Interpretation and Use of Binary RSR Data

This document describes and illustrates extraction of values from binary files generated according to the Radio Science Receiver (RSR) Software Interface Specification (SIS):

[1] *Deep Space Mission System (DSMS) External Interface Specification 820-013 (D-16765), 0159-SCIENCE, Radio Science Receiver Standard Format Data Unit (SFDU)*

which was released in 2001. Three updates have been released since 2001:

[2] The original document [1] with addition of header parameters *schan*, *fgain*, and *mult*, released in 2004.

[3] Document [2] with editorial improvements, released in 2008.

[4] An 'adaptation', based on document [3], which describes a non-standard RSR format delivered from the Mars Reconnaissance Orbiter mission to the NASA Planetary Data System, released in 2009.

When the RSR was replaced by the Open Loop Receiver (OLR) in 2019, one of the OLR output formats was designed to be compliant with [3]; so the RSR SIS remains useful even though the RSR hardware and software are no longer available.

For most users, any of the first three versions should be sufficient. Document [4] should be used only for data generated by an RSR in 'MRO' mode (see below).

Record Format:

Each RSR file comprises one or more records of fixed length. Record length depends on sampling rate and sample resolution; but all records within a file have the same record length, sample rate, and sample resolution. Each record includes a 260-byte header followed by n*1000 complex samples, each with an in-phase (I) and quadrature (Q) component. The header contains dozens of parameters in integer, floating point, and character formats occupying fields with 8, 16, 32, or 64 bits. The I and Q samples are binary integers each with 1, 2, 4, 8, or 16 bits. All header and data values are stored in most significant byte first (MSB, or big-endian) order.

Example Data:

Three examples of RSR data are used in this document. Each is a file, truncated to the first three records, from a Mars Express radio science observation with 16-bit I and 16-bit Q sample resolution:

Start Date/Time (UTC)	File Name[1]	Band/Poln	Obsn Type[2]	DSS	Sample Rate (sps)	Record Length (bytes)	Mode
2005-12-02T21:40:00	5336021a.rsr	X-RCP	Occn	65	2000	8260	Nominal
2010-06-06T14:22:00	a157142c.rsr	X-LCP	BSR	63	25000	25260	WVSR
2018-03-11T17:27:01	i070174a.rsr	X-RCP	Occn	43	2000	8260	MRO

[1] Truncated binary files (5336021a.rsr, a157142c.rsr, and i070174a.rsr) are associated with this document.
[2] Observation types are radio occultation (Occn) and bistatic radar (BSR)

Hexadecimal dumps of the first 704 bytes of each file are shown in Tables 1a, 2a, and 3a below[3]. Yellow highlighting indicates the boundary between the header and data parts of the record. Full extraction of the header information is shown in Tables 1b, 2b, and 3b; and conversion of the first four I/Q pairs in each file is shown in Tables 1c, 2c, and 3c[4].

Nominal RSR Storage Format (5336021a.rsr):

Table 1a shows the hexadecimal content of the first 704 bytes from an RSR file created in 2005. The appropriate SIS reference would be [3], since it includes updates to the record content as well as editorial improvements. The first four bytes in the record are hexadecimal "4e 4a 50 4c" (highlighted in green), which are interpreted as the SFDU Label Control Authority "NJPL". Byte 0000055_8 gives the RSR ID (4 in both hexadecimal and decimal), byte 0000105_8 gives the number of bits in each sample as "10" (hexadecimal) or "16" (decimal), bytes 0000107_8 and 0000110_8 give the sampling rate (2 ksps), and bytes 0000405_8 through 0000424_8 contain the first four I/Q pairs (also highlighted in green). From Table 3-1 in [3], we can confirm that the sample size (16) and the sampling rate (2) yield a record size of 8000 data bytes plus 260 header bytes.

Following document [3] Table 3-2[5] we can extract the first four 16-bit I/Q pairs from Table 1a and convert them as shown in Table 1c. The Q value precedes the I value in storage, as shown in the two left columns in Table 1c. The middle two columns in Table 1c give the equivalent decimal values; no 2's complement correction is needed since all of the raw values are positive. Because of a truncation procedure during data acquisition, described in the paragraph before document [3] Table 3-2, a bias transformation takes the 2's complement values (k) to their final values 2*k+1, shown in the right two columns.

