201, Rev. A
Frequency and Channel Assignments

Released September 19, 2008

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DSN Document Release Date

Change Log

Rev	Issue Date	Affected Paragraphs	Change Summary
Initial	11/30/2000	All	All
A	9/19/2008	2.4, Tables 1 & 2	Adds 26 GHz assignment. Removes suggested turn-around ratios in Ka-band

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.

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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) for the S- and X-bands. 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. There are no channel plans for the K or Ka-bands because their greater bandwidth cannot be serviced by a single turnaround ratio from the lower bands and modern Doppler processing does not require fixed ratios to be built in hardware as was the case with first-generation space communications equipment.

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—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 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, 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	15.071 – 15.235*
X	S	240/749
X	X	880/749
X	K_a	4.4506 – 4.4923*
K_a	S	0.066959 – 0.066282*
K_a	X	0.24561 – 0.24352*
K_a	K_a	0.92982 – 0.93084*

† K-band (25500-27000 MHz) is not listed because the DSN does not support radiometric measurements in this band.

* Specific integer turnaround ratios must be negotiated through the JPL Frequency Manager and must evaluate within the stated range.

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
K-band	*	*	*	25500–27000
Ka-band	34200–34700	31800–32300	*	*

* No allocation or not supported by the DSN.

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 and Deep Space Ka-band do not have a formal channelization plan. Tables 3 and 4 list the 37-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

$F_{ch}(n\text{-}1) = F_{ch}(n) - (10/27)$, 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 36

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.

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. The lack of a formal channel plan for the 32 GHz allocation is a recognition that this band normally used for high-rate telemetry downlinks – well in excess of the approximately 2.8 Msps per channel that would be provided by expansion of the existing plan to Ka-band. The 26 GHz band is allocated for near-Earth, high-rate telemetry downlinks that are normally not coherent with any uplink signals. Thus, selection of their frequencies is normally made based on considerations such as mission timing and orbital separation.

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)
5	2110.243056	2291.666667	8402.777780
6	2110.584105	2292.037037	8404.135803
7	2110.925154	2292.407407	8405.493826
8	2111.266204	2292.777778	8406.851853
9	2111.607253	2293.148148	8408.209876
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	8421.790124
20	2115.358796	2297.222222	8423.148147
21	2115.699846	2297.592593	8424.506174
22	2116.040895	2297.962963	8425.864197
23	2116.381944	2298.333333	8427.222220
24	2116.722994	2298.703704	8428.580248
25	2117.064043	2299.074074	8429.938271
26	2117.405092	2299.444444	8431.296294
27	2117.746142	2299.814815	8432.654321
28	2118.087191		8434.012344
29	2118.428241		8435.370371
30	2118.769290		8436.728395
31	2119.110339		8438.086418
32	2119.451389		8439.444445
33	2119.792438		8440.802468

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)
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