Universal Sounding Format (USF) for TEM-data import

Version 1.0, July 2014

HydroGeophysics Group
Department of Geoscience,
Aarhus University, Denmark

1 UNIVERSAL SOUNDING FORMAT (USF)

The HydroGeophysics Group (HGG), Aarhus University, uses the USF-format to import ground based TEM data into the ViewTEM and the SPIA processing and inversions software via the USFImporter program.

The standard USF-file format is specified by:
Universal Sounding Format,
C. H. Stoyer, Interpex Limited, Golden CO:
http://www.interpex.com/universalSoundingFormat.PDF

In our implementation of the USF file format additional parameters (keywords) have been added to the standard USF format. The following specifies the HGG implementation of the USF file format.

1.1 HGG-GROUP CONTACT INFO:

Email: hgg@geo.au.dk
Web: www.hgg.au.dk

2 GENERAL USF-FILE STRUCTURE

The USF file must have the extension .USF and must be an ASCII file. The USF file consists of a numbers of keywords followed by the keyword value(s). For example: /SWEEPS: 64

Lines starting with non-recognizes keywords are ignored.

A USF file for TEM will normally consist of:

- Main Header
- Sounding Header
- 1st sweep Header
    - Data columns, 1st sweep
- 2nd sweep Header
    - Data columns, 2nd sweep
- 3rd sweep Header
    - Data columns, 3rd sweep
- ….

All data from one sounding/location must be located as sweeps under the same sounding header if they are to be inverted to a single resistivity model. If a sounding consists of e.g. a low and a high moment part, these two parts are specified as different channels in the sweep header, as in the USF file example of at the end of this document. We recommend creating one USF file per sounding.

In the main header, two forward slashes (//) are used before the keyword. In the sounding and sweep headers, one forward slash (/) is used before the keyword. The keywords must be in upper case. The keyword and keyword value(s) must be delimited by a colon (:) and space(s) or tab(s). The order of the keywords within the three header types does not matter.

- The keyword values can have four formats depending on the keyword
- Value: One real or one integer is specified
- Array: Two or more values are specified, comma (,) separated
- Text: Text string. Use ASCII alphabet
- Fixed text: A specific text string e.g. ‘CENTRAL LOOP TEM’

3 KEYWORDS AND THE KEYWORD VALUES

The tables below explain the different Keywords. The last column in the tables holds the following letter code:

R: Parameter required.
N1: Parameter not required, but used in ViewTEM during data import if available.
N2: Parameter not required and not used in ViewTEM during data import, but stored in the database.

Note: Keywords from the complete USF format specification (http://www.interpex.com/universalSoundingFormat.PDF) not listed in below tables are skipped like other non-recognized keywords.

In general, we use SI-units for the keyword values. The unit for different keyword values are stated in brackets [].

3.1 MAIN HEADER

Keyword	Type	Description	
//USF:	text	Start of Main Header. Free text string	R
//SOUNDING_GROUP_NAME:	text	Project name (used as project node label in ViewTEM)	N1
//SOUNDINGS:	integer	Number of soundings in the USF-file	R
//EPSG:	integer	EPSG value. -1 for unknown EPSG	N1
//DUMMY:	real	Dummy parameter. Can only be used for missing values in the sweep data columns.	R
//END		Marks end of main header	R

3.2 SOUNDING HEADER

Note: Orange colored keywords can either be placed once in the sounding header or repeated in all the sweeps headers. If the orange colored keyword is specified in the sounding header, then all the sweep data will be associated with this value.

Keyword	Value type	Description	
/SOUNDING_NAME	text	Sounding name (used as station/sounding node label name in ViewTEM)	N1
/LOCATION	array 3 x real	UTMX, UTMY, Elevation [m]. The geographical position of the sounding. Required if //EPSG is present in main header.	R
/INSTRUMENT	text	Instrument description.	N2
/ARRAY	fixed text	Supported loop configurations: FIXED LOOP TEM (used for offset and central loop config.) CENTRAL LOOP TEM (used for central loop only) COINCIDENT LOOP TEM	R
/LOOP_SIZE	array 2 x real	X ,Y side length of rectangular transmitter loop [m].	R
/COIL_LOCATION	array 2 x real	X, Y position of the receiver coil relative to the (0,0) center position of the transmitter coil [m]. Only used if ARRAY = FIXED LOOP TEM. Default: 0,0	N1
/Z_DIRECTION	fixed text	The direction of positive Z-axis for the voltage data. Values: UP => Flips the sign of the voltage data in the sweeps. DOWN => Do not flip the sign of the voltage data (Default)	N1
/VOLTAGE_UNITS	fixed text	Voltage data unit (data normalization). V/AM2 (data is normalized with current and receiver area) V/AMP (data is normalized with current) V/M2 or T/SEC (data is normalized with receiver area), V (data is not normalized) Note: specifying data normalized with transmitter area is not possible If the unit is not “V/AM2”, data will be converted to “V/AM2” during database import.	R
/COIL_SIZE	real	Effective area of receiver coil [m^2]. Not required for: /ARRAY: COINCIDENT LOOP or //VOLTAGE_UNITS: V/AM2 , V/M2	R
/LOW_PASS	real, integer	Cut off frequency [Hz], order of low pass filter. Repeat the two parameter filter definition, in same line, to model more low pass filters. E.g. 60e3, 1, 450e3, 1 (max three low pass filters are supported).	N1
/HIGH_PASS	real, integer	Cut off frequency [Hz], order of high pass filter. Repeat the two parameter filter definition, in same line, to model more high pass filters (max three low pass filters are supported).	N1
/TIME_DELAY	real	Delay of all gate times [s]. The TIME_DELAY is added to values in the TIME column in the data columns.	N1
/FIELD_SHIFT_FACTOR	real	Static shift factor of the field. Values in the VOLTAGE column in the data columns is multiplied with the FIELD_SHIFT_FACTOR	N1
/SWEEPS	integer	Number of sweeps for the sounding	R