WVSR Storage Format:

When the number of RSRs at a DSN complex was insufficient to handle the channels required for a radio science observation, WVSRs could be substituted. The WVSR is normally used for VLBI; but the RSR and WVSR architectures are the same, and WVSR data records may be edited after storage to mimic the RSR format described in [3]. In these cases, the Minor Data Class in the header is set to 5 (rather than the usual 4), and a number larger than 6 is used for RSR ID. In Table 2b, the RSR ID (byte 0000055_8 in Table 2a) is 11. In practical terms, WVSR data which follow the specification in [3] are indistinguishable from RSR data.

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[3] Hex dumps were created using the (unix) command `od –t x1 <filename>`. Complete hexadecimal dumps of the three truncated files are given in the associated files 533021a.hex, a157142c.hex, and i070174a.hex.

[4] Fully converted I/Q pairs may be found in the associated files 533021a.tab, a157142c.tab, and i070174a.tab.

[5] Note that for lower resolution samples (1, 2, 4, and 8 bit samples), multiple Q values will precede multiple I values (as shown in [3] Table 3-2) and that the time order of those multiple values is reversed. The text preceding Table 3-2 is misleading in that it refers to LSB and MSB when referring to time order. This document shows only 16-bit I/Q pairs, which is the most common radio science output choice.

MRO Mode (i070174a.rsr):

Many ingress radio occultation observations are conducted in two-way mode; the spacecraft receiver is locked to the uplink from the DSN station as the ray path descends through the atmosphere, and the signal is eventually extinguished at occultation. When the downlink signal is captured by the receiving DSN station, its frequency is compared against a predicted value and a 'residual' frequency is recorded. The uplink signal is ramped; that is, its frequency is a first order linear function of time:

$$f(t) = f_{0j} + f_{1j}*(t-t_j) \qquad t_j \le t \le t_{j+1}$$

where f_{0j} and f_{1j} are constant over each time interval $[t_j, t_{j+1}]$, $f(t)$ is continuous at every interval boundary, and intervals must begin and end on integer seconds at the transmitting station.

The RSR operates in a similar fashion except that a higher order polynomial may be used. In the nominal mode, the RSR intervals must begin and end on integer seconds. Because the round-trip light time to the spacecraft is not an integer number of seconds, break-points in the uplink signal frequency profile that have been echoed by the spacecraft transponder will arrive at the receiving DSN station between break points in the RSR tuning profile and anomalously large frequency residuals will be recorded until synchronization is restored at the next RSR integer second. The MRO mission objected to having these anomalous frequency residuals in the data record.

Operation of the RSR was modified so that its frequency tuning profile could have break points at millisecond resolution; this did not make the synchronization error go away, but it made the anomalous residuals much smaller. Document [4] describes how the RSR tuning was modified. Coefficients for the RSR tuning stored in bytes 129 through 240 of each record header are not valid in MRO mode; in fact, 'NaN' can be found in several places in the latter half of Table 3b. Instead, the tuning information is included in a separate Downlink Frequency (DLF) file. An Everett polynomial is used to convert the DLF coefficients into an expected frequency profile, which is used to drive the RSR tuning and which should be used when analyzing the data after collection. Tables 3a, 3b, and 3c are example hexadecimal dump, header extraction, and data sample conversion for RSR data collected in MRO mode.

Document [4] should be used *only* with RSR files collected in MRO mode. Note, however, that MRO mode was used occasionally for collecting data from other missions (for example, MAVEN and Cassini). An easy way to identify MRO mode is by the 'NaN' header values.

Associated Files:

RSR Binary File	HEX Dump	Data Sample Conversion	Downlink Frequency File	DLF PDS3 Label
5336021a.rsr	5336021a.hex	5336021a.tab	N/A	N/A
a157142c.rsr	a157142c.hex	a157142c.tab	N/A	N/A
i070172a.rsr	i070172a.hex	i070172a.tab	i070135a.dlf	i070135a.lbl

Table 1a — Hexadecimal Dump of Record 1 (partial)
Mars Express RSR File (5336021a.rsr)
Created on 2005-12-02T21:40:00

