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Society of Exploration Geophysicists MT/EMAP Data Interchange Standard[1]

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Foreword

In early 1986, representatives from some of the major users of magnetotelluric (MT) and electromagnetic array profiling (EMAP) data formed an ad hoc committee to investigate a standard for the interchange and archiving of data. The original committee consisted of Richard Sisal (Amoco), Truman Holcombe (Standard), Roy Warren (Exxon), and Joe McNutt (Shell).

By June 1986, the committee produced a first draft describing an industry-wide standard for the interchange of MT and EMAP data. Over the course of the next sixteen months, the standard was circulated to a variety of audiences who deal with MT and EMAP data including oil company representatives, contractors, and consultants. A draft was presented to the SEG Standards Committee in November 1986 and copies were circulated to the committee members. During this period, successive drafts were produced which incorporated comments from the various reviewers. Also during this time, a FORTRAN program for reading and writing data in the standard format was implemented. This proved to be very valuable in uncovering discrepancies, inconsistencies, and implementation problems prior to adoption of the standard.

In August 1987, a meeting of the ad hoc committee was held to resolve the remaining issues and approve a final draft. The resulting draft was forwarded to Mr. Ben Thigpen, chairman of the SEG Standards Committee, for consideration at the committee's next meeting. After incorporating minor revisions proposed by the SEG Standards Committee, the Standard was presented to the SEG Executive committee and was adopted on December 14, 1987.

I would especially like to recognize Richard Sisal of Amoco and Truman Holcombe of Standard Oil for being major contributors to the data standard project. Although many people contributed to this data standard, I would like to thank the following persons for providing the valuable comments and criticisms which shaped this document: Karen Christophersen and Ransom Reddig of Standard Oil, Dwight Eggers of Arco, Michael Rudder of Exxon, Bob Anderson of Phoenix Geoscience, Arnold Orange of Emerald Exploration, and Francis Bostick of the University of Texas.

David Wight
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MT/EMAP Data Interchange Standard

1.0 Introduction

This data standard was developed with help from representatives of oil companies, contractors, and consultants involved in the acquisition, processing, and interpretation of magnetotelluric (MT) and electromagnetic array profiling (EMAP) data. Its primary purpose is to facilitate data exchange from contractors to clients and among clients. It also serves a very important function as a standard format for archiving data.

The format has been designed to accommodate a wide variety of different field measurement configurations and processing requirements which might arise from special applications or new developments. Although very similar in appearance to some existing formats, it has been slightly modified to be more consistent, unambiguous, extensible, and realizable. A number of refinements have been incorporated as a result of actually implementing the standard.

The format can accommodate any currently used data acquisition configuration, and has the flexibility to handle any reasonable future configuration. Supported configurations include single and multi-station MT, telluric-magnetotelluric (TMT) sounding, EMAP profiling, and combinations of the above. Provisions have been made for interchange of data at various levels of acquisition and processing including time series, power spectra, impedance, and computed parameters including non-standard parameters. The data interchange file is always an ASCII file. However, a provision has been made to store actual data values in a parallel binary data file and reference them through the (ASCII) data interchange file.

A standard file for the interchange of data from MT, EMAP, or similar electrical geophysical techniques is called an Electrical Data Interchange (EDI) file.

2.0 Purpose and Scope

This document addresses three separate areas:

(1) The physical format and media for data interchange.
(2) Definitions and conventions for representing electrical geophysical data.
(3) The syntax and semantics of a data interchange file.

The first area defines the physical format and media on which data interchange files may reside. Although the only media currently specified by the standard is magnetic tape, there are discussions of the use of non-standard media and data communication channels for data interchange.

Although the syntax and semantics define the set of characters and bytes which comprise the data, they do not, for example, define the units for power spectra or the quadrants for apparent resistivity phase. The use of a unique data block name for each defined data type assures no misunderstandings as to the meaning of a given data block. Provisions have been made for the addition of new data types and for the restricted use of non-standard data types.

The syntax and semantics of an electrical data interchange (EDI) file are completely specified by this document in the same way that a computer language is specified by its manual. In fact, a data interchange file may be thought of as a program written in a "data interchange programming language" as defined in this document. A program which reads data interchange files and converts the data into a usable form is very analogous to a compiler.

3.0 Organization of Standard

Section 4 defines the physical format and media on which EDI files may reside. Specifically, it defines the use of magnetic tape, the only currently standardized media. It also discusses the use of non-standard media and data communication channels.

In Section 5 units and conventions are defined for the geophysical quantities which may be represented within an EDI file.

Section 6 first introduces the concept of a context-free grammar and the BNF (Backus-Naur form) notation. This notation will be used in later sections to define the syntax of an EDI file. The section then uses this notation to define a series of constructs which will be the basic constituents of our syntactic definition.

Section 7 provides a high level syntactic and semantic overview of an EDI file. First, it introduces the concepts of data blocks and data sections. Then, it briefly discusses how an EDI file is made up of a Head block, an Info block, a measurement definition section, one or more data sections, and an end block.

Sections 8-20 of the standard provide detailed descriptions of all of the types of data blocks from which EDI files are made. The definitions for data blocks are grouped such that several blocks all having the same characteristics are defined in one place. Each definition includes (1) a list of the data blocks and a brief description of each, (2) a description of the restrictions regarding where in an EDI file the block(s) may appear, (3) a list of options which may be used with the block(s), (4) restrictions on the data set which may be part of the data block, and (5) any other notes regarding the use of the block(s).

