Deep Space Network

201
Frequency and Channel Assignments

Document Owner:		Approved by:	
Signature Provided	01/04/2021	Signature Provided	12/29/2020
Dong K. Shin DSN System Engineer	Date	Timothy Pham Communications Systems Chief Engineer	Date
Prepared by:		**Released by:**	
Signature Provided	01/04/2021	Signature Provided	2/5/2021
Dong K. Shin DSN System Engineer	Date	Christine Chang DSN Document Release Authority	Date

DSN No. **810-005, 201, Rev. E**
Issue Date: February 05, 2021
JPL D-19379; CL#21-0641

Jet Propulsion Laboratory
California Institute of Technology

Users must ensure that they are using the current version in DSN Telecommunications Link Design Handbook website:
http://deepspace.jpl.nasa.gov/dsndocs/810-005/

Review Acknowledgment

By signing below, the signatories acknowledge that they have reviewed this document and provided comments, if any, to the signatories on the Cover Page.

Signature Provided	12/07/2020	Signature Not Provided	
Jeff Berner DSN Project Chief Engineer	Date	Andrew O'Dea DSN TTC System Engineer	Date

Signature Provided	11/23/2020
Alina Bedrossian DSN OBD System Engineer	Date

Document Change Log

Rev	Issue Date	Prepared By	Affected Paragraphs	Change Summary
Initial	11/30/2000	Robert Sniffin	All	All
A	9/19/2008	Robert Sniffin	2.4, Tables 1 & 2	Adds 26 GHz assignment. Removes suggested turn-around ratios in Ka-band
B	12/15/2009	Andrew Kwok	Page 4	Removed references of the 26-m subnet stations for they have been decommissioned.
C	12/15/2014	Dong Shin	Page 6	Add a footnote for Deep Space S-band uplink restriction at Madrid tracking stations.
D	09/04/2020	Dong Shin	2, 2.2, 2.4, Table 1, 2, 3, 4, 6-1, 6-2, 6-3	Added K-band, updated Table 3 & 4 per SFCG recommendations, added Ka-band channels (Table 6-1, 6-2, 6-3) per SFCG recommendations
E	02/05/2021	Dong Shin	Table 1	Corrected K-band transponder turnaround ratio

Contents

Tables

1 Introduction

1.1 Purpose and Scope

This module provides basic information about the frequencies that are available in the Deep Space Network (DSN) and presents the way certain of the DSN frequency allocations have been divided into channels. It does not specify which stations can or will support assigned frequencies. That information is contained in the appropriate Telecommunications Interfaces modules (101, 70-m Antenna Subnet Telecommunications Interfaces; 103, 34-m HEF Antenna Subnet Telecommunications Interfaces; or 104, 34-m BWG Stations Telecommunications Interfaces) of this handbook. It also does not include propagation characteristics of the frequencies. This information is provided in module 105 (Atmospheric and Environmental Effects) and module 106 (Solar Corona and Solar Wind Effects) of this handbook.

2 General Information

The DSN has developed channel plans to provide for orderly selection and assignment of frequencies for deep-space missions (Category B, greater than 2 million km from Earth) for the S-, X-, and Ka-bands in compliance with Space Frequency Coordination Group (SFCG) recommendations. These deep space channel plans are based on bandwidth and transponder turnaround-ratio considerations. The plans allow simultaneous phase coherent uplink (Earth-to-space) and downlink (space-to-Earth) transmissions where the uplink and downlinks are in the same or different bands.

Through international agreements, the International Telecommunications Union (ITU) allocates and regulates portions of the frequency spectrum for both commercial and government use. The primary objective of the ITU is to establish regulatory procedures for the coordinated use of frequencies by those agencies permitted to operate in the allocated bands. The ITU has allocated certain bands to deep space (Category B) research. In some cases, the deep space missions may be required to conditionally share a frequency band between multiple users in the same band.