Byte No. (octal)	Byte Values (hexadecimal)															
0000000	4e	4a	50	4c	32	49	30	30	43	39	39	37	00	00	00	00
0000020	00	00	20	30	00	01	00	e8	00	02	00	04	15	04	18	00
0000040	00	68	00	dc	30	30	0a	ad	00	3b	3c	41	04	01	00	29
0000060	03	93	58	58	02	ff	40	6e	00	2f	1c	77	07	d5	01	50
0000100	00	00	1e	68	10	00	00	02	01	40	1f	a4	07	d5	01	50
0000120	40	be	78	00	00	00	00	00	00	00	00	00	00	00	00	00
0000140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
*																
0000200	41	ff	5e	0b	f4	9d	8e	c7	41	ff	5e	0b	f5	13	81	32
0000220	41	ff	5e	0b	f5	89	76	47	c0	fb	e4	9d	8e	c7	00	00
0000240	c0	fb	e5	13	81	32	00	00	c0	fb	e5	89	76	47	00	00
0000260	c0	fb	e4	9d	8e	c7	00	00	c0	2d	7c	45	80	00	00	00
0000300	bf	55	50	00	00	00	00	00	c1	ac	33	95	a0	00	00	00
0000320	bf	e8	64	96	55	5e	00	00	c0	fb	e4	9d	8e	c7	00	00
0000340	c0	1d	7c	45	80	00	00	00	bf	3c	6a	aa	aa	aa	aa	ab
0000360	3f	80	00	00	00	00	00	00	00	00	00	00	00	00	00	00
0000400	00	0a	1f	40	----------data part below----------											
----header part above----					2a	ea	14	5d	2b	c7	11	6b	2a	81	10	e7
0000420	29	5b	10	39	2c	7d	0f	7b	2e	08	0e	9d	2c	9a	0c	7c
0000440	2c	9d	0d	d3	2c	a5	0b	08	2c	d0	09	d2	2c	4b	08	93
0000460	2e	d8	08	65	2f	e4	05	8b	2b	aa	02	0a	2b	e3	06	51
0000500	2c	e6	03	92	2d	e8	01	82	2e	c4	02	c4	2d	18	fd	85
0000520	2d	6e	fc	22	2c	ad	fa	42	2e	9c	f7	cc	29	b4	f9	5b
0000540	2b	1e	f7	6f	2f	77	f6	c2	2b	40	f5	da	2d	46	f6	c1
0000560	2b	a0	f2	97	2c	64	f0	10	2b	ac	f1	ba	29	d2	f0	aa
0000600	2b	60	ee	a0	27	78	eb	fa	28	0b	ec	66	2b	06	ec	57
0000620	29	89	e9	7f	27	e9	ea	f7	29	97	ec	f6	29	1b	e7	49
0000640	25	db	e7	cb	25	9a	e7	53	24	d3	e4	cc	23	cb	e3	d3
0000660	22	30	e3	5a	24	25	e2	fd	23	c7	df	1b	20	69	e1	43
0000700	23	40	e1	15	1f	79	e0	3a	1c	cf	df	c9	1f	eb	dc	e0
0000720	1e	92	dc	f1	1b	d4	da	aa	1b	d7	d8	c8	1a	86	d8	23
0000740	17	1e	d9	32	19	09	d8	0f	1a	5e	d7	33	15	44	d7	52
0000760	11	76	d8	86	12	6e	d8	62	14	45	d3	93	13	17	d6	50
0001000	10	81	d6	e0	0e	ec	d2	3c	0e	03	d2	30	0b	4a	d4	4a
0001020	0d	3b	d5	3a	0d	ce	d2	b0	09	c3	d1	ae	09	69	d2	6a
0001040	07	da	d2	54	06	ae	d2	fb	03	2b	d2	ee	02	c2	d1	1d
0001060	01	60	d1	9c	00	02	d1	5a	03	18	d1	3f	fe	fe	d4	93
0001100	fd	6e	d0	80	fd	ae	d0	4c	fa	1d	d2	ea	fd	16	d1	86
0001120	f9	56	d4	bd	f4	d1	d3	58	f7	a8	d2	65	f6	e8	d5	91
0001140	f3	76	d2	a5	f4	1f	d2	74	f5	cc	d3	a5	f2	39	d4	0b
0001160	f1	6a	d5	8f	f0	cf	d4	30	ec	4d	d5	64	ec	09	d5	bd
0001200	eb	bd	d7	3a	e9	aa	d9	46	e8	53	d8	80	e8	1c	d7	64
0001220	e6	ad	d9	10	e4	8a	db	39	e6	28	d9	96	e6	49	da	c4
0001240	e5	96	dc	9a	e4	42	da	bf	e2	38	dc	97	df	b6	de	36
0001260	e0	79	dc	ce	e0	f6	de	eb	de	64	e0	94	dc	eb	e1	64

