SEED Format definitions

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Category: Passive source, SEED formatting,
Objective: to provide the user with an explanation of the SEED channel convention and recommended names for typical PASSCAL sensors.

1. MSEED HEADERS

MiniSEED (MSEED, mseed) format is strictly defined by the Standard for the Exchange of Earthquake Data (SEED) Reference Manual, SEED format version 2.4, Appendix A. The following document is a copy of the Appendix A in the SEED format manual (http://www.iris.edu/manuals/SEEDManual_V2.4.pdf).

Appendix A: Channel Naming

Contributed by Scott Halbert

Seismologists have used many conventions for naming channels. Usually, these conventions are designed to meet the particular needs of one network. But general recording systems — such as the various Global Seismographic Network (GSN) systems that can record many channels at high sample rates — create a need for a standard to handle the variety of instruments that can be recorded. Modern instrumentation and the need for conformity among cooperating networks have greatly complicated the problem. Sensors are available in narrow band and broadband configurations with pass bands in very different parts of the spectrum of interest. Each sensor may have several different outputs with different spectral shaping. In addition, station processors often derive several data streams from one sensor channel by digital filtering. These possibilities require a comprehensive convention. The desire to combine data from cooperating networks and to search for like channels automatically requires standardization.

The SEED format uses three letters to name seismic channels, and three letters to name weather or environmental channels. In the following convention, each letter describes one aspect of the instrumentation and its digitization. SEED does not require this convention, but we recommend it as a usage standard for Federation members to facilitate data exchange.

Band Code

The first letter specifies the general sampling rate and the response band of the instrument. (The "A" code is reserved for administrative functions such as miscellaneous state of health.)

Band code	Band type	Sample rate (Hz)	Corner period (sec)
F	...	≥ 1000 to < 5000	≥ 10 sec
G	...	≥ 1000 to < 5000	< 10 sec
D	...	≥ 250 to < 1000	< 10 sec
C	...	≥ 250 to < 1000	≥ 10 sec
E	Extremely Short Period	>= 80	< 10 sec
S	Short Period	>= 10 to < 80	< 10 sec
H	High Broad Band	>= 80	>= 10 sec
B	Broad Band	>= 10 to < 80	>= 10 sec
M	Mid Period	> 1 to < 10	
L	Long Period	= 1	
V	Very Long Period	= 0.1	
U	Ultra Long Period	= 0.01	
R	Extremely Long Period	= 0.001	
P	On the order of 0.1 to 1 day*	≥ 0.00001 to < 0.0001	
T	On the order of 1 to 10 days*	≥ 0.000001 to < 0.00001	
Q	Greater than 10 days*	< 0.000001	
A	Administrative Instrument Channel	Variable	NA
O	Opaque Instrument Channel	Variable	NA

Instrument Code and Orientation Code

The second letter specifies the family to which the sensor belongs and identifies what is being measured. The third letter specifies the physical configuration of the members of a multiple axis instrument package or other parameters as specified for each instrument.

Seismometer: Measures displacement/velocity/acceleration along a line defined by the dip and azimuth.

Instrument Code	
H	High Gain Seismometer
L	Low Gain Seismometer
G	Gravimeter
M	Mass Position Seismometer
N*	Accelerometer
	* *Historically, some channels from accelerometers have used instrument codes of L and G. The use of N is the FDSN convention as defined in August, 2000.*
Orientation Code	
Z N E	Traditional (Vertical, North-South, East-West)
A B C	Triaxial (Along the edges of a cube turned up on a corner)
T R	For formed beams (Transverse, Radial)
1 2 3	Orthogonal components but non traditional orientations
U V W	Optional components
Dip/Azimuth:	Ground motion vector (reverse dip/azimuth if signal polarity incorrect)
Signal Units	M, M/S, M/S**2, (for G & M) M/S**2 (usually)
Channel Flags	G

Tilt Meter: Measures tilt from the horizontal plane. Azimuth is typically N/S or E/W.

Instrument Code	
A	
Orientation Code	
N E	Traditional
Dip/Azimuth	Ground motion vector (reverse dip/azimuth if signal polarity incorrect)
Signal Units	Radians

Channel Flags	G

Creep Meter: Measures the absolute movement between two sides of a fault by means of fixing a metal beam on one side of the fault and measuring its position on the other side. This is also done with light beams.

The orientation and therefore the dip and azimuth would be perpendicular to the measuring beam (light or metal), which would be along the average travel vector for the fault. Positive/Negative travel would be arbitrary, but would be noted in the dip/azimuth.
Another type of Creep Meter involves using a wire that is stretched across the fault. Changes in wire length are triangulated to form movement vector.