The Consultative Committee for Space Data Systems (CCSDS) is an international organization for space agencies interested in mutually developing standard transmission and data handling techniques to support space research, including space science and applications. As a member of the CCSDS, NASA has submitted recommendations for various space systems applications.

The National Telecommunications and Information Administration (NTIA), an agency of the U.S. Department of Commerce, is the Executive Branch's principal authority on domestic and international telecommunications and information technology issues. During the planning phase of all missions using the DSN, the proposed operating frequencies and other operating parameters are reviewed by the NTIA for approval through the System Review process. The NTIA evaluations are based upon the technical and regulatory criteria for the efficient and coordinated use of the frequency spectrum by NASA missions.

2.1 Tracking Modes of Operation

The following paragraphs describe the various ways in which the telecommunications link can be configured for radio tracking. The source of the uplink signal and the choice of references for measuring the received frequency determine the mode of operation.

2.1.1 One-way

The spacecraft generates the downlink signal(s) from an onboard oscillator. The DSN compares the received frequency against a locally generated frequency.

2.1.2 Two-way

The DSN transmits a signal to the spacecraft. The spacecraft tracks the phase of the uplink signal and generates a phase coherent downlink signal. The DSN compares the received frequency with the same reference frequency from which the uplink was generated.

2.1.3 Three-way

The spacecraft is tracked by two stations—the uplink is transmitted from one antenna and the downlink is received at a different antenna. The most common application of this mode is during the handover between stations at two different Deep Space Communication Complexes (DSCCs). When three-way tracking is done within one DSCC, both uplink and downlink equipment share a common frequency reference. When three-way tracking is done across two DSCCs, higher noise performance is expected due to the use of two different frequency references.

2.1.4 Coherent Three-way

Coherent three-way tracking is three-way tracking when the transmitting and receiving stations share a common frequency reference. This is possible at all three DSN complexes as all antennas at a complex share the same frequency reference.

2.2 Spacecraft Transponder Turnaround Ratios

To measure two-way or three-way Doppler shift, the spacecraft must transmit a downlink signal that is phase coherent with the uplink signal. Table 1 provides the recommended spacecraft transponder turnaround ratios for various uplink and downlink frequency bands. The tracking equipment at the DSN 34-m and 70-m stations can accommodate other turnaround ratios but this support must be negotiated through the JPL Frequency Manager, see <https://deepspace.jpl.nasa.gov/about/commitments-office/>.

Table 1. Spacecraft Transponder Turnaround Ratios

Uplink	Downlink	Ratio (downlink/uplink)
S	S	240/221
S	X	880/221
S	Ka	3328/221, 3344/221, 3360/221
X	S	240/749
X	X	880/749
X	K_a	3328/749, 3344/749, 3360/749
K*	K**	2720/2407, 2760/2407, 2816/2407***
K_a	K_a	3344/3599, 3360/3599

* K-band uplink implementation, at two 34-meter BWG antennas per complex, will start November 2021 and complete July 2024.

** K-band Doppler and ranging data are not supported by the DSN.

*** Due to the bandwidth difference between 600 MHz uplink and 1500 MHz downlink, the coherency between uplink and downlink using these transponder ratios does not apply to the entire allocated bandwidth.

2.3 Frequency Bands Allocated by the International Telecommunication Union (ITU)

Frequency ranges have been allocated by the ITU for use in deep space and near-Earth research. These ranges are listed in Table 2.

Table 2. Allocated Frequency Bands

Band Designation	Deep Space Bands (for spacecraft outside 2 million km from Earth)		Near Earth Bands (for spacecraft within 2 million km from Earth)	
	Uplink (Earth to space)	Downlink (space to Earth)	Uplink (Earth to space)	Downlink (space to Earth)
S-band	2110–2120*	2290–2300	2025–2110	2200–2290
X-band	7145–7190	8400–8450	7190–7235	8450–8500
K-band (Near Earth)	N/A	N/A	22550-23150	25500–27000
Ka-band (Deep Space)	34200–34700	31800–32300	N/A	N/A

* Deep Space S-band is not available at Madrid tracking stations due to a conflict with IMT-2000 users, per agreement between NASA and Secretaria de Estado de Telecomunicaciones para la Sociedad de la Informacion (SETSI), January 2001”

2.4 Deep Space Frequency Channels

The DSN has divided the frequency ranges allocated for deep space use into channels for tracking support associated with a given transponder ratio. Note that the frequencies out of the allocated ranges for deep space research are not shown in the tables.

