

BINARY FORMAT DESCRIPTION

Introduction

This section describes an optional binary format for the numerical portion under the [Network Data] and [Noise Data] keywords. A binary format is useful for large files as it can reduce memory storage requirements significantly compared to the same data represented in ASCII format.

The binary format is designated by the [Binary] keyword and is supported in [Version] 2.1 and above Touchstone files. The rules and limitations are discussed under the keyword descriptions.

Conversions to and from the binary format shall preserve all existing ASCII content in the file except for the numerical portions under the [Network Data] and/or [Noise Data] keywords. The [Binary] section of a Touchstone 2.1 file shall contain binary data only. Any conversion utility shall not process (shall ignore) comment characters, and the text which follows, to the end of the commented line. Blank lines shall also be ignored by binary conversion utilities.

[Binary]

Rules for Version 1.0 Files:

The [Binary] keyword is not permitted in Version 1.0 files.

Rules for Version 2.0 and Greater Files:

The [Binary] keyword is not permitted in Version 2.0 files. The [Binary] keyword is optional for Version 2.1 and greater files.

The [Binary] keyword indicates that network data is presented in binary format, for purposes of file size compression and faster file parsing. The binary data is to be presented using the interchange format defined by the IEEE 754-2008 standard.

The [Binary] keyword shall follow immediately after the [Network Data] and/or the [Noise Data] keywords, excepting blank lines and comments, whenever the numerical data indicated by those keywords is encoded in a binary format. The [Binary] keyword is the only keyword permitted within the hierarchical scopes of the [Network Data] and [Noise Data] keywords.

The [Binary] keyword may appear only once under the [Network Data] keyword and only once under the [Binary Data] keyword.

[Binary] shall be followed by three arguments separated from the keyword and each other by whitespace.

The first argument indicates the numerical precision of the frequency information.

The second argument indicates numerical precision of the data.

The third argument indicates the assumed significance ordering of the bytes within each data word, where a word is either 4 or 8 bytes, depending on the value of the precision arguments.

Only one of the two strings below is permitted for each of the first two (precision) arguments; these shall include the numerical values and '-' (dash) character as shown:

32-Bit: also known as single precision floating point

64-Bit: also known as double precision

Only one of the two strings below is permitted for the third (byte order) argument; this shall include the '-' (dash) character as shown:

Big-Endian: most significant byte first

Little-Endian: least significant byte first

Example #:

```
[Binary] 64-Bit 32-Bit Little-Endian
```

The example above indicates 64-bit precision frequency and 32-bit precision floating point data in little-endian order.

The [Binary] keyword arguments shall be followed by a line-termination sequence. Immediately following the line-termination sequence shall be a single byte with value 0 (e.g., binary 00000000) to indicate that the information that follows will be in binary format.

No other keywords or comments are permitted after line-termination sequence following the [Binary] keyword's arguments.

The file shall be terminated by the [End] keyword, regardless of the presence of the [Binary] keyword.

Example #:

```
[Version] 2.1
# MHZ S RI R 50
[Number of Ports] 4
[Number of Frequencies] 1
! FREQ S11 S12 S13 S14
! S21 S22 S23 S24
! S31 S32 S33 S34
! S41 S42 S43 S44
!
[Network Data] ! numerical data in (hex) binary format
! Note that binary data is NOT to be represented as hexadecimal values in
! actual Touchstone files. Hexadecimal values have been shown here for
! educational purposes only, to ease comparison of binary and ASCII data.
! Similarly, spaces between the hexadecimal values are shown for readability
! only. Whitespace is not to be inserted into binary network data.
[Binary] 64-Bit 32-Bit Little-Endian
```

```
00 00 00 00 00 00 00 00 f0 3f 48 0f a9 3c 98 a4 72 bc 52 3d 74 3f ff 28 45 be fc
2d 17 bb ec b5 f6 3b bf 41 b8 bb 72 1b a5 ba 68 3d 74 3f 0c 29 45 be 73 0f a9
3c ee a4 72 bc ca 3c b8 bb 64 22 a5 ba a1 39 17 bb f2 b7 f6 3b 01 2c 17 bb bf
b5 f6 3b 6c 40 b8 bb 28 1d a5 ba b9 0f a9 3c 83 a4 72 bc 54 3d 74 3f e4 28 45
be 47 40 b8 bb ff 1d a5 ba ed 3b 17 bb 4e b8 f6 3b 6a 3d 74 3f 06 29 45 be cd
11 a9 3c 7b a6 72 bc
```

[End]

The example corresponds to the following ASCII text, with the addition of the [Binary] keyword, its arguments and the hex data shown:

```
[Version] 2.1
# MHZ S RI R 50
[Number of Ports] 4
[Number of Frequencies] 1
! FREQ S11 S12 S13 S14
! S21 S22 S23 S24
! S31 S32 S33 S34
! S41 S42 S43 S44
!
[Network Data]
1.000000e+001
2.063717e-002 -1.480975e-002 9.540607e-001 -1.925392e-001
-2.306818e-003 7.529011e-003 -5.623072e-003 -1.259668e-003
9.540620e-001 -1.925394e-001 2.063725e-002 -1.480983e-002
-5.622481e-003 -1.259875e-003 -2.307512e-003 7.529252e-003
-2.306700e-003 7.528990e-003 -5.622914e-003 -1.259719e-003
2.063738e-002 -1.480973e-002 9.540608e-001 -1.925388e-001
-5.622897e-003 -1.259744e-003 -2.307649e-003 7.529295e-003
9.540621e-001 -1.925393e-001 2.063837e-002 -1.481020e-002
[End]
```