

Interpretation and Use of Binary RSC-11-6 Data

This document describes and illustrates extraction of values from binary files generated according to the NASA Deep Space Network (DSN) RSC-11-6 Software Interface Specification (SIS). RSC-11-6 is one of several modules within DSN 820-013 that governed open loop radio science raw data products created over about two decades starting in the late 1970s. In this document, RSC-11-6 is referenced as:

[1] *Document 820-013 (Rev. A), DSN System Requirements, Detailed Interface Design, RSC-11-6, DSN Interfaces Radio Science, Medium Band Computer Compatible IDR, effective date 1 July 1981.*

The RSC-11-6 SIS specifies the format and content of the most important open loop radio science files generated during the Voyager encounters with Saturn. These digital data were originally recorded on high-speed analog tapes (the Digital Recording Assembly, or DRA), which were later played back at slower speed so that the samples could be copied to computer compatible tapes (CCTs) for distribution to science investigators. During playback, the data could be down-sampled (or ‘decimated’) to reduce data volume.

During the Voyager encounters, S- and X-band receiver outputs in right- and left-circular polarization at 150 ksps were written in parallel to the analog tape. It was common for the S-band data to be decimated by a factor of 3 during playback so that the resulting effective sample rate was 50 ksps. Because the S-band signals were low-pass filtered prior to analog recording, the quality of the final S-band CCT samples was not affected by the decimation.

Analog recordings were occasionally corrupted by minor changes in tape speed, which caused ‘drop outs’. If the drop out occurred during playback, the missing samples could sometimes be recovered by repeating the playback. If the drop out occurred during recording, the recovery possibilities were limited to times when redundant recorders were both operating (Figure 1).

File and Record Formats:

Each RSC-11-6 record comprises 56 bytes of header data followed by 5000 8-bit receiver samples (Figure 2). Note that Figure 2 is labeled in terms of 16-bit words rather than 8-bit bytes. Note also that the more significant byte appears first in the tape record; most modern computers (c. 2021) write, and expect to read, the least significant byte first.

The content and format of the record fields are described in [1]. The first four bits in each record are validity flags; in particular,

- the first bit (‘V’ in Figure 1) indicates whether time information in words 6-9 is valid
- the third bit (‘E’ in Figure 1) indicates a parity error in the original data, and
- the fourth bit (‘S’ in Figure 1) indicates an error in the sample count

The RSC-11-6 file contains no information on receiver tuning. A programmable Oscillator Control Assembly (POCA) drove the local oscillator that ensured signals remained within the recorded passband. POCA data were recorded separately.

DAY 318	1	2	3	4	5	6	7	8	9
UT	ET	A SR	A SL	A XR	A XL	B SR	B SL	B XR	B XL
4:20	15 600	6194	6206	6236	6272	6092	6104	6122	6158
:21:40	700			6237	6273			6123	6159
:23:20	800			6238	6274			6124	6160
4:25	900	6195	6207	6239	6275	6093	6105	6125	6161
:26:40	16000			6240	6276			6126	6162
:28:20	100			6241	6277			6127	6163
4:30	200	6196	6208	6242	6278	6094	6106	6128	6164
:31:40	300			6243	6279			6129	6165
:33:20	400			6244	6280			6130	6166
4:35	500					6095	6107	6131	6167
:36:40	600							6132	6168
:38:20	700							6133	6169
4:40	800					6096	6108	6134	6170
:41:40	900							6135	6171
:43:20	17000							6136	6172
4:45	100	6001	6012	6023	6056	6097	6109	6137	6173
:46:40	200			6024	6057			6138	6174
:48:20	300			6025	6058			6139	6175
4:50	400	6002	6013	6026	6059	6098	6110	6140	6176
:51:40	500			6027	6060			6141	6177
:53:20	600			6028	6061			6142	6178
4:55	700	6003	6014	6029	6062	6099	6111	6143	6179
:56:40	800			6030	6063			6144	6180
:58:20	900			6031	6064			6145	6181
5:00	18000	6004	6015	6032	6065	6100	6112	6146	6182
:01:40	100			6033	6066			6147	6183
:03:20	200			6034	6067			6148	6184
5:05	300	6005	6016	6035	6068				
:06:40	400			6036	6069				
:08:20	500			6037	6070				

Figure 1. Chart showing coverage of RSC-11-6 CCTs during part of the Voyager 1 Saturn encounter. High-speed analog recorders A and B captured digital samples directly from four receiver channels (S-RCP, S-LCP, X-RCP, and X-LCP). While one recorder was being rewound and reloaded with a fresh tape (for example, Recorder A was off-line between 04:35:00 and 04:45:00), the other collected data. Momentary recording failures (drop outs) could be recovered when both recorders were operating; but a drop out with only one recorder (e.g., 04:35:00 to 04:45:00) was lost.