The S-band downlink center frequency ($F_{ch}(14)$ = 2295 MHz) is used to derive all entries in the tables using the expressions

$F_{ch}(n)$ = $(n\text{-}14)*(10/27)$ + 2295 MHz, rounded to the nearest Hertz

where $F_{ch}(n)$ is the center frequency (in MHz) of channel *n* rounded to the nearest Hz, and the ratio 10/27 is the spacing (in MHz) between the centers of two adjacent channels.

Frequencies for other columns are derived by the procedure described below. The calculated downlink frequencies may differ by one or two Hertz between the tables because each table assumes an integer uplink frequency and precise turnaround ratios.

(1) The uplink frequency specified in the table is calculated from the expression

$f_{ch}(n) = F_{ch}(n) \times TM/240$, rounded to the nearest Hertz,

where

$f_{ch}(n)$ is the frequency of uplink channel *n* being calculated;

Fch(*n*) is the frequency of channel *n* calculated for the S-band downlink column (including values for out-of-band channels);

TM is the Transmit Multiplier of the frequency band, that is, *TM* = 221 for S-uplink and 749 for X-uplink.

(2) The downlink frequencies specified in the table are calculated from the expression

$F_{ch}(n) = f_{ch}(n) \times TR$, rounded to the nearest Hertz,

where

$F_{ch}(n)$ is the frequency of channel *n* for the downlink columns;

$f_{ch}(n)$ is the frequency of channel *n* in the uplink column;

TR is the Turnaround Ratio for the downlink frequency band provided in Table 1.

Because Ka-band has a wide bandwidth, channels are divided into three categories: channel L1 to L50 for a low-band as shown in Table 6-1, channel 1 to 42 for a mid-band as shown in Table 6-2, and channel H1 to H34 for a high-band as shown in Table 6-3.

Although the DSN is capable of supporting two-way and three-way tracking in S-and X-band where the downlink frequency is not at the frequency specified for the selected uplink channel, the use of non-standard turn-around rations is highly discouraged. Therefore, only channels 5 through 27 fully support coherent uplink and downlink for both frequency bands. Channel 28, for example, supports S- or X-band uplink with a coherent X-band downlink, but not with a coherent S-band downlink.

Channel selection is also highly dependent on bandwidth considerations. The channel plan was developed to accommodate both low-rate spacecraft operating within a single channel and higher-rate spacecraft requiring one or more adjacent channels on each side of the nominal operating channel. Before selecting operating frequencies or channels for a project, the telecommunication designer should consult the JPL Frequency Spectrum Management (see< https://deepspace.jpl.nasa.gov/about/commitments-office/>) to avoid frequency interference with other spacecraft, present or planned.

Table 3. Frequency and Channel Assignments for S-band Uplink and S/X-bands Downlink

