≤ 2 Hz for X-band and ≤ 10 Hz for Ka-band). However some K-up/K-down frequency channel pairs, there will still be a 1 Hz error in the turnaround ratio. In Recommendation SFCG 7-1R6, this is taken care of by including a note in the recommendation that frequencies may deviate by 1 or 2 Hz from the exact turnaround ratio due to rounding. This solution was accepted by the SFCG, and the recommendation was provisionally approved at the most recent SFCG meeting.

III. Summary

Changes to the deep space frequency channel plan in CCSDS Recommendation 3.1.6B are proposed in order to align the recommendation with recent changes in SFCG Recommendation 7-1R6. These changes were made to correct certain errors in the X-band and Ka-band frequencies in the previous version of the SFCG recommendation, which caused the uplink and downlink frequencies not to correspond with the CCSDS recommended turnaround ratios. The proposed changes are shown in the Annex below.

References

- [1] SF39-23/D, “Proposed Modification of Deep Space Frequency Plan (REC SFCG 07-1R5)”, SFCG-39, July 1-8, 2019.

3.1.6B CHANNEL FREQUENCY PLAN FOR 2, 7, 8, 32, AND 34 GHZ, CATEGORY B

The CCSDS,

considering

- (a) that channel frequency plans for Category B missions exist for the 2, 7, 8, 32, and 34 GHz bands;
- (b) that the sets of channel frequency pairs in these existing plans are based upon the recommended turnaround ratios;
- (c) that members of the Space Frequency Coordination Group (SFCG) have resolved to select frequencies for their Category B missions from the existing channel frequency plans;
- (d) that most past, existing, and planned Category B missions have assigned frequencies that were selected on the basis of these existing channel frequency plans;
- (e) that CCSDS agencies conducting Category B missions have coordinated the selection of frequencies from those embodied in the existing channel frequency plans in order to avoid interference between missions;

recommends

- (1) that CCSDS agencies select frequencies for their Category B missions operating in the 2, 7, 8, 32, and 34 GHz bands from the channel frequency plan contained in Table 3.1.6B-1;
- (2) that frequency selection be coordinated with an appropriate organization, such as the SFCG, to ensure the orderly use of the channel frequency plan.

TABLE 3.1.6B-1: Channel Frequencies for Category B (Deep-Space) Missions

BAND (GHz):	2 E-S	2 S-E	7 E-S	8 S-E	32 S-E	32 S-E	32 S-E	34 E-S
FACTOR:	221	240	749	880	3328	3344	3360	3599
CHANNEL	F2DN							
1	*2108.878858	2290.185185	7147.286265	*8397.345679	#31757.234568	#	31909.91357880	#32062.5925912 # 34343.2353379
2	*2109.219908	2290.555556	7148.4421312	*8398.703706	#31762.370379	#	31915.0740803	#32067.7777847 # 34348.78935861
3	*2109.560957	2290.925926	7149.597994	8400.061729	#31767.506176	#	31920.23456971	#32072.9629646 # 34354.3433658
4	*2109.902006	2291.296296	7150.753857	8401.419752	#31772.641973	#	31925.3950579	#32078.1481446 # 34359.8973724
5	2110.243056	2291.666667	7151.9097234	8402.7777980	31777.777784		31930.55555962	32083.33333740 34365.4513936
6	2110.584105	2292.037037	7153.0655867	8404.1358023	31782.913581		31935.71604850	32088.5185179 34371.005399402
7	2110.925154	2292.407407	7154.22144950	8405.4938256	31788.049378		31940.8765368	32093.7036969 34376.5594068
8	2111.266204	2292.777778	7155.377316	8406.851853	31793.185190		31946.037042	32098.8888943 34382.1134321
9	2111.607253	2293.148148	7156.533179	8408.2098776	31798.320986		31951.1975310	32104.0740743 34387.6674387
10	2111.948303	2293.518519	7157.689045	8409.567903	31803.456798		31956.358033	32109.259267 34393.22145960
11	2112.289352	2293.888889	7158.844908	8410.925927	31808.592595		31961.518521	32114.444447 34398.775466
12	2112.630401	2294.259259	7160.000771	8412.283950	31813.728392		31966.67901009	32119.6296276 34404.329472
13	2112.971451	2294.629630	7161.156637	8413.641977	31818.864203		31971.839512	32124.8148201 34409.8834934
14	2113.312500	2295.000000	7162.312500	8415.000000	31824.000000		31977.000000	32130.000000 34415.437500
15	2113.653549	2295.370370	7163.468363	8416.358023	31829.135797		31982.160488	32135.18518079 34420.9915076
16	2113.994599	2295.740741	7164.624229	8417.716050	31834.271608		31987.3209901	32140.3703734 34426.545528
17	2114.335648	2296.111111	7165.780092	8419.074073	31839.407405		31992.481479	32145.555553 34432.099534
18	2114.676697	2296.481481	7166.935955	8420.432097	31844.543202		31997.641967	32150.740733 34437.6535410
19	2115.017747	2296.851852	7168.091821	8421.7901234	31849.6790124		32002.80246970	32155.9259267 34443.2075623
20	2115.358796	2297.222222	7169.247684	8423.148147	31854.814810		32007.962958	32161.1111067 34448.7615689
21	2115.699846	2297.592593	7170.4035510	8424.5061754	31859.9506242		32013.1234642	32166.2963041 34454.3155942

Note – Channel frequencies marked “*” are not within the Category B band allocation.

