

SAC Data Format

Overview

This section discusses the contents of the SAC data file, describes the binary and alphanumeric formats of this file, and documents the SAC header in detail.

Since version 100.0, SAC can handle binary data files in either endian (byte order), so big-endian systems (Sun Solaris, Mac PPC) can read SAC data files written on little-endian systems (Linux, MAC i686, Cygwin) and vice versa.

Each signal is stored on disk in a separate SAC data file. These files contain a fixed length header section followed by one or two data sections. The header contains floating point, integer, logical, and character fields. Evenly spaced data files have only one data section which contains the dependent variable. Unevenly spaced data and spectral data files contain two data sections. For unevenly spaced data, the first data section contains the dependent variable and the second contains the independent variable. For spectral files the first component is either the amplitude or the real component and the second component is either the phase or imaginary component.

SAC Binary Format

This is the format that you will use most often. It is used in SAC itself (READ and WRITE commands) and in the subroutine library (RSAC1, RSAC2, WSAC1, WSAC2, WSAC0.) These are binary (unformatted) files so that they can be quickly read from disk into memory. The header is 158 32-bit words in length, followed by the data section(s). In order to rapidly read only a small section of a data file (see the CUT command), these files also have a physical record length of 512 bytes (128 32-bit words) and are opened for direct-access. There is no physical record structure. This format is shown schematically in the following figure.

Structure of SAC Binary Data File

Header Section	First Data Section	Second Data Section (if present)
start word: 0	start word: 158	start word: 158+NPTS
word length: 158	word length: NPTS	word length: NPTS
see table	<ul style="list-style-type: none">• dependent variable• amplitude• real component	<ul style="list-style-type: none">• independent variable unevenly spaced• phase• imaginary component

SAC Binary Header

The following table shows the contents and layout of the SAC binary data file header. The W and T columns give the beginning word and header data type for the header variables named on that line. These header variables and data types are described later in this section. If the name is INTERNAL then that variable is internal to SAC and not normally of interest to the user. If the name is UNUSED then that variable is not currently being used. For any given file, some of these variables will not have meaningful values. These are referred to as “undefined variables” for that file. For each data type, a special value signifies this undefined state. They are listed in a table at the end of this section.

Header Data Types

This table lists the header types and their definitions. The third column lists the special value used to signify that a particular header variable is undefined in a particular file.

Type	Definition	Undefined	Description
F	Floating	-12345.0	Single precision.
N	Integer	-12345	Name begins with an “N”.
I	Enumerated	-12345	Name begins with an “I”. Has a limited set of integer values. Each value is given a specific name. Each value represents a specific condition. Subroutines use the equivalent alphanumeric name.
L	Logical	FALSE	Name begins with an “L”. Value is either TRUE or FALSE.
K	Alphanumeric	“-12345..”	Name begins with a “K”. Either 8 or 16 characters long.
A	Auxiliary		Not really in the header. Derived from other header fields.

Header Variables

Word	Type	NAMES				
0	F	DELTA	DEPMIN	DEPMAX	SCALE	ODELTA
5	F	B	E	O	A	INTERNAL
10	F	T0	T1	T2	T3	T4
15	F	T5	T6	T7	T8	T9
20	F	F	RESP0	RESP1	RESP2	RESP3
25	F	RESP4	RESP5	RESP6	RESP7	RESP8
30	F	RESP9	STLA	STLO	STEL	STDP
35	F	EVLA	EVLO	EVEL	EVDP	MAG
40	F	USER0	USER1	USER2	USER3	USER4
45	F	USER5	USER6	USER7	USER8	USER9
50	F	DIST	AZ	BAZ	GCARC	INTERNAL
55	F	INTERNAL	DEPMEN	CMPAZ	CMPINC	XMINIMUM
60	F	XMAXIMUM	YMINIMUM	YMAXIMUM	UNUSED	UNUSED