Channel	S-band U/L (MHz)	S-band D/L (MHz)	X-band D/L (MHz)
1		2290.185185	
2		2290.555556	
3		2290.925926	8400.061729
4		2291.296296	8401.419752
5	2110.243056	2291.666667	8402.777779
6	2110.584105	2292.037037	8404.135802
7	2110.925154	2292.407407	8405.493825
8	2111.266204	2292.777778	8406.851853
9	2111.607253	2293.148148	8408.209877
10	2111.948303	2293.518519	8409.567903
11	2112.289352	2293.888889	8410.925927
12	2112.630401	2294.259259	8412.283950
13	2112.971451	2294.629630	8413.641977
14	2113.312500	2295.000000	8415.000000
15	2113.653549	2295.370370	8416.358023
16	2113.994599	2295.740741	8417.716050
17	2114.335648	2296.111111	8419.074073
18	2114.676697	2296.481481	8420.432097
19	2115.017747	2296.851852	8421.790123
20	2115.358796	2297.222222	8423.148147
21	2115.699846	2297.592593	8424.506175
22	2116.040895	2297.962963	8425.864198
23	2116.381944	2298.333333	8427.222221
24	2116.722994	2298.703704	8428.580248
25	2117.064043	2299.074074	8429.938271
26	2117.405092	2299.444444	8431.296295
27	2117.746142	2299.814815	8432.654321
28	2118.087191		8434.012345
29	2118.428241		8435.370372
30	2118.769290		8436.728395
31	2119.110339		8438.086418
32	2119.451389		8439.444446
33	2119.792438		8440.802469
34			8442.160493
35			8443.518520
36			8444.876543
37			8446.234570
38			8447.592593
39			8448.950616

Table 4. Frequency and Channel Assignments for X-band Uplink and S-/X-bands Downlink

Channel	X-band U/L (MHz)	S-band D/L (MHz)	X-band D/L (MHz)
1	7147.286265	2290.185185	
2	7148.442131	2290.555556	
3	7149.597994	2290.925926	8400.061729
4	7150.753857	2291.296296	8401.419752
5	7151.909723	2291.666667	8402.777779
6	7153.065586	2292.037037	8404.135802
7	7154.221449	2292.407407	8405.493825
8	7155.377316	2292.777778	8406.851853
9	7156.533179	2293.148148	8408.209877
10	7157.689045	2293.518519	8409.567903
11	7158.844908	2293.888889	8410.925927
12	7160.000771	2294.259259	8412.283950
13	7161.156637	2294.629630	8413.641977
14	7162.312500	2295.000000	8415.000000
15	7163.468363	2295.370370	8416.358023
16	7164.624229	2295.740741	8417.716050
17	7165.780092	2296.111111	8419.074073
18	7166.935955	2296.481481	8420.432097
19	7168.091821	2296.851852	8421.790123
20	7169.247684	2297.222222	8423.148147
21	7170.403551	2297.592593	8424.506175
22	7171.559414	2297.962963	8425.864198
23	7172.715277	2298.333333	8427.222221
24	7173.871143	2298.703704	8428.580248
25	7175.027006	2299.074074	8429.938271
26	7176.182869	2299.444444	8431.296295
27	7177.338735	2299.814815	8432.654321
28	7178.494598		8434.012345
29	7179.650464		8435.370372
30	7180.806327		8436.728395
31	7181.962190		8438.086418
32	7183.118057		8439.444446
33	7184.273920		8440.802469
34	7185.429783		8442.160493
35	7186.585649		8443.518520
36	7187.741512		8444.876543
37	7188.897378		8446.234570
38			8447.592593
39			8448.950616

Table 5. Frequency and Channel Assignments for X-band Uplink and Ka-band Downlink

