# Binary 3D Data Cube Format for E-fields Versions 1 to 5

Version 1: Adam B. Birchfield, Texas A&M University, 3/24/2017

Version 2: Thomas J. Overbye, Texas A&M University, January 2020

Version 3: Thomas J. Overbye, Texas A&M University, April 2021

Version 4: Thomas J. Overbye, Texas A&M University, May 2021

Version 4: Thomas J. Overbye, Texas A&M University, July 12, 2023. Added support for fields. Modified the Metadata section to support the optional storage of field names. Also, clarified that the TIME_0 value will not be the first time point if variable time points are used and the first value is not zero; the TIME_0 value

Version 5: Thomas J. Overbye, Texas A&M University, August 2023. Added support for multiple separate events. This is done by allowing everything after the VERSION field to be repeated multiple times, once for each event.

This document describes the Version 2, 3, 4 and 5 data format for *.b3d files which hold two-dimensional, time-varying data such as electric fields. It is a binary format which uses little-endian order. The types allowed are: unsigned 32-bit integers (UINT), bytes, and single-precision 32-bit floating-point numbers (FLOAT). In addition, the metadata is specified with single-byte ASCII null-terminated strings. All new code should use version 2 as its default. The version 1 format is given below, but as of January 2020 version 1 is deprecated.

Version 3 only adds one additional UINT field to allow non-integer second starting times

Version 4 only adds one additional UINT field to provide more time field flexibility

July 12, 2023: Modified the Metadata section to support the optional storage of field names. Also, clarified that the TIME_0 value will not be the first time point if variable time points are used and the first value is not zero; the TIME_0 value is now known as the REFERENCE TIME.

| Name | Bytes | Type | Description | Example |
|---|---|---|---|---|
| KEY | 4 | UINT | Use decimal code 34280 to confirm the file type. | Hex: E8 85 00 00 |
| VERSION | 4 | UINT | Use decimal code 5 for this current version | Hex: 05 00 |
| | | | Starting with Version 5 everything after this point can be repeated once for each event. If there is a single event then a Version 5 file is identical to a Version 4 file. With multiple events the | |

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|---|---|---|---|---|
| META_STRINGS | 4 | UINT | Number of strings in the metadata section | 6 |
| (Metadata) | variable | ASCII Strings | META_STRINGS number of ASCII strings terminated with 1-byte null characters.<br>Starting in July 2023, this section can contain fields, with one field per line. The format for fields is "<fieldname> field value. Currently PowerWorld supports two fields: NAME is used to indicate the name of the associated event and ACTIVE with a YES field value indicating the data should be used in any associated event analysis. | First Event<br><ACTIVE>Yes<br><NAME>EventA |
| FLOAT_CHANNELS | 4 | UINT | Number of floating point number channels at each point. For data with X and Y directional E-fields, this value will be 2. Convention will be to put X first and then Y. | Hex: 02 00 |
| BYTE_CHANNELS | 4 | UINT | Number of byte channels at each point. Usually this value is either zero or one to indicate a quality flag byte | Hex: 01 00 |
| LOC_FORMAT | 4 | UINT | Used to indicate the location format. In version 2 this value should be either 0 or 1. If zero the point locations are specified by a grid with the next six FLOAT fields. This was the only approach used in Version 1. If the LOC_FORMAT is 1 then the points are specified by UINT number of points and then three location fields for each point. | |
| LON_0 | 4 | FLOAT | Longitude of first point in degrees (only if LOCATION FORMAT = 0) | -112.0 |
| LON_STEP | 4 | FLOAT | Longitude step in degrees (only if LOCATION FORMAT = 0) | 0.5 |
| LON_POINTS | 4 | UINT | Number of longitude points (only if LOCATION FORMAT = 0) | 30 |
| LAT_0 | 4 | FLOAT | Latitude of first point in degrees (only if LOCATION FORMAT = 0) | 40.0 |
| LAT_STEP | 4 | FLOAT | Latitude step in degrees (only if LOCATION FORMAT = 0) | 0.5 |
| LAT_POINTS | 4 | UINT | Number of latitude points (only if LOCATION FORMAT = 0) | 25 |
| NUM_ POINTS | 4 | UINT | Number of point locations. Each point location is specified by three FLOATs with details in the next row. (only if LOCATION FORMAT = 1) | 125 |
| (Location Data Section) | variable | FLOATs | If the LOC_ FORMAT = 1 this section contains the point locations, with each point specified by three FLOATs. The first FLOAT gives the point's longitude in degrees, the second FLOAT gives the point's latitude in degrees, and the third FLOAT gives the distance to the nearest measurement station in km. Hence the third float is used to indicate if a point has been interpolated. If the point corresponds to a measurement station then this field should | |