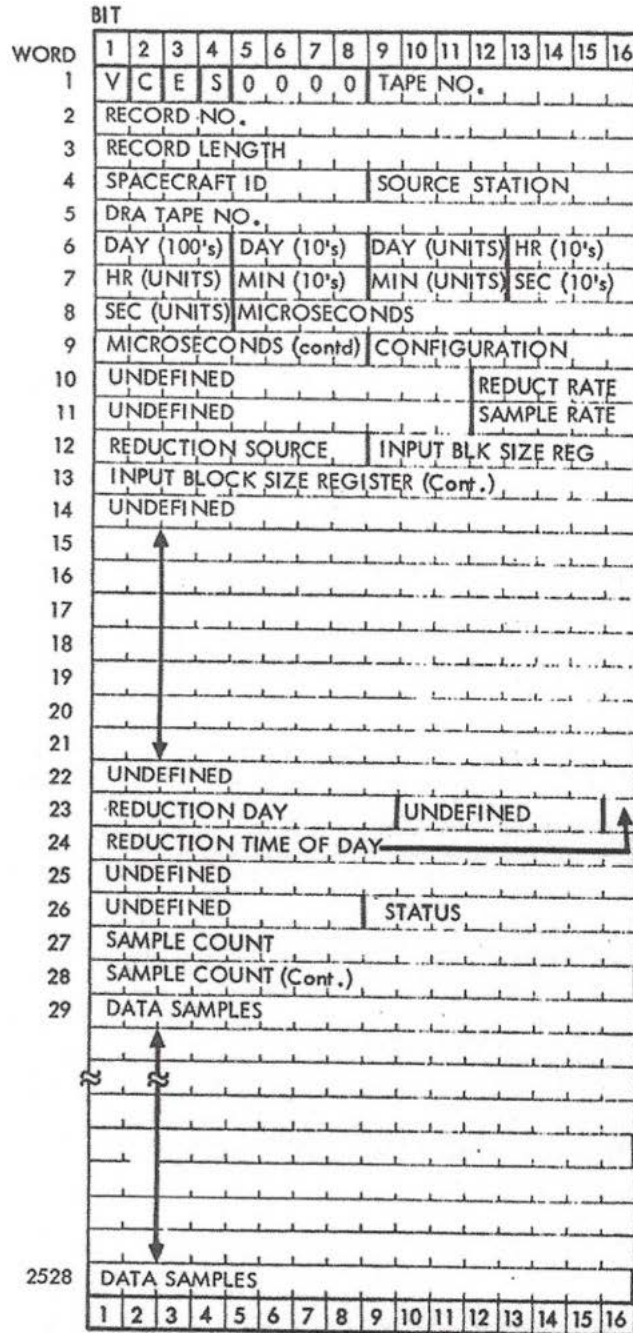


Figure 2. Structure of one record of RSC-11-6 data.

Example Data File:

An example RSC-11-6 file generated during the Voyager 1 encounter with Saturn has been included in the Radio Science Documentation bundle. Data were collected at DSN ground station 63 on 1980-318. The example file is a truncated version of the original file shown at 04:45:00 in the third column of Figure 1. The logical identifier of the example product is