Word	Type	NAMES				
65	F	UNUSED	UNUSED	UNUSED	UNUSED	UNUSED
70	I	NZYEAR	NZJDAY	NZHOURL	NZMIN	NZSEC
75	I	NZMSEC	NVHDR	NORID	NEVID	NPTS
80	I	INTERNAL	NWFID	NXSIZE	NYSIZE	UNUSED
85	I	IFTYPE	IDEP	IZTYPE	UNUSED	IINST
90	I	ISTREG	IEVREG	IEVTYP	IQUAL	ISYNTH
95	I	IMAGTYP	IMAGSRC	UNUSED	UNUSED	UNUSED
100	I	UNUSED	UNUSED	UNUSED	UNUSED	UNUSED
105	L	LEVEN	LPSPOL	LOVROK	LCALDA	UNUSED
110	K	KSTNM	KEVNM*			
116	K	KHOLE	KO	KA		
122	K	KT0	KT1	KT2		
128	K	KT3	KT4	KT5		
134	K	KT6	KT7	KT8		
140	K	KT9	KF	KUSER0		
146	K	KUSER1	KUSER2	KCMPNM		
152	K	KNETWK	KDATRD	KINST		

KEVNM is 16 characters (4 words) long.

All other K fields are 8 characters (2 words) long.

SAC Alphanumeric Format

This file is essentially the alphanumeric equivalent of the SAC binary data file. The header section is stored on the first 30 cards. This is followed by one or two data sections. The data is in 5G15.7 format. The following table shows the card number, formats and names of the variables on the header section cards.

CN	FOR-MAT	NAMES				
01	(5G15.7)	DELTA	DEPMIN	DEPMAX	SCALE	ODELTA
02	(5G15.7)	B	E	O	A	INTERNAL
03	(5G15.7)	T0	T1	T2	T3	T4
04	(5G15.7)	T5	T6	T7	T8	T9
05	(5G15.7)	F	RESP0	RESP1	RESP2	RESP3
06	(5G15.7)	RESP4	RESP5	RESP6	RESP7	RESP8
07	(5G15.7)	RESP9	STLA	STLO	STEL	STDP
08	(5G15.7)	EVLA	EVLO	EVEL	EVDP	MAG
09	(5G15.7)	USER0	USER1	USER2	USER3	USER4
10	(5G15.7)	USER5	USER6	USER7	USER8	USER9
11	(5G15.7)	DIST	AZ	BAZ	GCARC	INTERNAL
12	(5G15.7)	INTERNAL	DEPMEN	CMPAZ	CMPINC	XMINIMUM
13	(5G15.7)	XMAXIMUM	YMINIMUM	YMAXIMUM	MADJTM	UNUSED

CN	FOR-MAT	NAMES				
14	(5G15.7)	UNUSED	UNUSED	UNUSED	UNUSED	UNUSED
15	(5I10)	NZYEAR	NZJDAY	NZHOURL	NZMIN	NZSEC
16	(5I10)	NZMSEC	NVHDR	NORID	NEVID	NPTS
17	(5I10)	NSPTS	NWFID	NXSIZE	NYSIZE	UNUSED
18	(5I10)	IFTYPE	IDEP	IZTYPE	UNUSED	IINST
19	(5I10)	ISTREG	IEVREG	IEVTYP	IQUAL	ISYNTH
20	(5I10)	IMAGTYP	IMAGSRC	UNUSED	UNUSED	UNUSED
21	(5I10)	UNUSED	UNUSED	UNUSED	UNUSED	UNUSED
22	(5I10)	LEVEN	LPSPOL	LOVROK	LCALDA	UNUSED
23	(A8,A16)	KSTNM	KEVNM			
24	(3A8)	KHOLE	KO	KA		
25	(3A8)	KT0	KT1	KT2		
26	(3A8)	KT3	KT4	KT5		
27	(3A8)	KT6	KT7	KT8		
28	(3A8)	KT9	KF	KUSER0		
29	(3A8)	KUSER1	KUSER2	KCMPNM		
30	(3A8)	KNETWK	KDATRD	KINST		

SAC Alphanumeric Data File Example

The header section and first five lines of the data section of a sample SAC alphanumeric data file is shown below. You can reproduce this file (with the entire data section) on your system by executing the following commands:

```
SAC> FUNCGEN SEISMOGRAM
SAC> WRITE ALPHA TEMP1
```

