201
Frequency and Channel Assignments

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Note to Readers

There are two sets of document histories in the 810-005 document, and these histories are reflected in the header at the top of the page. First, the entire document is periodically released as a revision when major changes affect a majority of the modules. For example, this module is part of 810-005, Revision E. Second, the individual modules also change, starting as an initial issue that has no revision letter. When a module is changed, a change letter is appended to the module number on the second line of the header and a summary of the changes is entered in the module's change log.

This is a new module in Revision E of 810-005.

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; 102, 26-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). (The DSN has not developed channel plans for near-Earth missions [Category A, less than 2 million km from Earth].) The deep space channel plans are based on bandwidth, hardware implementation, and transponder turnaround-ratio considerations. The plans must allow phase coherent uplink (Earth-to-space) and downlink (space-to-Earth) transmissions.

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. As an example, the standard NASA K_a-band spacecraft transponder turnaround ratio was first presented for review and approval to the CCSDS prior to its implementation.

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—one with the two-way mode while the other receives and compares the signal to a locally generated frequency. The most common application of this mode is during the handover between stations at two different Deep Space Communication Complexes (DSCCs).

2.1.4 Coherent Three-way

Coherent three-way tracking is three-way tracking when the transmitting and receiving stations share a common reference frequency.

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, who is resident in the Plans and Commitments Program Office <http://deepspace.jpl.nasa.gov/advmiss/>.

Table 1. Spacecraft Transponder Turnaround Ratios

Uplink	Downlink	Ratio (downlink/uplink)
S	S	240/221
S	X	880/221
S	K_a	3344/221
X	S	240/749
X	X	880/749
X	K_a	3344/749
K_a	S	240/3599*
K_a	X	880/3599*
K_a	K_a	3344/3599*

* While these are the recommended ratios, all existing K_a-band spacecraft have used turnaround ratios negotiated through the JPL Frequency Manager.

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 greater than 2 million km from Earth)		Near Earth Bands (for spacecraft less than 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
Ka-band	34200–34700	31800–32300		

2.4 Deep Space Coherent 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. The frequency ranges allocated for near-Earth uses do not have a formal channelization plan. Tables 3, 4, and 5 list the 42-channel assignments by frequency bands. Note that 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

$F_{ch}(n-1) = F_{ch}(n) - (10/27)$, rounded to the nearest hertz for n = 2 to 14

$F_{ch}(n+1) = F_{ch}(n) + (10/27)$, rounded to the nearest hertz for n = 14 to 41

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 1 or 2 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 a frequency band, that is, TM = 221, 749, and 3599 for S uplink, X uplink, and K_a 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 as provided in Table 1.

The DSN only supports two-way or three-way tracking with uplink and downlink frequencies having the same channel number. Therefore, only channels 5 through 27 fully support coherent uplink and downlink for all frequency bands. Channel 28, for example, supports S- or X-band uplink with coherent X- or K_a-band downlink, but not with coherent S-band downlink.

Before selecting operating frequencies or channels for a project, the telecommunication designer should consult the JPL Frequency Manager, who is resident in the Plans and Commitments Program Office <http://deepspace.jpl.nasa.gov/advmiss/>, to avoid frequency interference with other spacecraft, present or planned.

Table 3. Frequency and Channel Assignments for S-band Uplink

Channel	S-band U/L (MHz)	S-band D/L (MHz)	X-band D/L (MHz)	K_a-band D/L (MHz)
5	2110.243056	2291.666667	8402.777780	31930.555562
6	2110.584105	2292.037037	8404.135803	31935.716050
7	2110.925154	2292.407407	8405.493826	31940.876538
8	2111.266204	2292.777778	8406.851853	31946.037042
9	2111.607253	2293.148148	8408.209876	31951.197530
10	2111.948303	2293.518519	8409.567903	31956.358033
11	2112.289352	2293.888889	8410.925927	31961.518521
12	2112.630401	2294.259259	8412.283950	31966.679009
13	2112.971451	2294.629630	8413.641977	31971.839512
14	2113.312500	2295.000000	8415.000000	31977.000000
15	2113.653549	2295.370370	8416.358023	31982.160488
16	2113.994599	2295.740741	8417.716050	31987.320991
17	2114.335648	2296.111111	8419.074073	31992.481479
18	2114.676697	2296.481481	8420.432097	31997.641967
19	2115.017747	2296.851852	8421.790124	32002.802470
20	2115.358796	2297.222222	8423.148147	32007.962958
21	2115.699846	2297.592593	8424.506174	32013.123462
22	2116.040895	2297.962963	8425.864197	32018.283950
23	2116.381944	2298.333333	8427.222220	32023.444438
24	2116.722994	2298.703704	8428.580248	32028.604941
25	2117.064043	2299.074074	8429.938271	32033.765429
26	2117.405092	2299.444444	8431.296294	32038.925917
27	2117.746142	2299.814815	8432.654321	32044.086420
28	2118.087191		8434.012344	32049.246908
29	2118.428241		8435.370371	32054.407411
30	2118.769290		8436.728395	32059.567899
31	2119.110339		8438.086418	32064.728387
32	2119.451389		8439.444445	32069.888891
33	2119.792438		8440.802468	32075.049379