urn:nasa:pds:radiosci.documentation:dsn.rsc-11-6:vj6001

It includes 10 binary records (*vj6001.dat*), their unpacked headers (*vj6001.hdr*), and their unpacked sample values (*vj6001.tab*). A hexadecimal dump of the first 800 bytes of the binary file is shown in Figure 3. It was generated using the unix command

```
od -t x1 vj6001.dat +0. | head -50
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0000000	d0	01	00	01	09	e0	1f	15	00	1c	31	80	44	45	9f	41
0000016	20	25	01	60	01	a2	50	fe	db	08	00	00	00	00	00	00
0000032	00	00	00	00	00	00	00	00	00	00	00	00	1e	81	30	20
0000048	01	a2	50	5d	00	00	00	03	b6	72	74	93	74	55	62	8c
0000064	8a	86	82	97	64	4b	84	77	85	8c	7d	50	72	74	6f	84
0000080	6f	66	95	74	8b	a2	96	86	84	6f	58	7f	81	4d	6e	82
0000096	76	7e	62	5c	68	8b	70	57	56	70	84	8f	72	61	74	8c
0000112	8b	94	ab	84	78	68	7e	66	73	85	68	66	7e	82	71	5f
0000128	79	7f	4e	86	5e	85	7c	74	5a	2e	55	78	88	78	92	6e
0000144	64	92	95	6c	a7	78	72	77	5e	7f	90	6c	54	88	7e	73
0000160	a8	97	84	84	5f	61	6a	84	7c	68	94	68	73	84	92	76
0000176	72	9c	96	64	7f	72	58	94	64	5f	b0	7f	8a	7f	4a	58
0000192	7e	71	7e	69	7d	48	76	9c	88	9a	76	7c	5f	74	76	8c
0000208	7e	7a	84	74	81	7d	78	7f	85	6f	84	86	64	6e	70	9a
0000224	6a	66	7f	47	7a	8a	68	5c	88	a5	78	8f	72	6e	a5	2f
0000240	83	72	66	58	87	6c	88	9b	76	4e	67	70	67	8e	7a	66
0000256	4f	6c	68	61	67	92	6a	6e	74	7e	98	8c	88	8a	73	6a
0000272	41	5a	46	74	75	91	62	6e	89	7c	8e	4c	49	6a	7e	5c
0000288	79	54	7f	84	a8	ac	6f	74	4f	90	76	7f	6a	50	5e	91
0000304	b2	6a	49	66	91	c4	ac	6c	7b	8a	83	58	8a	6d	9c	7a
0000320	93	5e	7b	4b	6d	84	70	81	6f	78	6d	73	34	73	5e	48
0000336	78	b2	66	62	66	78	65	67	85	98	88	5f	72	64	ad	7f
0000352	5a	b8	68	4c	70	88	61	6e	7a	6c	6f	58	8c	8d	7c	7b
0000368	79	85	63	4c	a2	a6	76	6d	aa	50	4e	77	84	88	73	8c
0000384	5f	6f	71	56	70	6f	5f	6d	7c	86	64	6d	72	5a	6e	88
0000400	8c	8d	58	66	8d	91	aa	48	7a	8a	6a	83	7f	8c	86	64
0000416	6c	62	4c	74	9f	9a	6a	63	78	b0	85	89	94	60	77	5f
0000432	52	76	4f	4c	a6	8c	7c	5a	6a	61	7a	64	84	aa	5c	78
0000448	8f	8c	2d	59	74	64	79	7a	7e	97	7a	4c	a1	7a	86	97
0000464	66	68	79	75	5f	6a	7e	89	86	92	92	7a	5d	7c	86	74
0000480	8a	64	99	92	76	60	2c	a1	87	7c	54	57	88	74	94	8b