Table 1b — Extraction of Header Values from Record 1
Mars Express RSR File (5336021a.rsr)
Created on 2005-12-02T21:40:00

```
RSRHPR2 -- Input File:         5336021a.rsr
Record Number:             1   of      1141
Program version:                 2019-10-22
Today is:          Fri Feb 21 15:34:32 2020
--------------------
SFDU Label:
     Control Authority        =   NJPL
     Version ID               =      2
     Class ID                 =      I
     SFDU Reserved            =     00
     Data Desc ID             =   C997
     SFDU Value Length High   =      0
     SFDU Value Length Low    =   8240
Header Aggregation CHDO Label:
     Type Attribute           =      1
     Length Attribute         =    232
Primary Header CHDO:
     Type Attribute           =      2
     Length Attribute         =      4
     Major Data Class         =     21
     Minor Data Class         =      4
     Mission ID               =     24 (Unexpected value)
     Format Code              =      0
Secondary Header CHDO:
     Type Attribute           =    104
     Length Attribute         =    220
     Originator ID            =     48
     Last Modifier ID         =     48
     RSR Software ID          =   2733
     Record Sequence Number   =     59
     SPC ID                   =     60
     DSS ID                   =     65
     RSR ID                   =      4
     SCHAN ID                 =      1
     Reserved                 =      0
     Spacecraft               =     41
     Predicts Pass Number     =    915
     Uplink Band              =      X
     Downlink Band            =      X
     Tracking Mode            =      2
     Uplink DSS ID            =    255
     FGAIN Px/No (dB-Hz)      =     64
     FGAIN IF BW (MHz)        =    110
     Freq Pred Overide Flag   =      0
     DIG Attenuation (0.5 dB) =     47
     DIG ADC RMS              =     28
     DIG ADC Peak Amplitude   =    119
     ADC Year                 =   2005
     ADC Day of Year          =    336
```

```
ADC Seconds               =   7784
Bits per Sample           =     16
Data Error Count          =      0
Sample Rate (ksps)        =      2
DDC LO (MHz)              =    320
RF to IF LO (MHz)         =   8100
SFDU Year                 =   2005
SFDU Day of Year          =    336
SFDU Seconds              =  7.8000000000000000E+03
Pred Time Shift (sec)     =  0.0000000000000000E+00
Pred Freq Override (Hz)   =  0.0000000000000000E+00
Pred Freq Rate (Hz/s)     =  0.0000000000000000E+00
Pred Freq Offset (Hz)     =  0.0000000000000000E+00
SubChan Freq Offset (Hz)  =  0.0000000000000000E+00
RF Freq Point 1           =  8.4201142498473577E+09
RF Freq Point 2           =  8.4201142572190418E+09
RF Freq Point 3           =  8.4201142645913763E+09
SC Freq Point 1           = -1.1424984735774994E+05
SC Freq Point 2           = -1.1425721904182434E+05
SC Freq Point 3           = -1.1426459137630463E+05
SC F Poly Coef 1          = -1.1424984735774994E+05
SC F Poly Coef 2          = -1.4742717742919922E+01
SC F Poly Coef 3          = -1.3008117675781250E-03
SC Accum Phase            = -2.3657134400000000E+08
SC P Poly Coef 1          = -7.6227871583250817E-01
SC P Poly Coef 2          = -1.1424984735774994E+05
SC P Poly Coef 3          = -7.3713588714599609E+00
SC P Poly Coef 4          = -4.3360392252604168E-04
```

Table 1c — Extraction of Data Values from Record 1
Mars Express RSR File (5336021a.rsr)
Created on 2005-12-02T21:40:00

Q1 (hex)	I1 (hex)	Q1 (decimal)	I1 (decimal)	Q1 (after corrections)	I1 (after corrections)
2aea	145d	10986	5213	21973	10427
2bc7	116b	11207	4454	22415	8919
2381	10e7	10881	4327	21763	8655
295b	1039	10587	4153	21175	8307
...	...	...	...	...	...