Channel frequencies marked “#” may be used in conjunction with the corresponding channel in a lower frequency band if that channel is available not marked by “*” within the Category B allocation.

F2DN = $N(10/27) + 2295$ MHz, where N is in the range -13 to +28 for this Table. The value of F2DN is rounded to the nearest Hz. Frequencies in the 82 GHz E-S band are then computed and rounded to the nearest Hz. Channel numbers are equal to N + 14. Frequencies in other bands are derived from the 82 GHz E-S frequencies by using the corresponding ratio of frequency factors, and then rounding to the nearest Hz. Due to rounding, ratios of the uplink to downlink frequency may differ by 1 or 2 Hz from the exact turnaround ratio in some cases.

TABLE 3.1.6B-1 (Continued): Channel Frequencies for Category B (Deep-Space) Missions

BAND (GHZ):	2 E-S	2 S-E	7 E-S	8 S-E	32 S-E	32 S-E	32 S-E	34 E-S
FACTOR:	221	240	749	880	3328	3344	3360	3599
CHANNEL	F2DN							
22	2116.040895	2297.962963	7171.55941 43	8425.86419 87	31865.0864 2219	32018.28395 20	32171.48148 31	34459.869 601598
23	2116.381944	2298.333333	7172.71527 76	8427.22222 10	31870.22221 96	32023.44444 4138	32176.66666 30	34465.42360 74
24	2116.722994	2298.703704	7173.871143	8428.580248	31875.35802 97	32028.60494 31	32181.85185 64	34470.97762 86
25	2117.064043	2299.074074	7175.027006	8429.938271	31880.49382 64	32033.76543 129	32187.03703 64	34476.53163 52
26	2117.405092	2299.444444	7176.18286 98	8431.29629 54	31885.62962 41	32038.9259 2017	32192.22221 63	34482.08564 239
27	2117.746142	2299.814815	7177.338735	8432.654321	31890.76543 42	32044.08642 20	32197.40740 98	34487.63966 31
28	2118.087191	* 2300.185185	7178.49459 87	8434.01234 54	#31895.90123 129	# 32049.2469 1008	#32202.59258 97	# 34493.19366 97
29	2118.428241	* 2300.555556	7179.65046 43	8435.37037 21	#31901.03704 21	# 32054.40741 21	#32207.777782	# 34498.7476 9089
					#			
30	2118.769290	* 2300.925926	7180.806327	8436.728395	#31906.17283 98	32059.567 901899	#32212.96296 21	# 34504.30169 75
31	2119.110339	* 2301.296296	7181.962190	8438.086418	#31911.30863 64	# 32064.72838 97	#32218.14814 20	# 34509.85570 31
32	2119.451389	* 2301.666667	7183.11805 76	8439.44444 65	#31916.4444 5146	# 32069.88889 51	#32223.3333 4035	# 34515.40972 94
33	2119.792438	* 2302.037037	7184.2739 2019	8440.80246 98	#31921.58024 83	# 32075.0493 8479	#32228.5185 2014	# 34520.96373 61
34	* 2120.133487	* 2302.407407	7185.42978 32	8442.16049 31	#31926.71604 50	# 32080.2098 7267	#32233.70369 94	# 34526.51774 237
35	* 2120.474537	* 2302.777778	7186.58564 98	8443.5185 2018	#31931.85185 61	# 32085.37037 40	#32238.8888 9388	# 34532.0717 6359
36	* 2120.815586	* 2303.148148	7187.74151 21	8444.87654 32	#31936.9876 5348	# 32090.5308 6358	#32244.0740 7368	# 34537.6257 7065
37	* 2121.156636	* 2303.518519	7188.89737 87	8446.2345 7069	#31942.12346 30	# 32095.69136 51	#32249.25926 62	# 34543.1797 9187
38	* 2121.497685	* 2303.888889	* 7190.053240	8447.59259 32	#31947.2592 6056	# 32100.8518 5349	#32254.44444 62	# 34548.73379 83
					#			
39	* 2121.838734	* 2304.259259	* 7191.209103	8448.95061 65	#31952.39505 83	# 32106.0123 4137	#32259.62962 51	34554.287 804799
40	* 2122.179784	* 2304.629630	* 7192.364969	* 8450.308642	#31957.53086 85	# 32111.17284 30	#32264.81481 96	# 34559.84182 52
41	* 2122.520833	* 2305.000000	* 7193.520832	* 8451.666665	#31962.66666 52	# 32116.3333 3228	#32269.99999 95	# 34565.3958 3228
42	* 2122.861882	* 2305.370370	* 7194.676696	* 8453.024689	#31967.8024 6258	# 32121.4938 2016	#32275.18517 84	# 34570.94983 84

Note — Channel frequencies marked “*” are not within the Category B band allocation.

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F2DN = N(10/27) + 2295 MHz, where N is in the range -13 to +28 for this Table. The value of F2DN is rounded to the nearest Hz. Frequencies in the 8.2 GHz E-S band are then computed and rounded to the nearest Hz. Channel numbers are equal to N + 14. Frequencies in other bands are derived from the 8.2 GHz E-S frequencies by using the corresponding ratio of frequency factors, and then rounding to the nearest Hz. Due to rounding, ratios of the uplink to downlink frequency may differ by 1 or 2 Hz from the exact turnaround ratio in some cases.