Table 4. Frequency and Channel Assignments for X-band Uplink

Channel	X-band U/L (MHz)	S-band D/L (MHz)	X-band D/L (MHz)	K_a-band D/L (MHz)
1	7147.286265	2290.185185		31909.913580
2	7148.442131	2290.555556		31915.074083
3	7149.597994	2290.925926	8400.061729	31920.234571
4	7150.753857	2291.296296	8401.419752	31925.395059
5	7151.909723	2291.666667	8402.777779	31930.555562
6	7153.065586	2292.037037	8404.135802	31935.716050
7	7154.221449	2292.407407	8405.493825	31940.876538
8	7155.377316	2292.777778	8406.851853	31946.037042
9	7156.533179	2293.148148	8408.209877	31951.197530
10	7157.689045	2293.518519	8409.567903	31956.358033
11	7158.844908	2293.888889	8410.925927	31961.518521
12	7160.000771	2294.259259	8412.283950	31966.679009
13	7161.156637	2294.629630	8413.641977	31971.839512
14	7162.312500	2295.000000	8415.000000	31977.000000
15	7163.468363	2295.370370	8416.358023	31982.160488
16	7164.624229	2295.740741	8417.716050	31987.320991
17	7165.780092	2296.111111	8419.074073	31992.481479
18	7166.935955	2296.481481	8420.432097	31997.641967
19	7168.091821	2296.851852	8421.790123	32002.802470
20	7169.247684	2297.222222	8423.148147	32007.962958
21	7170.403551	2297.592593	8424.506175	32013.123462
22	7171.559414	2297.962963	8425.864198	32018.283950
23	7172.715277	2298.333333	8427.222221	32023.444438
24	7173.871143	2298.703704	8428.580248	32028.604941
25	7175.027006	2299.074074	8429.938271	32033.765429
26	7176.182869	2299.444444	8431.296295	32038.925917
27	7177.338735	2299.814815	8432.654321	32044.086420
28	7178.494598		8434.012345	32049.246908
29	7179.650464		8435.370372	32054.407411
30	7180.806327		8436.728395	32059.567899
31	7181.962190		8438.086418	32064.728387
32	7183.118057		8439.444446	32069.888891
33	7184.273920		8440.802469	32075.049379
34	7185.429783		8442.160493	32080.209867
35	7186.585649		8443.518520	32085.370370
36	7187.741512		8444.876543	32090.530858
37	7188.897378		8446.234570	32095.691361

Table 5. Frequency and Channel Assignments for K_a-band Uplink

Channel	K_a-band U/L (MHz)	S-band D/L (MHz)	X-band D/L (MHz)	K_a-band D/L (MHz)
1	34343.235337	2290.185185		31909.913578
2	34348.789359	2290.555556		31915.074080
3	34354.343365	2290.925926	8400.061729	31920.234569
4	34359.897372	2291.296296	8401.419752	31925.395058
5	34365.451394	2291.666667	8402.777779	31930.555560
6	34371.005401	2292.037037	8404.135802	31935.716049
7	34376.559407	2292.407407	8405.493826	31940.876538
8	34382.113429	2292.777778	8406.851853	31946.037040
9	34387.667436	2293.148148	8408.209876	31951.197529
10	34393.221458	2293.518519	8409.567903	31956.358031
11	34398.775465	2293.888889	8410.925926	31961.518520
12	34404.329471	2294.259259	8412.283950	31966.679009
13	34409.883493	2294.629630	8413.641977	31971.839511
14	34415.437500	2295.000000	8415.000000	31977.000000
15	34420.991507	2295.370370	8416.358023	31982.160489
16	34426.545529	2295.740741	8417.716050	31987.320991
17	34432.099535	2296.111111	8419.074074	31992.481480
18	34437.653542	2296.481481	8420.432097	31997.641969
19	34443.207564	2296.851852	8421.790124	32002.802471
20	34448.761571	2297.222222	8423.148147	32007.962960
21	34454.315593	2297.592593	8424.506174	32013.123462
22	34459.869599	2297.962963	8425.864198	32018.283951
23	34465.423606	2298.333333	8427.222221	32023.444440
24	34470.977628	2298.703704	8428.580248	32028.604942
25	34476.531635	2299.074074	8429.938271	32033.765431
26	34482.085641	2299.444444	8431.296295	32038.925920
27	34487.639663	2299.814815	8432.654322	32044.086422
28	34493.193670		8434.012345	32049.246911
29	34498.747692		8435.370372	32054.407414
30	34504.301699		8436.728395	32059.567902
31	34509.855705		8438.086419	32064.728391
32	34515.409727		8439.444446	32069.888894
33	34520.963734		8440.802469	32075.049382
34	34526.517741		8442.160492	32080.209871
35	34532.071763		8443.518519	32085.370373
36	34537.625769		8444.876543	32090.530862
37	34543.179791		8446.234570	32095.691365
38	34548.733798		8447.592593	32100.851853
39	34554.287805		8448.950616	32106.012342
40	34559.841827			32111.172845
41	34565.395833			32116.333333
42	34570.949840			32121.493822