Table 2a — Hexadecimal Dump of Record 1 (partial)
Mars Express RSR File (a157142c.rsr)
Created on 2010-06-06T14:22:00

Byte No. (octal)	Byte Values (hexadecimal)															
0000000	4e	4a	50	4c	32	49	00	00	43	39	39	37	00	00	00	00
0000020	00	00	62	98	00	01	00	e8	00	02	00	04	15	05	ff	00
0000040	00	68	00	dc	7b	7b	00	64	00	00	3c	3f	0b	04	00	29
0000060	00	9d	58	58	01	00	00	00	00	00	00	00	00	00	00	00
0000100	00	00	00	00	10	00	00	19	01	40	1f	a4	07	da	00	9d
0000120	40	e9	41	00	00	00	00	00	00	00	00	00	00	00	00	00
0000140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
*																
0000260	c0	da	33	8b	df	d8	00	00	40	11	e9	32	00	00	00	00
0000300	bf	0c	00	00	00	00	00	00	00	00	00	00	00	00	00	00
0000320	bf	e8	ee	df	55	59	80	00	c0	da	33	8b	df	d8	00	00
0000340	40	01	e9	32	00	00	00	00	be	f2	aa	aa	aa	aa	aa	ab
0000360	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
0000400	00	0a	61	a8	----------data part below----------											
----header part above----					07	4c	fe	b9	06	b0	01	59	04	1f	06	bb
0000420	fc	2c	04	a5	f9	bc	fd	cd	fe	d0	f9	d6	01	ab	f7	4a
0000440	03	b9	f8	7d	06	42	01	c3	01	a8	0a	d5	fc	b1	09	d8
0000460	fb	bc	ff	a5	fa	1e	fd	6d	fc	78	03	64	00	38	fd	e7
0000500	04	02	fb	1a	04	15	02	81	05	70	03	85	fe	21	02	23
0000520	fb	44	00	a4	ff	46	00	48	01	4a	fb	ae	00	4a	f8	a0
0000540	03	dd	fe	c7	0a	7d	00	3c	fe	81	03	c4	fa	b7	02	f4
0000560	fd	4c	ff	43	fa	72	fd	66	02	fc	f9	c9	04	b4	f9	a5
0000600	01	18	00	23	03	08	04	c1	ff	6a	04	70	fd	2b	01	f2
0000620	fa	04	fb	44	fd	a2	fb	4e	05	5d	fc	26	02	bb	fe	88
0000640	05	1f	00	2f	03	75	06	54	fd	ec	08	aa	fa	7a	01	e5
0000660	fa	09	fd	c9	ff	b4	fb	51	ff	1f	fa	fb	05	58	fd	fc
0000700	04	fb	03	6b	fa	98	04	58	fb	56	05	3d	fe	f0	ff	9a
0000720	ff	9f	fb	2e	fc	5f	f6	64	00	b0	f8	48	01	57	01	98
0000740	ff	30	00	73	00	f8	05	b3	fc	e1	08	32	fb	7c	00	34
0000760	fc	c9	fe	2a	00	15	fb	43	04	bd	f9	18	06	f0	fe	53
0001000	04	e0	02	8f	ff	b1	05	9d	fd	8a	00	bb	f9	f4	fd	b1
0001020	fc	ec	ff	05	01	95	ff	c3	ff	de	01	2b	02	1f	ff	21
0001040	01	06	05	74	fc	7d	02	a4	fb	7a	fa	c9	00	1a	fb	39
0001060	02	70	f9	2d	06	3b	fa	c6	06	a4	00	34	01	31	03	eb
0001100	01	42	04	7a	fd	2c	01	b0	fa	71	ff	82	fd	70	fd	52
0001120	01	0a	ff	85	04	b3	02	ab	07	45	fd	ce	03	dd	02	7c
0001140	fe	84	09	2d	00	60	03	f2	fe	6a	fd	84	fd	0f	fc	9b
0001160	05	4b	fc	52	05	89	fb	74	05	46	00	e9	01	0b	08	16
0001200	fa	c6	03	d0	fd	c8	00	29	f9	39	00	53	fd	30	fd	2d
0001220	04	44	fb	84	02	e0	fd	1b	00	82	06	ee	fe	47	03	e6
0001240	fc	37	04	80	fb	45	01	97	fd	cd	f2	8e	00	66	fc	9a
0001260	04	e1	fa	4d	04	0c	fe	95	00	14	09	5f	ff	f0	01	7b