You can then convert this alphanumeric file to a binary one and read it into SAC with the following commands:

```
SAC> CONVERT FROM ALPHA TEMP1 TO SAC TEMP2
SAC> READ TEMP2
```

This little test shows the equivalence of the alphanumeric and binary file formats.:

0.01000000	-1.569280	1.520640	-12345.00	-12345.00
9.459999	19.45000	0.000000	10.47000	2.000000
-12345.00	20.00000	-12345.00	-12345.00	-12345.00
-12345.00	-12345.00	-12345.00	-12345.00	-12345.00
17.78000	-12345.00	-12345.00	-12345.00	-12345.00
-12345.00	-12345.00	-12345.00	-12345.00	-12345.00
-12345.00	87.99997	-120.0000	-12345.00	-12345.00
47.99997	-125.0000	-12345.00	-12345.00	-12345.00
123.4560	-12345.00	-12345.00	-12345.00	-12345.00
-12345.00	-12345.00	-12345.00	-12345.00	-12345.00
4461.052	0.2719055	185.2047	40.18595	-12345.00
-12345.00	-0.09854718	0.000000	0.000000	-12345.00

```

-12345.00      -12345.00      -12345.00      -12345.00      -12345.00
-12345.00      -12345.00      -12345.00      -12345.00      -12345.00
1981          88          10          38          14
0            6            0            0          1000
-12345      -12345      -12345      -12345      -12345
1           50           9          -12345      -12345
-12345      -12345          42          -12345      -12345
-12345      -12345      -12345      -12345      -12345
-12345      -12345      -12345      -12345      -12345
1            1            1            1            0
CDV          K8108838
-12345 HOLE      IPD0
XYZ      -12345 KT1
-12345 -12345 -12345
-12345 -12345 -12345
-12345 -12345 ABKD
USER0    -12345 Q
-12345 -12345 -12345
-0.09728001 -0.09728001 -0.09856002 -0.09856002 -0.09728001
-0.09600000 -0.09472002 -0.09344001 -0.09344001 -0.09344001
-0.09344001 -0.09344001 -0.09472002 -0.09472002 -0.09344001
-0.09344001 -0.09216000 -0.09216000 -0.09216000 -0.09216000
-0.09088002 -0.09088002 -0.09216000 -0.09344001 -0.09472002
-0.09472002 -0.09472002 -0.09472002 -0.09472002 -0.09472002
-0.09344001 -0.09344001 -0.09216000 -0.09088002 -0.09088002
-0.09216000 -0.09216000 -0.09216000 -0.09344001 -0.09472002
....

```

SAC Header Variables

This table lists the header variables, their types, and descriptions. They are grouped by category: required fields, time fields, phase picks, instrument parameters, station parameters, event parameters, misc. The header types are defined in the second table.

Name	Type	Description
NPTS	N	Number of points per data component. [required]
NVHDR	N	Header version number. Current value is the integer 6. Older version data (NVHDR > 6) are automatically updated when read into sac. [required]
B	F	Beginning value of the independent variable. [required]
E	F	Ending value of the independent variable. [required]

Name	Type	Description
IFTYPE	I	Type of file [required]: <ul style="list-style-type: none"> • ITIME {Time series file} • IRLIM {Spectral file---real and imaginary} • IAMPH {Spectral file---amplitude and phase} • IXY {General x versus y data} • IXYZ {General XYZ (3-D) file}
LEVEN	L	TRUE if data is evenly spaced. [required]
DELTA	F	Increment between evenly spaced samples (nominal value). [required]
ODELTA	F	Observed increment if different from nominal value.
IDEP	I	Type of dependent variable: <ul style="list-style-type: none"> • IUNKN (Unknown) • IDISP (Displacement in nm) • IVEL (Velocity in nm/sec) • IVOLTS (Velocity in volts) • IACC (Acceleration in nm/sec/sec)
SCALE	F	Multiplying scale factor for dependent variable [not currently used]
DEPMIN	F	Minimum value of dependent variable.
DEPMAX	F	Maximum value of dependent variable.
DEPMEN	F	Mean value of dependent variable.
NZYEAR	N	GMT year corresponding to reference (zero) time in file.
NZJDAY	N	GMT julian day.
NZHOURL	N	GMT hour.
NZMIN	N	GMT minute.
NZSEC	N	GMT second.
NZMSEC	N	GMT millisecond.
NZDTTM	N	GMT date-time array. Six element array equivalenced to NZYEAR, NZJDAY, NZHOURL, NZMIN, NZSEC, and NZMSEC.
KZDATE	A	Alphanumeric form of GMT reference date. Derived from NZYEAR and NZJDAY.
KZTIME	A	Alphanumeric form of GMT reference time. Derived from NZHOURL, NZMIN, NZSEC, and NZMSEC.