0000496	6f	78	b0	7f	6b	7c	6f	7a	98	66	5f	5c	77	79	64	7b
0000512	5e	6e	aa	a0	61	68	62	a1	d8	5a	8f	8f	4e	6a	38	8c
0000528	8b	6d	84	80	4f	94	8e	96	65	51	9b	79	7c	6a	7e	7f
0000544	91	4e	6c	94	ac	9e	8c	72	84	89	84	8a	68	82	84	92
0000560	71	8e	57	92	70	34	6f	74	b8	66	78	6c	8d	3f	ac	7f
0000576	6e	82	5c	88	66	74	8c	92	58	66	54	87	66	7c	60	90
0000592	7d	6c	8e	7f	78	68	7f	9e	76	44	75	6d	53	70	71	8e
0000608	88	84	79	74	48	6a	c3	99	82	7c	79	6f	77	83	90	6a
0000624	70	7f	78	a3	67	44	66	7e	82	7d	9a	76	66	77	b8	8a
0000640	54	68	97	8c	90	8c	64	78	7a	70	64	89	53	54	99	88
0000656	90	7c	a8	6e	57	66	7e	7c	3b	3c	86	84	6c	59	66	54
0000672	7c	89	9e	81	64	88	64	96	74	98	a2	86	5e	78	7a	85
0000688	79	45	a8	72	6a	7f	6c	52	5d	7f	97	94	5f	68	56	85
0000704	5e	6c	8c	61	91	88	7c	66	5e	9e	c5	7b	8f	78	7e	5c
0000720	64	61	5e	42	3d	48	7f	85	6c	7d	79	8c	8c	97	6f	84
0000736	74	8a	68	6e	76	8f	9c	6f	5f	53	7a	8a	87	6d	78	60
0000752	66	66	5e	6e	7e	87	9f	8e	84	74	94	52	64	7f	8e	93
0000768	8c	68	9c	88	62	6b	8a	90	83	54	6c	7f	70	7f	7f	54
0000784	8e	3e	5a	92	6f	4f	77	97	68	9c	92	78	58	83	8f	87

Figure 3. Hexadecimal dump of the first 800 bytes in example file *vj6001.dat*; the byte counter along the left margin is given in decimal. The first 56 bytes (yellow highlighting) contain header information; the first three data samples are hexadecimal 'b6', '72', and '74' in bytes 57-59.

Header Values: The first header may be unpacked as shown in Table 1. Asterisks (*) in the right column denote flag values; see [1] for interpretations. Nine other headers are included in the example product (see file *vj6001.hdr*).

Table 1. Unpacked Header from Record 1

Bytes	Bit Numbers	Value (b = binary) (h = hexadecimal)	Description	Unpacked Value
1	1	1 _b	Time tag validity indicator	1*
1	2	1 _b	Record continuity Indicator	1*
1	3	0 _b	Copy source error	0*
1	4	1 _b	Sample count validity indicator	1*
1	5-8	0 _h	ODA tape type indicator	0
2	9-16	01 _h	Tape number	1
3-4	17-32	0001 _h	Record number	1
5-6	33-48	09e0 _h	Record length	5056
7	49-56	1f _h	Spacecraft number	31
8	57-64	15 _h	Source station	21
9-10	65-80	001c _h	Digital Recording Assembly (DRA) tape number	28