Table 2b — Extraction of Header Values from Record 1
Mars Express RSR File (a157142c.rsr)
Created on 2010-06-06T14:22:00

```
RSRHPR2 -- Input File:         a157142c.rsr
Record Number:             1   of     10084
Program version:                 2019-10-22
Today is:          Fri Feb 21 15:34:49 2020
--------------------
SFDU Label:
     Control Authority        =   NJPL
     Version ID               =      2
     Class ID                 =      I
     SFDU Reserved            =  <NULL> (Unexpected value)
     Data Desc ID             =   C997
     SFDU Value Length High   =      0
     SFDU Value Length Low    =  25240
Header Aggregation CHDO Label:
     Type Attribute           =      1
     Length Attribute         =    232
Primary Header CHDO:
     Type Attribute           =      2
     Length Attribute         =      4
     Major Data Class         =     21
     Minor Data Class         =      5 (source is not RSR)
     Mission ID               =    255
     Format Code              =      0
Secondary Header CHDO:
     Type Attribute           =    104
     Length Attribute         =    220
     Originator ID            =    123 (Unexpected value)
     Last Modifier ID         =    123 (PRRSG Group for VSR)
     RSR Software ID          =    100
     Record Sequence Number   =      0
     SPC ID                   =     60
     DSS ID                   =     63
     RSR ID                   =     11
     SCHAN ID                 =      4
     Reserved                 =      0
     Spacecraft               =     41
     Predicts Pass Number     =    157
     Uplink Band              =      X
     Downlink Band            =      X
     Tracking Mode            =      1
     Uplink DSS ID            =      0
     FGAIN Px/No (dB-Hz)      =      0
     FGAIN IF BW (MHz)        =      0
     Freq Pred Overide Flag   =      0
     DIG Attenuation (0.5 dB) =      0
     DIG ADC RMS              =      0
     DIG ADC Peak Amplitude   =      0
     ADC Year                 =      0
     ADC Day of Year          =      0
```

```
ADC Seconds               =      0
Bits per Sample           =     16
Data Error Count          =      0
Sample Rate (ksps)        =     25
DDC LO (MHz)              =    320
RF to IF LO (MHz)         =   8100
SFDU Year                 =   2010
SFDU Day of Year          =    157
SFDU Seconds              =  5.1720000000000000E+04
Pred Time Shift (sec)     =  0.0000000000000000E+00
Pred Freq Override (Hz)   =  0.0000000000000000E+00
Pred Freq Rate (Hz/s)     =  0.0000000000000000E+00
Pred Freq Offset (Hz)     =  0.0000000000000000E+00
SubChan Freq Offset (Hz)  =  0.0000000000000000E+00
RF Freq Point 1           =  0.0000000000000000E+00
RF Freq Point 2           =  0.0000000000000000E+00
RF Freq Point 3           =  0.0000000000000000E+00
SC Freq Point 1           =  0.0000000000000000E+00
SC Freq Point 2           =  0.0000000000000000E+00
SC Freq Point 3           =  0.0000000000000000E+00
SC F Poly Coef 1          = -2.6830185537338257E+04
SC F Poly Coef 2          =  4.4777297973632812E+00
SC F Poly Coef 3          = -5.3405761718750000E-05
SC Accum Phase            =  0.0000000000000000E+00
SC P Poly Coef 1          = -7.7915922803731519E-01
SC P Poly Coef 2          = -2.6830185537338257E+04
SC P Poly Coef 3          =  2.2388648986816406E+00
SC P Poly Coef 4          = -1.7801920572916668E-05
```

Table 2c — Extraction of Data Values from Record 1
Mars Express RSR File (a157142c.rsr)
Created on 2010-06-06T14:22:00

Q1 (hex)	I1 (hex)	Q1 (decimal)	I1 (decimal)	Q1 (after corrections)	I1 (after corrections)
074c	feb9	1868	65209	3737	−653
06b0	0159	1712	345	3425	691
041f	06bb	1055	1723	2111	3447
fc2c	04a5	64556	1189	−1959	2379
...	...	...	...	...	...