Instrument Code

B

Orientation Code

Unknown

Dip/Azimuth:	Along the fault or wire vector
Signal Units:	M
Channel Flags:	G

Calibration Input: Usually only used for seismometers or other magnetic coil instruments. This signal monitors the input signal to the coil to be used in response evaluation. Usually tied to a specific instrument. Sometimes all instruments are calibrated together, sometimes horizontals are done separately from verticals.

Instrument Code

C

Orientation Code

A B C D... for when there are only a few cal sources for many devices.
Blank if there is only one calibrator at a time or, Match Calibrated Channel (i.s. Z, N or E)

Pressure: A barometer, or microbarometer measures pressure. Used to measure the weather pressure or sometimes for state of health monitoring down hole. This includes infrasonic and hydrophone measurements.

Instrument Code

D

Orientation Code

O	Outside
I	Inside
D	Down Hole
F	Infrasound
H	Hydrophone
U	Underground
Dip/Azimuth:	Not applicable Should be zero.
Signal Units:	Pa (Pascals)
Channel Flags:	W or H

Electronic Test Point: Used to monitor circuitry inside recording system, local power or seismometer. Usually for power supply voltages, or line voltages.

Instrument Code

E

Orientation code

Designate as desired, make mnemonic as possible, use numbers for test points, etc.

Dip/Azimuth:	Not applicable
Signal Units:	V, A, Hz, Etc.
Channel Flags:	H

Magnetometer: Measures the magnetic field where the instrument is sitting. They measure the part of the field vector that is aligned with the measurement coil. Many magnetometers are three axis. The instrument will typically be oriented to local magnetic north. The dip and azimuth should describe this in terms of the geographic north.

Example: Local magnetic north is 13 degrees east of north in Albuquerque. So if the magnetometer is pointed to magnetic north, the azimuth would be + 103 for the E channel. Some magnetometers do not record any vector quantity associated with the signal, but record the total intensity. So, these would not have any dip/azimuth.

Instrument Code

F

Orientation Code

Z N E	Magnetic
Signal Units:	T Teslas
Channel Flags:	G

Humidity: Absolute/Relative measurements of the humidity. Temperature recordings may also be essential for meaningful results.

Instrument Code

I

Orientation Code

O	Outside Environment
I	Inside Building
D	Down Hole
1 2 3 4	Cabinet Sources

All other letters available for mnemonic source types.

Dip/Azimuth:	Not applicable Should be zero.
Signal Units:	%
Channel Flags:	W

Rotational Sensor: Measures solid-body rotations about an axis, commonly given in "displacement" (radians), velocity (radians/second) or acceleration (radians/second^2).

Instrument Code

J

Orientation Code

Z N E	Traditional (Vertical, North-South, East-West)
A B C	Triaxial (Along the edges of a cube turned up on a corner)
T R	For formed beams (Transverse, Radial)
1 2 3	Orthogonal components but non traditional orientations
U V W	Optional components
Dip/Azimuth:	Axis about which rotation is measured following right-handed rule.
Signal Units:	rad, rad/s, rad/s^2 – following right-handed rule
Channel Flags:	G

Temperature: Measurement of the temperature at some location. Typically used for measuring:

1. Weather	- Outside Temperature
2. State of Health	- Inside recording building
	- Down hole
	- Inside electronics

Instrument Code

K

Orientation Code

O	Outside Environment
I	Inside Building
D	Down Hole
1 2 3 4	Cabinet sources

All other letters available for mnemonic types.

Dip Azimuth:	Not applicable Should be zero.
Signal Units:	deg C or deg K
Channel Flags:	W or H

Water Current: This measurement measures the velocity of water in a given direction. The measurement may be at depth, within a borehole, or a variety of other locations.

Instrument Code

O

Orientation Code

Unknown

Dip/Azimuth:	Along current direction
Signal Units:	M/S
Channel Flags:	G

Geophone: Very short period seismometer, with natural frequency 5 - 10 Hz or higher.

Instrument Code

P

Orientation Code

Z N E	Traditional
Dip/Azimuth:	Ground Motion Vector (Reverse dip/azimuth if signal polarity incorrect)
Signal Units:	M, M/S, M/S
Channel Flags:	G

Electric Potential: Measures the Electric Potential between two points. This is normally done using a high impedance voltmeter connected to two electrodes driven into the ground. In the case of magnetotelleuric work, this is one parameter that must be measured.

Instrument Code

Q

Orientation Code

Unknown

Signal Units: V Volts

Channel Flags: G

Rainfall: Measures total rainfall, or an amount per sampling interval.

Instrument Code

R

Orientation Code

Unknown

Dip/Azimuth:	Not applicable Should be zero.
Signal Units:	M, M/S
Channel Flags:	W

Linear Strain: One typical application is to build a very sensitive displacement-measuring device, typically a long quartz rod. One end is affixed to a wall. On the free end, a pylon from the floor reaches up to the rod where something measures the position of the pylon on the rod (like a large LVDT).