3.3 SWEEP HEADER

Keyword	Value type	Description	
/SWEEP_NUMBER	integer	Sweep number	R
/SWEEP_IS_NOISE	integer	Specifies if the sweep is a noise sweep (data recorded with transmitter off) or a regular data sweep . 1 = Noise sweep, 0 = regular data sweep (default).	N1
/CHANNEL	integer	Software channel number. Sweeps with same CHANNEL number will be stacked in the ViewTEM program. Used for separating for example the low moment and high moment part of a sounding .	R
/CURRENT	real	Transmitter current [A]. If unknown for VOLTAGE_UNITS: V/AM2, V/AMP, then just state 1.0 A.	R
/FREQUENCY	real	Repetition frequency [Hz]. Used for calculating the length of the transmitter pulse assuming a 50% duty cycle. Length of transmitter pulse = 1/(4*FREQUENCY) If data not recorded with a 50% duty cycle, then specified the length of transmitter pulse under \TX_ONTIME	R
/TX_ONTIME	real	Length of transmitter pulse (waveform) [s]. Overwrites the length of transmitter pulse calculated based on the /FREQUENCY. Specify a /TX_ONTIME if you data is not recorded with a 50% duty cycle.	N1
/RAMP_TIME_ON or /RAMP_ON_TIME	real	Length of transmitter turn on ramp [s]	R
/RAMP_TIME	real	Length of transmitter turn off ramp [s]	R
/RX_FRONTGATE	real	Time the opening of the front gate [s]. Only very few TEM systems have a front gate.	N1
/POINTS	integer	Number of data points in the sweep. Sweeps with same /CHANNEL number must have the same number of data points.	R
/END		Marks end of sweep header.	R

3.4 HEADER LINE, DATA COLUMNS

Keyword	TIME,	VOLTAGE,	ST_DEV,	ERROR_BAR,	QUALITY
Description	Gate times [s]	Voltage data. Unit defined by /VOLTAGE_UNITS	Absolute voltage data uncertainty [absolute STD]	Relative voltage data uncertainty [relative STD]	0: Data point is default disabled. 1: Data point is default enabled
Required	Yes (R)	Yes (R)	No (N1)	No (N1)	No (N1)
Type	Real,	Real,	Real,	Real,	Integer
	\End Marks end of sweep data columns				

4 WAVEFORM DEFINITION, MODELING, AND GATE TIME REFERENCE

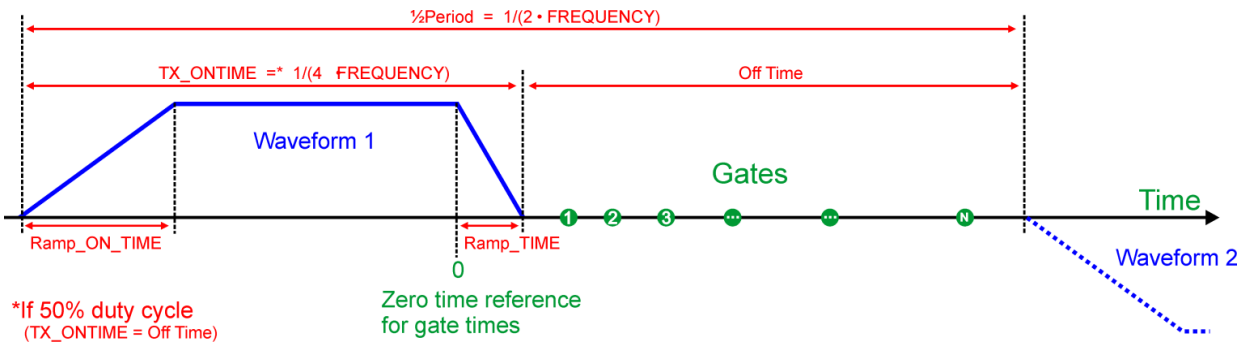

Figure 4.1 Waveform definition, modeling and gate time reference.

If the gate times are not "zero time" referenced as in Figure 4.1, then use the /TIME_DELAY setting to shift all the gates to obtain the correct "zero time" reference.