11	81-84	3 _h	Data time tag (hundreds of days)	3
11	85-88	1 _h	Data time tag (tens of days)	1
12	89-92	8 _h	Data time tag (units of days)	8
12	93-96	0 _h	Data time tag (tens of hours)	0
13	97-100	4 _h	Data time tag (units of hours)	4
13	101-104	4 _h	Data time tag (tens of minutes)	4
14	105-108	4 _h	Data time tag (units of minutes)	4
14	109-112	5 _h	Data time tag (tens of seconds)	5
15	113-116	9 _h	Data time tag (units of seconds)	9
15-17	117-136	f4120 _h	Data time tag (microseconds)	999712
18	137-139	001 _b	DRA input selection	1*
18	140	0 _b	DRA 1-PPS status	0*
18	141	0 _b	DRA clock sync status	0*
18	142	1 _b	Real-time recording monitor source	1*
18	143	0 _b	DRA microseconds time status	0*
18	144	1 _b	DRA time-track sync	1*
19-20	145-155	00000001011 _b	Unused	11
20	156-160	00000 _b	Reduction rate	0*
21-22	161-171	00000001011 _b	Unused	11
22	172-176	00010 _b	Channel sampling rate	2*
23	177	0 _b	Reduction data source	0*
23	178-180	101 _b	Reduction decimation ratio	5*
23	181	0 _b	1-PPS track selection	0*
23	182	0 _b	Time track selection	0*
23	183-184	00 _b	Reduction channel selection	0*
24-26	185-208	fedb08 _h	Input block size register	-75000
27-44	209-352	0000 _h	Unused	0
45-46	353-361	000111101 _b	Reduction day of year	61
46	362-367	000000 _b	Unused	0
46-48	368-384	13020 _h	Reduction time of day (seconds)	77856
49-50	385-400	01a2 _h	Unused	418
51	401-408	50 _h	Unused	80
52	409	0 _b	Input buffer overflow status	0*
52	410	1 _b	1-PPS sync status	1
52	411	0 _b	Bit slip status	0*
52	412-413	1 _{1b}	Spares	3
52	414-416	101 _b	Decimation counter value	5*
53-56	417-448	00000003 _h	Sample count	3

Data Values: After the 56-byte header, each RSC-11-6 binary record includes 5000 8-bit data samples. In Figure 3, these begin with hexadecimal value 'b6' (decimal 182) in byte 57. The full set of unpacked sample values is given in file *vj6001.tab* in the example product. The first 200 samples are shown in Figure 4 below.

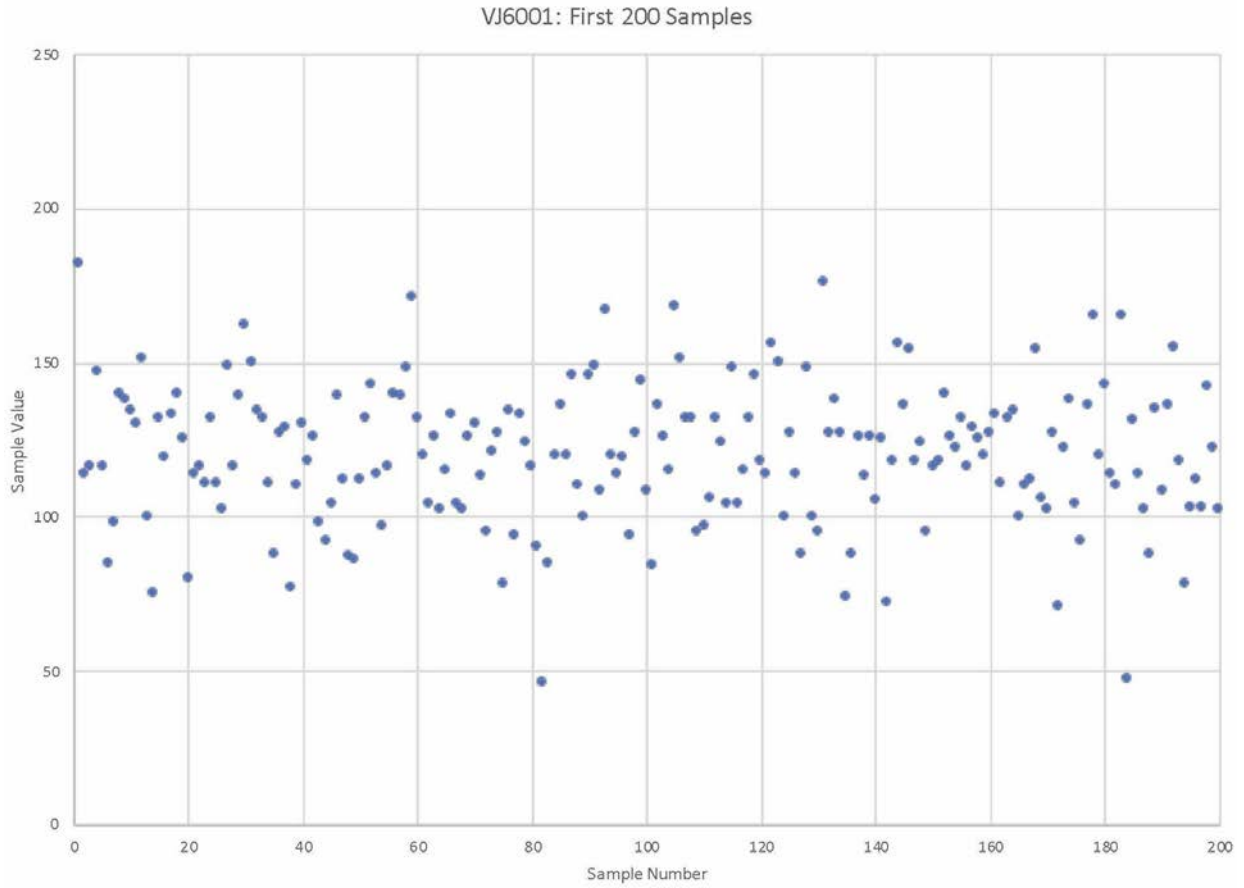


Figure 4. First 200 samples from *vj6001.dat*. The first sample has value 182. Values are distributed approximately symmetrically about their mean (119.85).