There are also some interferometry projects that measure distance with lasers. Dip/Azimuth are the line of the movement being measured. Positive values are obtained when stress/distance increases, negative, when they decrease.

Instrument Code

S

Orientation Code

Z N E	Vertical, North-South, East-West
Dip/Azimuth:	Along axis of instrument
Signal Units:	M/M
Channel Flags:	G

Tide: Not to be confused with lunar tidal filters or gravimeter output. Tide instruments measure the depth of the water at the monitoring site.

Instrument Code

T

Orientation Code

Z Always vertical

Dip/Azimuth: Always vertical

Signal Units: M Relative to sea level or local ocean depth

Channel Flags: G

Bolometer: Infrared instrument used to evaluate average cloud cover. Used in astronomy to determine observability of sky.

Instrument Code

U

Orientation Code

Unknown

Dip/Azimuth: Not applicable Should be zero.

Signal Units: Unknown

Channel Flags: W

Volumetric Strain: Unknown

Instrument Code

V

Orientation Code

Unknown

Dip/Azimuth: Not Applicable Should be zero.

Signal Units: M**3/M**3

Channel Flags: G

Wind: Measures the wind vector or velocity. Normal notion of dip and azimuth does not apply.

Instrument Code

W

Orientation Code

S	Wind speed
D	Wind Direction Vector Relative to geographic North
Dip/Azimuth:	Not Applicable Should be zero.
Channel Flags:	W

Synthesized Beams: This is used when forming beams from individual elements of an array. Refer to blockettes 35, 400, & 405.

Instrument Code

Z

Orientation Code

I	Incoherent Beam
C	Coherent Beam
F	FK Beam
O	Origin Beam
Dip/Azimuth:	Ground motion vector (reverse dip/azimuth if signal polarity incorrect)
Signal Units:	M, M/S, M/S**2, (for G & M) M/S**2 (usually)
Channel Flags:	G

Channel Code

We suggest that two sequences be reserved for special channels: the “LOG” channel for the console log, and the “SOH” channel for the main state of health channel. Subsidiary logs and state of health channels should begin with the “A” code; the source and orientation fields can then be used in any way.

Here are some typical channel arrangements used by a GSN system:

Channel	Description
EHZ/EHN/EHE	Short Period 100 sps
BHZ/BHN/BHE	Broad Band 20 sps

LHZ/LHN/LHE	Long Period 1 sps
VHZ/VHN/VHE	Very Long Period 0.1 sps
BCI	Broad Band Calibration Signal
ECI	Short Period Cal
LOG	Console Log
ACE	Administrative Clock Error
LCQ	1hz Clock Quality
OCF	Opaque Configuration File

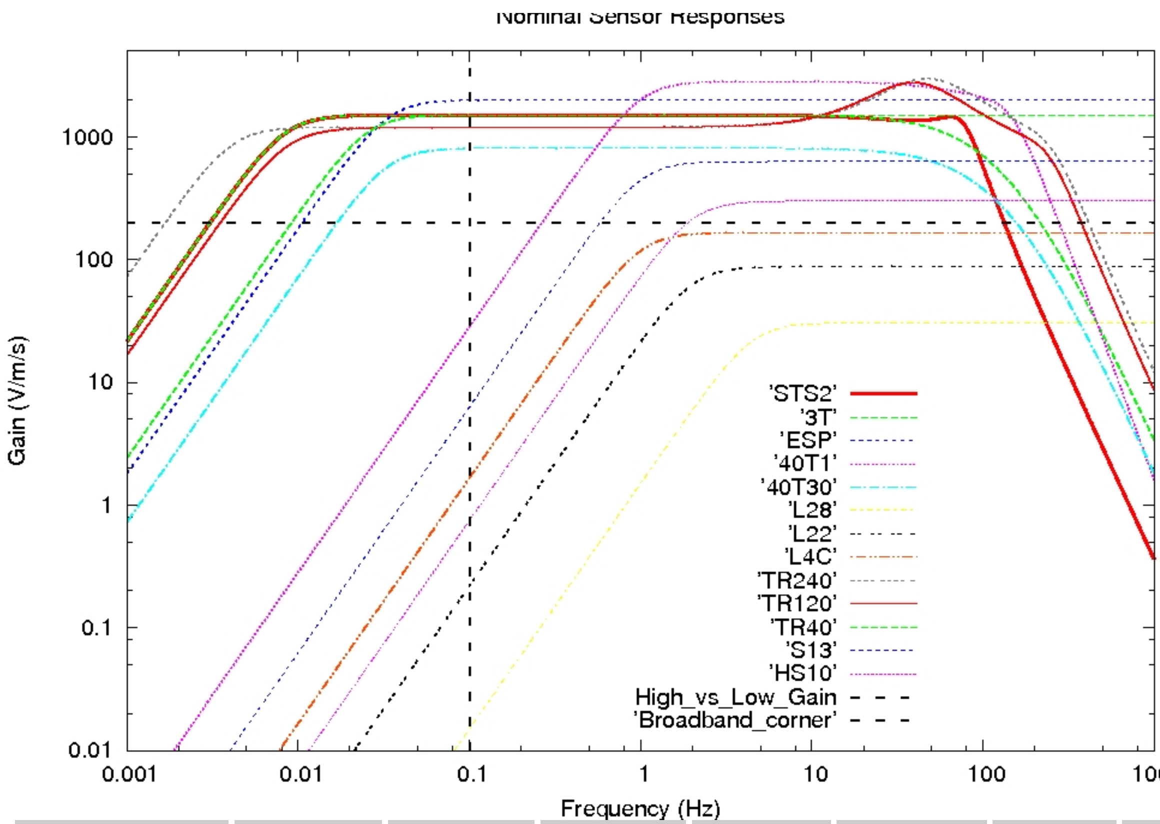
NOTE: Log Records: Log records have a channel identifier code of "LOG" and a sample rate of zero. The number of samples field is the number of characters in the record (including the carriage return and line feed that terminates each line). Log messages are packed into records until a message falls into a new minute. Log records have no blockettes, so the strings start at offset 48. For examples of Log Records, ACE, and OCF channels, refer to the end of Appendix E.