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| | | | be 0. If the measurement station location is unknown, then the value should be less than zero. | |
| TIME_0 | 4 | UINT | Seconds of first time point, using midnight 1/1/1970 as epoch, not counting leap seconds. (Same as IEEE Std. C37.118.2-2011) | 5/7/2016 00:00:00 = 1,462,665,600 |
| TIME_1 | 4 | UINT | Starting with Version 4. Indicates the TIME_UNITS scaling used for subsequent time values. Valid entries are 0 indicating milliseconds, 1 indicating seconds, -1 for microseconds, -2 for nanoseconds | 0 indicates TIME_UNITS of milliseconds, -2 for nanoseconds |
| TIME_2 | 4 | UINT | Starting with Version 3. Number of TIME_UNITS offset in first time point | With TIME_UNITS of milliseconds, 400 would be an offset of 0.4 seconds |
| TIME_STEP | 4 | UINT | Constant time step in TIME_UNITS. If set to zero, indicates variable time step (see below). | 10,000 with TIME_UNITS of 0 would be 10 seconds. |
| TIME_POINTS | 4 | UINT | Number of time points | 25,920 |
| (Variable time points) | variable | UINTs | If TIME_STEP > 0, this section will be skipped. Otherwise, the section consists of TIME_POINTS number of 4-byte UINTs, giving the time in TIME_UNITS of each point since TIME_0. | |
| (Data Section) | variable | FLOATs | This section contains the actual data. The section contains (FLOAT_CHANNEL*4 + BYTE_CHANNEL) * NUM_POINTS * TIME_POINTS bytes.<br>If LOC_FORMAT = 0 then NUM_POINTS is automatically set from the grid values. The first element is at TIME_0, LAT_0, LON_0, and the first FLOAT channel. Then the rest of the FLOAT_CHANNELs are given for this location and time followed by the BYTE_CHANNELS. Then the data for the next point is given. If LOC_FORMAT is zero then the grid points are given by latitude rows so the next point would be LAT_0, LON_1, continuing for all the longitude points in the row; then the next row of latitude will be given, still at the same time point.<br><br>Once all the data for the first time point is given, the second time point will be given in the same way, continuing to the end of the time series.<br><br>Note that for electric fields the convention is to record the data in units of V/km. | |
| | | | Optionally starting with Version 5 the fields repeat for a second and subsequent events | |
| META_STRINGS (for the second event) | 4 | UINT | Number of strings in the metadata section | 6 |
| (Metadata) (for the second event) | variable | ASCII Strings | For the second and following events the <NAME> field should be used to identify the event. | Second Event<br><ACTIVE>Yes<br><NAME>EventB |
| … | | | Fields as noted above for the second event | |

# Binary 3D Data Cube Format for E-fields Version 1

Adam B. Birchfield, Texas A&M University, 3/24/2017

This document describes the version 1 data format for *.b3d files which hold two-dimensional, time-varying data such as electric fields. It is a binary format which uses little-endian order. The types allowed are: unsigned 32-bit integers (UINT), and single-precision 32-bit floating-point numbers (FLOAT). In addition, the metadata is specified with single-byte ASCII null-terminated strings. All new code should implement version 2, given above.

| Name | Bytes | Type | Description | Example |
|---|---|---|---|---|
| KEY | 4 | UINT | Use decimal code 34280 to confirm the file type. | Hex: E8 85 00 00 |
| VERSION | 4 | UINT | Use decimal code 1 for this current version | Hex: 01 00 |
| META_STRINGS | 4 | UINT | Number of strings in the metadata section | 6 |
| (Metadata) | variable | ASCII Strings | META_STRINGS number of ASCII strings terminated with 1-byte null characters. | “test_meta\0” |
| CHANNELS | 4 | UINT | Number of channels at each point. For data with X and Y directional E-fields, this value will be 2. Convention will be to put X first and then Y. | Hex: 02 00 |
| LON_0 | 4 | FLOAT | Longitude of first point in degrees | -112.0 |
| LON_STEP | 4 | FLOAT | Longitude step in degrees | 0.5 |
| LON_POINTS | 4 | UINT | Number of longitude points | 30 |
| LAT_0 | 4 | FLOAT | Latitude of first point in degrees | 40.0 |
| LAT_STEP | 4 | FLOAT | Latitude step in degrees | 0.5 |
| LAT_POINTS | 4 | UINT | Number of latitude points | 25 |
| TIME_0 | 4 | UINT | Seconds of first time point, using midnight 1/1/1970 as epoch, not counting leap seconds. (Same as IEEE Std. C37.118.2-2011) | 5/7/2016 00:00:00 = 1,462,665,600 |
| TIME_STEP | 4 | UINT | Constant time step in milliseconds. If set to zero, indicates variable time step (see below). | 10,000 |
| TIME_POINTS | 4 | UINT | Number of time points | 25,920 |
| (Variable time points) | variable | UINTs | If TIME_STEP > 0, this section will be skipped. Otherwise, the section consists of TIME_POINTS number of 4-byte UINTs, giving the time in milliseconds of each point since TIME_0. | |
| (Data section) | variable | FLOATs | This section contains the actual data. The section contains CHANNELS*LON_POINTS*LAT_POINTS*TIME_POINTS number of 4-byte elements of type FLOAT. The first element is at TIME_0, LAT_0, LON_0, and the first channel. Then the rest of the channels are given for that location and time. Then the next longitude point is given, continuing along LAT_0 until there are CHANNELS*LON_POINTS elements. Then the next row of latitude will be given, still at the same time point. Each row of latitude will be added until there are CHANNELS*LON_POINTS*LAT_POINTS elements. Once all the data for the first time point is given, the | |

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| | | | second time point will be given in the same way, continuing to the end of the time series.<br>Note that for electric fields the convention is to record the data in units of V/km. |