5 USF EXAMPLE FILE:

Central loop setup with two moments (only one sweep per moment in this case).

```
% --------Main Header----------------
//USF: Universal Sounding Format
//SOUNDINGS: 1
//EPSG: 32632
//DUMMY: 99999
//END

% --------Sounding Header----------------
/SOUNDING_NAME: Aarhus01
/LOCATION: 564518,  6224472,  76.1
/ARRAY: CENTRAL LOOP TEM
/LOOP_SIZE: 40, 40
/VOLTAGE_UNITS: V/M2
/LOW_PASS: 450000, 1, 300000, 1
/FIELD_SHIFT_FACTOR: 1.03
/TIME_DELAY: -3.1E-6
/SWEEPS: 2

% --------Sweep 1 Header (Low moment)----------------
/SWEEP_NUMBER: 1
/SWEEP_IS_NOISE: 0
/CHANNEL: 1
/CURRENT: 0.99
/FREQUENCY: 25
/COIL_SIZE: 105
/RAMP_ON_TIME: 125E-06
/RAMP_TIME: 3.5E-06
/POINTS: 35
/END

% --------Data block, sweep 1 (low moment) ----------------
 TIME,           VOLTAGE,    QUALITY
1.1950E-06,   -1.5378E-007,    0
3.1950E-06,    3.9253E-004,    0
5.1950E-06,    5.1950E-003,    0
7.1950E-06,    4.3798E-003,    0
9.1950E-06,    1.9204E-003,    1
1.1195E-05,    7.7604E-004,    1
1.3195E-05,    3.5579E-004,    1
1.5195E-05,    1.9107E-004,    1
1.7195E-05,    1.1658E-004,    1
1.9195E-05,    7.8583E-005,    1
2.1695E-05,    5.2881E-005,    1
2.4695E-05,    3.5887E-005,    1
2.8195E-05,    2.5202E-005,    1
3.2695E-05,    1.7051E-005,    1
```

3.8695E-05, 1.1501E-005, 1
4.6195E-05, 7.5158E-006, 1
5.5195E-05, 5.0101E-006, 1
6.6695E-05, 3.2791E-006, 1
8.1195E-05, 2.2362E-006, 1
9.9695E-05, 1.5122E-006, 1
1.2319E-04, 1.0307E-006, 1
1.5219E-04, 7.1772E-007, 1
1.8919E-04, 4.9140E-007, 1
2.3570E-04, 3.5989E-007, 1
2.9370E-04, 2.4386E-007, 1
3.6720E-04, 1.6446E-007, 1
4.5969E-04, 1.1303E-007, 1
5.7620E-04, 7.8907E-008, 1
7.2269E-04, 5.4941E-008, 1
9.0719E-04, 4.3368E-008, 1
1.1397E-03, 2.3627E-008, 1
1.4322E-03, 1.6296E-008, 1
1.8002E-03, 8.7267E-009, 1
2.2637E-03, 5.9160E-009, 1
2.8472E-03, 2.9153E-009, 1
/END

% --------Sweep 2 Header (High moment)----------
/SWEEP_NUMBER: 2
/SWEEP_IS_NOISE: 0
/CHANNEL: 2
/CURRENT: 7.53
/FREQUENCY: 12.5
/COIL_SIZE: 4200.00
/RAMP_ON_TIME: 700E-06
/RAMP_TIME: 5.5E-06
/POINTS: 33
/END
% --------Data block, sweep 1 (High moment) ----------
TIME , VOLTAGE, QUALITY
2.1695E-05, 2.1167E-009, 0
2.4695E-05, -3.2766E-009, 0
2.8195E-05, 3.1237E-009, 0
3.2695E-05, 2.3968E-009, 0
3.8695E-05, -6.9841E-010, 0
4.6195E-05, 3.9780E-011, 0
5.5195E-05, 4.8039E-010, 0
6.6695E-05, 4.5612E-010, 0
8.1195E-05, 6.6019E-006, 0
9.9695E-05, 1.1240E-005, 0
1.2319E-04, 7.6403E-006, 1
1.5219E-04, 5.2985E-006, 1
1.8919E-04, 3.6850E-006, 1
2.3570E-04, 2.5626E-006, 1
2.9370E-04, 1.7841E-006, 1
3.6720E-04, 1.2333E-006, 1
4.5969E-04, 8.5324E-007, 1

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5.7620E-04,   5.9200E-007,   1
7.2269E-04,   4.1178E-007,   1
9.0719E-04,   2.8314E-007,   1
1.1397E-03,   1.9052E-007,   1
1.4322E-03,   1.2378E-007,   1
1.8002E-03,   7.7346E-008,   1
2.2637E-03,   4.6304E-008,   1
2.8472E-03,   2.6655E-008,   1
3.5817E-03,   1.4727E-008,   1
4.5067E-03,   7.8615E-009,   1
5.6712E-03,   4.0616E-009,   1
7.1367E-03,   2.1845E-009,   1
8.8532E-03,   1.2058E-009,   1
1.0753E-02,   7.6607E-010,   1
1.3253E-02,   4.8091E-010,   1
1.7253E-02,   2.7445E-010,   1
/END
```