Table 3a — Hexadecimal Dump of Record 1 (partial)
Mars Express RSR File (i070174a.rsr)
Created on 2018-03-11T17:27:01

Byte No. (octal)	Byte Values (hexadecimal)															
0000000	4e	4a	50	4c	32	49	30	30	43	39	39	37	00	00	00	00
0000020	00	00	20	30	00	01	00	e8	00	02	00	04	15	04	ff	00
0000040	00	68	00	dc	30	30	0a	ad	00	01	28	2b	04	01	00	29
0000060	00	46	58	58	02	ff	4b	6e	00	1a	1e	7b	07	e2	00	46
0000100	00	00	f5	4f	10	00	00	02	01	41	1f	a4	07	e2	00	46
0000120	40	ee	ac	a0	00	00	00	00	00	00	00	00	00	00	00	00
0000140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
*																
0000200	41	ff	5e	c4	e7	d8	8b	00	7f	ff	ff	ff	ff	ff	ff	ff
0000220	7f	ff	ff	ff	ff	ff	ff	ff	40	ff	4c	27	75	00	53	95
0000240	7f	ff	ff	ff	ff	ff	ff	ff	7f	ff	ff	ff	ff	ff	ff	ff
0000260	40	ff	4c	27	75	00	53	95	7f	ff	ff	ff	ff	ff	ff	ff
0000300	7f	ff	ff	ff	ff	ff	ff	ff	41	b6	8d	4e	9e	00	00	00
0000320	3f	78	95	50	82	00	00	00	7f	ff	ff	ff	ff	ff	ff	ff
0000340	7f	ff	ff	ff	ff	ff	ff	ff	7f	ff	ff	ff	ff	ff	ff	ff
0000360	3f	80	00	00	00	00	00	00	00	00	00	00	00	00	00	00
0000400	00	0a	1f	40	----------data part below----------											
-----header part above-----					06	55	e9	35	06	6f	ea	5a	06	05	e9	3a
0000420	06	80	ea	38	07	44	ea	1d	08	77	e9	c0	07	82	eb	71
0000440	08	b9	ea	db	09	48	ea	ef	09	3d	eb	81	0a	5c	eb	64
0000460	0a	42	ec	62	0a	d5	ec	2e	0b	03	ec	c4	0c	55	ec	98
0000500	0c	1e	eb	8c	0b	df	ec	62	0b	e9	ec	67	0c	27	ed	33
0000520	0d	1a	ed	7f	0e	1e	ec	f3	0e	d8	ed	9a	0d	55	ed	fd
0000540	0e	49	ed	87	0e	5b	ee	1d	0e	dc	ef	0d	10	68	ef	aa
0000560	0f	25	ef	56	0f	2b	ef	1c	10	18	f0	1a	10	32	f0	54
0000600	10	6d	f0	6a	11	d6	f0	29	11	d7	f0	fd	11	0a	f2	24
0000620	11	35	f2	2a	11	f5	f2	c3	12	eb	f3	66	12	e5	f3	aa
0000640	13	27	f3	ad	13	84	f3	b6	13	b4	f4	9b	13	e0	f3	e6
0000660	13	4f	f4	29	13	b9	f5	9c	14	ed	f6	7d	14	b3	f8	31
0000700	14	8d	f7	ba	15	3a	f7	06	15	0f	f7	93	14	fc	f6	c6
0000720	15	bb	f7	43	16	26	f8	f4	15	86	f9	11	15	b7	f8	eb
0000740	16	4b	fa	c1	16	06	fa	f4	15	a9	fa	c1	16	4e	fb	76
0000760	16	83	fb	26	16	43	fc	73	16	78	fc	92	15	f1	fc	c0
0001000	16	91	fd	ee	16	f4	fd	7a	16	76	fd	78	17	41	fe	63
0001020	17	13	fe	8e	16	6e	fe	dc	16	c9	ff	2c	16	9e	ff	8c
0001040	16	f5	00	6d	16	bd	00	17	16	cd	01	31	16	da	03	34
0001060	16	3c	02	da	15	97	03	b4	15	e7	03	36	16	fb	03	a6
0001100	15	b3	04	5d	15	3d	03	5d	15	76	04	c0	15	6c	05	2a
0001120	16	57	05	a3	15	b4	06	38	14	fb	06	c6	15	4b	07	43
0001140	15	d6	07	9e	15	e6	07	8a	15	0b	08	1e	15	a8	08	8e
0001160	15	0d	08	8a	13	d4	09	ed	14	7f	0a	8a	14	67	0a	67
0001200	14	84	0a	76	15	11	0a	a4	14	51	0a	89	13	7d	0b	3f
0001220	13	b6	0a	f2	13	80	0b	b9	13	75	0c	9c	12	94	0c	1b
0001240	11	f1	0d	56	11	9d	0d	88	11	72	0d	b3	11	18	0e	61
0001260	10	35	0f	13	10	bd	0f	54	0f	b8	10	0c	0f	d6	10	75