Name	Type	Description
IZTYPE	I	Reference time equivalence: <ul style="list-style-type: none"> • IUNKN (Unknown) • IB (Begin time) • IDAY (Midnight of reference GMT day) • IO (Event origin time) • IA (First arrival time) • ITn (User defined time pick n, n=0,9)
O	F	Event origin time (seconds relative to reference time.)
KO	A	Event origin time identification.

Phase Picks

Name	Type	Description
A	F	First arrival time (seconds relative to reference time.)
KA	K	First arrival time identification.
F	F	End or end of event time (seconds relative to reference time.)
KF	A	End identification.
Tn	F	User defined time picks or markers, n = 0 - 9 (seconds relative to reference time).
KT{n}	K	A User defined time pick identifications, n = 0 - 9.

Instrument Fields

Name	Type	Description
KINST	K	Generic name of recording instrument.
IINST	I	Type of recording instrument. [not currently used]
RESPn	F	Instrument response parameters, n=0,9. [not currently used]

Station Fields

Name	Type	Description
KNETWK	K	Name of seismic network.
KSTNM	K	Station name.
ISTREG	I	Station geographic region. [not currently used]
STLA	F	Station latitude (degrees, north positive)
STLO	F	Station longitude (degrees, east positive).

Name	Type	Description
STEL	F	Station elevation (meters). [not currently used]
STDP	F	Station depth below surface (meters). [not currently used]
CMPAZ	F	Component azimuth (degrees clockwise from north).
CMPINC	F	Component incident angle (degrees from vertical).
KCMPNM	K	Component name.
KSTCMP	A	Station component. Derived from KSTNM, CMPAZ, and CMPINC.
LPSPOL	L	TRUE if station components have a positive polarity (left-hand rule).

Event Fields

Name	Type	Description
KEVNM	K	Event name.
IEVREG	I	Event geographic region. [not currently used]
EVLA	F	Event latitude (degrees, north positive).
EVLO	F	Event longitude (degrees, east positive).
EVEL	F	Event elevation (meters). [not currently used]
EVDP	F	Event depth below surface (meters). [not currently used]
MAG	F	Event magnitude.
IMAGTYP	I	<p>Magnitude type:</p> <ul style="list-style-type: none"> • IMB (Bodywave Magnitude) • IMS (Surfacewave Magnitude) • IML (Local Magnitude) • IMW (Moment Magnitude) • IMD (Duration Magnitude) • IMX (User Defined Magnitude)

Name	Type	Description
IMAGSRC	I	<p>Source of magnitude information:</p> <ul style="list-style-type: none"> • INEIC (National Earthquake Information Center) • IPDE (Preliminary Determination of Epicenter) • IISC (International Seismological Centre) • IREB (Reviewed Event Bulletin) • IUSGS (US Geological Survey) • IBRK (UC Berkeley) • ICALTECH (California Institute of Technology) • ILLNL (Lawrence Livermore National Laboratory) • IEVLOC (Event Location (computer program)) • IJSOP (Joint Seismic Observation Program) • IUSER (The individual using SAC2000) • IUNKNOWN (unknown)