End of appendix A from SEED Manual

Recommended SEED Channel Names

George Slad (Data Group at PASSCAL)

Instrument	Sample Rates (Hz)							
	>= 1000 to < 5000	>= 250 to < 1000	>= 80 to < 250	10 >= to < 80	>1 to < 10	1	0.1	0.01
STS-2	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
CMG-3T	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
CMG-ESP	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
TR-240	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
TR-120	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
TR-40	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
CMG-40T 30s	FH?	CH?	HH?	BH?	MH?	LH?	VH?	UH?
CMG-40T 1s	GH?	DH?	EH?	SH?	MH?	LH?	VH?	UH?
S-13	GH?	DH?	EH?	SH?	MH?	LH?	VH?	UH?
HS-10	GH?	DH?	EH?	SH?	MH?	LH?	VH?	UH?
L-4C*	GH?	DL?	EL?	SL?	ML?	LL?	VL?	UL?
L-22*	GH?	DL?	EL?	SL?	ML?	LL?	VL?	UL?



L-28	GL?	DL?	EL?	SL?	ML?	LL?	VL?	UL?
L-28LB (4.5 Hz geophone)*	GH?	DL?	EL?	SL?	ML?	LL?	VL?	UL?
L-40A (40 Hz geophone)*	GH?	DL?	EP?	SP?	MP?	LP?	VP?	UP?
FBA ES-T	FN?	CN?	HN?	BN?	MN?	LN?	VH?	UN?

Table 1. Recommended SEED channel names for many of the sensors available from PASSCAL.

* The use of "H", denoting high gain, assumes that the dataloggers are programmed using a gain of 32, which is the recommended gain setting for a typical PASSCAL experiment. In the event the gain is set to 1 at the datalogger, then the second character of the channel name should be set to "L" .

Figure 1. General responses of most sensors available from PASSCAL. The black horizontal and vertical dash lines indicate the suggested division between low and high gains instruments and the SEED manual division between broadband and short-period sensors respectively.

Notes regarding recommendations:

A gain of 250 V/m/s was somewhat arbitrarily chosen as the division between 'High gain' and 'Low gain' for our velocity sensors (the SEED manual does not quantitatively define High and Low gain). **Those sensors with a gain of 250 V/m/s and higher would use 'H' as the instrument code of the channel name, those less than 250 V/m/s would use 'L'.** This division places the STS-2, Guralps, Trilliums, S-13, and HS-10 in the high gain regime (for SEED channel naming) and the Mark Products sensors in the low-gain regime. [Note: the HS-10 is rarely shipped by PASSCAL; a search of the DMC's database shows the HS-10 (gain = 300

V/m/s @ 10 Hz) has been archived as a high gain sensor. The choice of 250 V/m/s therefore is consistent with the only instrument code used for previous submissions of HS-10 data.]

For consistency with the SEED manual, “L” is recommended as the instrument code for the 4.5 Hz geophone sensor, though in practice it is considered a geophone. The SEED manual recommends “P”, the geophone code, for sensors with a natural frequency of 5 - 10 Hz and higher.

For accelerometers, the use of the broadband band codes, "H" and "B", for the band code of the channel name are recommended. While the term "broad-band" typically is with respect to the flat portion of the response curve of velocity sensors, its use is logical for accelerometers when one considers their responses are flat with respect to acceleration.