Table 3b — Extraction of Header Values from Record 1
Mars Express RSR File (i070174a.rsr)
Created on 2018-03-11T17:27:01

```
RSRHPR2 -- Input File:         i070172a.rsr
Record Number:             1   of      2760
Program version:                 2019-10-22
Today is:          Fri Feb 21 16:22:04 2020
--------------------
SFDU Label:
     Control Authority        =   NJPL
     Version ID               =      2
     Class ID                 =      I
     SFDU Reserved            =     00
     Data Desc ID             =   C997
     SFDU Value Length High   =      0
     SFDU Value Length Low    =   8240
Header Aggregation CHDO Label:
     Type Attribute           =      1
     Length Attribute         =    232
Primary Header CHDO:
     Type Attribute           =      2
     Length Attribute         =      4
     Major Data Class         =     21
     Minor Data Class         =      4
     Mission ID               =    255
     Format Code              =      0
Secondary Header CHDO:
     Type Attribute           =    104
     Length Attribute         =    220
     Originator ID            =     48
     Last Modifier ID         =     48
     RSR Software ID          =   2733
     Record Sequence Number   =      1
     SPC ID                   =     40
     DSS ID                   =     43
     RSR ID                   =      4
     SCHAN ID                 =      1
     Reserved                 =      0
     Spacecraft               =     41
     Predicts Pass Number     =     70
     Uplink Band              =      X
     Downlink Band            =      X
     Tracking Mode            =      2
     Uplink DSS ID            =    255
     FGAIN Px/No (dB-Hz)      =     75
     FGAIN IF BW (MHz)        =    110
     Freq Pred Overide Flag   =      0
     DIG Attenuation (0.5 dB) =     26
     DIG ADC RMS              =     30
     DIG ADC Peak Amplitude   =    123
     ADC Year                 =   2018
     ADC Day of Year          =     70
```

```
ADC Seconds              =  62799
Bits per Sample          =     16
Data Error Count         =      0
Sample Rate (ksps)       =      2
DDC LO (MHz)             =    321
RF to IF LO (MHz)        =   8100
SFDU Year                =   2018
SFDU Day of Year         =     70
SFDU Seconds             =  6.2821000000000000E+04
Pred Time Shift (sec)    =  0.0000000000000000E+00
Pred Freq Override (Hz)  =  0.0000000000000000E+00
Pred Freq Rate (Hz/s)    =  0.0000000000000000E+00
Pred Freq Offset (Hz)    =  0.0000000000000000E+00
SubChan Freq Offset (Hz) =  0.0000000000000000E+00
RF Freq Point 1          =  8.4208718055339355E+09
RF Freq Point 2          =                     NaN
RF Freq Point 3          =                     NaN
SC Freq Point 1          =  1.2819446606476449E+05
SC Freq Point 2          =                     NaN
SC Freq Point 3          =                     NaN
SC F Poly Coef 1         =  1.2819446606476449E+05
SC F Poly Coef 2         =                     NaN
SC F Poly Coef 3         =                     NaN
SC Accum Phase           =  3.7835945400000000E+08
SC P Poly Coef 1         =  6.0017723881173879E-03
SC P Poly Coef 2         =                     NaN
SC P Poly Coef 3         =                     NaN
SC P Poly Coef 4         =                     NaN
```

Table 3c — Extraction of Data Values from Record 1
Mars Express RSR File (i070172a.rsr)
Created on 2018-03-11T17:27:01

Q1 (hex)	I1 (hex)	Q1 (decimal)	I1 (decimal)	Q1 (after corrections)	I1 (after corrections)
e935	0655	59701	1621	-11669	3243
ea52	066f	59994	1647	-11083	3295
e93a	0605	59706	1541	-11659	3083
ea38	0680	59960	1664	-11151	3329
...	...	...	...	...	...