Name	Type	Description
IEVTYP	I	<p>Type of event:</p> <ul style="list-style-type: none"> • IUNKN (Unknown) • INUCL (Nuclear event) • IPREN (Nuclear pre-shot event) • IPOSTN (Nuclear post-shot event) • IQUAKE (Earthquake) • IPREQ (Foreshock) • IPOSTQ (Aftershock) • ICHEM (Chemical explosion) • IQB (Quarry or mine blast confirmed by quarry) • IQB1 (Quarry/mine blast with designed shot info-ripple fired) • IQB2 (Quarry/mine blast with observed shot info-ripple fired) • IQBX (Quarry or mine blast - single shot) • IQMT (Quarry/mining-induced events: tremors and rockbursts) • IEQ (Earthquake) • IEQ1 (Earthquakes in a swarm or aftershock sequence) • IEQ2 (Felt earthquake) • IME (Marine explosion) • IEX (Other explosion) • INU (Nuclear explosion) • INC (Nuclear cavity collapse) • IO (Other source of known origin) • IL (Local event of unknown origin) • IR (Regional event of unknown origin) • IT (Teleseismic event of unknown origin) • IU (Undetermined or conflicting information) • IOTHER (Other)
NEVID	N	Event ID (CSS 3.0)
NORID	N	Origin ID (CSS 3.0)
NWFID	N	Waveform ID (CSS 3.0)
KHOLE	K	Hole identification if nuclear event.
DIST	F	Station to event distance (km).
AZ	F	Event to station azimuth (degrees).
BAZ	F	Station to event azimuth (degrees).
GCARC	F	Station to event great circle arc length (degrees).

Miscellaneous Fields

Name	Type	Description
LCALDA	L	TRUE if DIST, AZ, BAZ, and GCARC are to be calculated from station and event coordinates.
IQUAL	I	Quality of data [not currently used]: <ul style="list-style-type: none"> • IGOOD (Good data) • IGLCH (Glitches) • IDROP (Dropouts) • ILOWSN (Low signal to noise ratio) • IOTHER (Other)
ISYNTH	I	Synthetic data flag [not currently used]: <ul style="list-style-type: none"> • IRLDTA (Real data) • ????? (Flags for various synthetic seismogram codes)
KDATRD	K	Date data was read onto computer.
USER{ <i>n</i> }	F	User defined variable storage area, <i>n</i> = 0,9.
KUSER{ <i>n</i> }	K	User defined variable storage area, <i>n</i> = 0,2.
LOVROK	L	TRUE if it is okay to overwrite this file on disk.
NXSIZE	N	Spectral Length (Spectral files only)
NYSIZE	N	Spectral Width (Spectral files only)
XMINIMUM	F	Minimum value of X (Spectral files only)
XMAXIMUM	F	Maximum value of X (Spectral files only)
YMINIMUM	F	Minimum value of Y (Spectral files only)
YMAXIMUM	F	Maximum value of Y (Spectral files only)

Enumerated Header Field Values

The enumerated header field values are stored in the header as integers. Their names and values are given in the table below.

Name	ID
itime	01
irlim	02
iamph	03
ixy	04
iunkn	05
idisp	06

Name	ID
ivel	07
iacc	08
ib	09
iday	10
io	11
ia	12
it0	13
it1	14
it2	15
it3	16
it4	17
it5	18
it6	19
it7	20
it8	21
it9	22
iradnv	23
itannv	24
iradev	25
itanev	26
inorth	27
ieast	28
ihorza	29
idown	30
iup	31
illlbb	32
iwwsn1	33
iwwsn2	34
ihglp	35
isro	36
inucl	37
ipren	38
ipostn	39
iquake	40
ipreq	41
ipostq	42
ichem	43
iother	44
igood	45
iglch	46
idrop	47
ilowsn	48
irltda	49

Name	ID
ivolts	50
ixyz	51
imb	52
ims	53
iml	54
imw	55
imd	56
imx	57
ineic	58
ipde	59
iisc	60
ireb	61
iusgs	62
ibrk	63
icaltech	64
illnl	65
ievloc	66
ijsop	67
iuser	68
iunknown	69
iqb	70
iqb1	71
iqb2	72
iqbx	73
iqmt	74
ieq	75
ieq1	76
ieq2	77
ime	78
iex	79
inu	80
inc	81
io	82
il	83
ir	84
it	85
iu	86