Channel	X-band U/L (MHz)	Ka-band D/L (MHz), 3328/749	Ka-band D/L (MHz), 3344/749	Ka-band D/L (MHz), 3360/749
1	7147.286265		31909.913578	32062.592591
2	7148.442131		31915.074080	32067.777784
3	7149.597994		31920.234569	32072.962964
4	7150.753857		31925.395057	32078.148144
5	7151.909723		31930.555559	32083.333337
6	7153.065586		31935.716048	32088.518517
7	7154.221449		31940.876536	32093.703696
8	7155.377316		31946.037042	32098.888894
9	7156.533179		31951.197531	32104.074074
10	7157.689045	31803.456798	31956.358033	32109.259267
11	7158.844908	31808.592595	31961.518521	32114.444447
12	7160.000771	31813.728392	31966.679010	32119.629627
13	7161.156637	31818.864203	31971.839512	32124.814820
14	7162.312500	31824.000000	31977.000000	32130.000000
15	7163.468363	31829.135797	31982.160488	32135.185180
16	7164.624229	31834.271608	31987.320990	32140.370373
17	7165.780092	31839.407405	31992.481479	32145.555553
18	7166.935955	31844.543202	31997.641967	32150.740733
19	7168.091821	31849.679012	32002.802469	32155.925926
20	7169.247684	31854.814810	32007.962958	32161.111106
21	7170.403551	31859.950624	32013.123464	32166.296304
22	7171.559414	31865.086422	32018.283952	32171.481483
23	7172.715277	31870.222219	32023.444441	32176.666663
24	7173.871143	31875.358029	32028.604943	32181.851856
25	7175.027006	31880.493826	32033.765431	32187.037036
26	7176.182869	31885.629624	32038.925920	32192.222216
27	7177.338735	31890.765434	32044.086422	32197.407409
28	7178.494598	31895.901231	32049.246910	32202.592589
29	7179.650464	31901.037042	32054.407412	32207.777782
30	7180.806327	31906.172839	32059.567901	32212.962962
31	7181.962190	31911.308636	32064.728389	32218.148142
32	7183.118057	31916.444451	32069.888895	32223.333340
33	7184.273920	31921.580248	32075.049384	32228.518520
34	7185.429783	31926.716045	32080.209872	32233.703699
35	7186.585649	31931.851856	32085.370374	32238.888893
36	7187.741512	31936.987653	32090.530863	32244.074073
37	7188.897378	31942.123463	32095.691365	32249.259266
38		31947.259260	32100.851853	32254.444446
39		31952.395058	32106.012341	32259.629625
40		31957.530868	32111.172843	32264.814819
41		31962.666665	32116.333332	32269.999999
42		31967.802462	32121.493820	32275.185178

Table 6-1. Frequency and Channel Assignments for Ka-band Uplink and Ka-band Downlink (Channel L1 to L50)

Channel	Ka-band U/L (MHz)	Ka-band D/L (MHz), 3344/3599	Ka-band D/L (MHz), 3360/3599
L1			31803.333340
L2			31808.518520
L3			31813.703699
L4			31818.888893
L5			31824.074073
L6			31829.259266
L7			31834.444446
L8			31839.629625
L9			31844.814819
L10			31849.999999
L11			31855.185178
L12			31860.370376
L13			31865.555556
L14			31870.740736
L15			31875.925929
L16			31881.111109
L17			31886.296302
L18			31891.481482
L19			31896.666662
L20			31901.851855
L21			31907.037035
L22			31912.222215
L23			31917.407408
L24			31922.592592
L25			31927.777785
L26	34204.385033		31932.962965
L27	34209.939040		31938.148145
L28	34215.493061		31943.333338
L29	34221.047067		31948.518518
L30	34226.601074	31801.543204	31953.703698
L31	34232.155095	31806.703706	31958.888891
L32	34237.709102	31811.864194	31964.074071
L33	34243.263123	31817.024696	31969.259264
L34	34248.817129	31822.185185	31974.444444
L35	34254.371136	31827.345673	31979.629624
L36	34259.925162	31832.506180	31984.814822
L37	34265.479168	31837.666668	31990.000001
L38	34271.033175	31842.827157	31995.185181
L39	34276.587196	31847.987659	32000.370375
L40	34282.141202	31853.148147	32005.555554
L41	34287.695209	31858.308635	32010.740734
L42	34293.249230	31863.469137	32015.925927
L43	34298.803237	31868.629626	32021.111107
L44	34304.357258	31873.790128	32026.296301
L45	34309.911264	31878.950616	32031.481480
L46	34315.465271	31884.111105	32036.666660
L47	34321.019297	31889.271611	32041.851858
L48	34326.573303	31894.432099	32047.037038
L49	34332.127310	31899.592588	32052.222218
L50	34337.681331	31904.753090	32057.407411

Table 6-2. Frequency and Channel Assignments for Ka-band Uplink and Ka-band Downlink (Channel 1 to 42)

Channel	Ka-band U/L (MHz)	Ka-band D/L (MHz), 3344/3599	Ka-band D/L (MHz), 3360/3599
1	34343.235337	31909.913578	32062.592591
2	34348.789358	31915.074080	32067.777784
3	34354.343365	31920.234569	32072.962964
4	34359.897372	31925.395057	32078.148144
5	34365.451393	31930.555559	32083.333337
6	34371.005399	31935.716048	32088.518517
7	34376.559406	31940.876536	32093.703696
8	34382.113432	31946.037042	32098.888894
9	34387.667438	31951.197531	32104.074074
10	34393.221459	31956.358033	32109.259267
11	34398.775466	31961.518521	32114.444447
12	34404.329472	31966.679010	32119.629627
13	34409.883493	31971.839512	32124.814820
14	34415.437500	31977.000000	32130.000000
15	34420.991507	31982.160488	32135.185180
16	34426.545528	31987.320990	32140.370373
17	34432.099534	31992.481479	32145.555553
18	34437.653541	31997.641967	32150.740733
19	34443.207562	32002.802469	32155.925926
20	34448.761568	32007.962958	32161.111106
21	34454.315594	32013.123464	32166.296304
22	34459.869601	32018.283952	32171.481483
23	34465.423607	32023.444441	32176.666663
24	34470.977628	32028.604943	32181.851856
25	34476.531635	32033.765431	32187.037036
26	34482.085642	32038.925920	32192.222216
27	34487.639663	32044.086422	32197.407409
28	34493.193669	32049.246910	32202.592589
29	34498.747690	32054.407412	32207.777782
30	34504.301697	32059.567901	32212.962962
31	34509.855703	32064.728389	32218.148142
32	34515.409729	32069.888895	32223.333340
33	34520.963736	32075.049384	32228.518520
34	34526.517742	32080.209872	32233.703699
35	34532.071763	32085.370374	32238.888893
36	34537.625770	32090.530863	32244.074073
37	34543.179791	32095.691365	32249.259266
38	34548.733798	32100.851853	32254.444446
39	34554.287804	32106.012341	32259.629625
40	34559.841825	32111.172843	32264.814819
41	34565.395832	32116.333332	32269.999999
42	34570.949838	32121.493820	32275.185178

Table 6-3. Frequency and Channel Assignments for Ka-band Uplink and Ka-band Downlink (Channel H1 to H34)

Channel	Ka-band U/L (MHz)	Ka-band D/L (MHz), 3344/3599	Ka-band D/L (MHz), 3360/3599
H1	34576.503864	32126.654327	32280.370376
H2	34582.057871	32131.814815	32285.555556
H3	34587.611877	32136.975304	32290.740736
H4	34593.165898	32142.135806	32295.925929
H5	34598.719905	32147.296294	
H6	34604.273926	32152.456796	
H7	34609.827933	32157.617284	
H8	34615.381939	32162.777773	
H9	34620.935960	32167.938275	
H10	34626.489967	32173.098763	
H11	34632.043973	32178.259252	
H12	34637.597994	32183.419754	
H13	34643.152006	32188.580246	
H14	34648.706027	32193.740748	
H15	34654.260033	32198.901237	
H16	34659.814040	32204.061725	
H17	34665.368061	32209.222227	
H18	34670.922067	32214.382716	
H19	34676.476074	32219.543204	
H20	34682.030095	32224.703706	
H21	34687.584102	32229.864194	
H22	34693.138123	32235.024696	
H23	34698.692129	32240.185185	
H24		32245.345673	
H25		32250.506180	
H26		32255.666668	
H27		32260.827157	
H28		32265.987659	
H29		32271.148147	
H30		32276.308635	
H31		32281.469137	
H32		32286.629626	
H33		32291.790128	
H34		32296.950616	