Section 2.1 describes the mechanism for orderly evolution of this standard.

Appendix 1 contains a list of terms and definitions used within this document. It is recommended that this list be read prior to reading the main text of the standard.

Appendix 2 contains a complete summary of the syntax for an EDI file using BNF notation.

Appendix 3 is a diagram summarizing the ordering of data blocks within an EDI file.

Appendices 4 and 5 give simple examples of EDI files for an MT site and an EMAP line.

The Reference section lists the sources for the geophysical conventions embraced by this standard.

4.0 Physical Format and Media

4.1 Magnetic Tape and Tape Cartridges

At the present time, the only universal media is still 9 track 1/2" magnetic tape. This is the only standard media for electrical data interchange. Tapes must meet the specifications set forth in ANSI standard for unrecorded information interchange X3.40-1976.

The IBM 3480 tape cartridge is rapidly gaining acceptance as a standard media. Therefore, it is also acceptable as an interchange media. If this media is used, it is to be organized in the same manner as a magnetic tape.

The preferred and recommended media and format for the interchange and archival of electrical geophysical data is:

(1) 1/2" magnetic tape recorded at l600 characters per inch (CPI) using phase encoding (PE) as specified by ANSI X3.39-1973

The standard, however, allows use of the following alternative media and formats if they are more appropriate:

(2) 1/2" magnetic tape recorded at 800 characters per inch (CPI) using non-return-to-zero inverted (NRZI) encoding as specified by ANSI X3.22-1973.

(3) 1/2" magnetic tape recorded at 6250 characters per inch (CPI) using group-coding as specified by ANSI X3.54-1976.

(4) IBM 3480 compatible 1/2" tape cartridge recorded as specified by ANSII X3B5 (Draft 7 or later) "Proposed Standard for Recorded Magnetic Tape and Cartridge for Information Interchange".

Whichever format and media are used, they must comply with the corresponding ANSI standard and must be clearly labeled as to which recording format was used for recording. These are standard formats and drivers for reading and writing tapes in these formats are provided on most computer systems. Copies of the ANSI standards cited above are available from:

American National Standards Institute
1430 Broadway
New York, N.Y. 10018

Many computer systems support a flexible record structure and method of writing labels and organizing data on magnetic tapes. Many are unique to a particular computer system. The most available system independent format is the ANSI Standard for Magnetic Tape Labels and File Structure for Information Interchange (X3.27-1978). Although such tape organizations are more versatile, they are not necessary for the exchange of EDI data.

This data interchange standard requires only the following very simple, "least common denominator" record structure and data organization. Tapes written in the following manner can be read or written by almost any computer system. Such tapes are often referred to as "unlabeled tapes". Most computer systems will provide a "Read/Write Foreign Tape" utility which can read and write tapes in the above format. If such a utility is not available, its simple structure allows a special driver to be written with a minimal effort.

Logical records must always be exactly 80 bytes in length. Space characters (ASCII 32) should be used to pad records. No explicit delimiters such as carriage returns or linefeeds are to be used. Physical records (or blocks) are to always be exactly 2000 bytes. Tapes may be 600, 1200 or 2400 feet as appropriate for the data set.

The first file on the tape, immediately after the beginning of tape (BOT) mark, will be a tape header file. This will be followed by one or more EDI files. There will be exactly one end-of-file mark <EOF> between files and two end-of-file <EOF> marks after the last data interchange file on the tape. The overall tape layout is as follows:

Leader
<BOT>
Tape Header File
<EOF>
Electrical Data Interchange File 1
<EOF>
Electrical Data Interchange File 2
<EOF>

…

Electrical Data Interchange File
<EOF>
<EOF>
Unused tape
<EOT>
Trailer

The contents of the tape header file are not in a fixed format. The header must contain legal ASCII characters (see Sections 6.21, 6.22) which convey all of the following information in a form which is clear and understandable to a person who does not have prior knowledge of the contents of the tape.

(1) Name and address of the creator of the tape.

(2) Date tape was generated,

(3) Computer system on which tape was generated and format information,

(4) Description of data on the tape.

(5) List of file numbers with a brief description of the contents of that file.

(6) If parallel binary data files are included (see Section 6.23), appropriate information must be included to uniquely associate each binary file with the corresponding EDI file.

Example of Tape Header File:

```
Tape Created by:        BIG OIL Geophysics
                        8108 Ness Drive, Suite A-230
                        Austin, Texas

Tape Creation Date: March 19, 1987

Tape Created Using:    Hewlett-Packard 9000/320 computer
                       Hewlett-Packard 7974A tape drive
                       1600 BPI PE. Rec size = 2000 bytes

The first 2 files are data from a combination EMAP/HT survey which was acquired by Big
Oil Geophysics (BOG) in Nolan County, Texas from August 1-Sept 15, 1986. The first file
is an EMAP Line (Line A) with 30 dipoles. The second is a parallel EMAP Line (Line S)
with 40 dipoles and 8 remote-reference MT stations located near dipoles 1, 6, 11, 16, 21,
26, 31, and 36. The third file is a synthetic EMAP data based on 2D forward model of the
first EMAP tine.

File Number Description

1       Field Data       EMAP Line A-1.00 - A-30.04
2       Field Data       EMAP Line B-l.00 - B-40.08,
                         MT B1, MT B6, MT-B11, MT-B16, MT B21, MT B26, MT B31, MT B36
3       Model Date       EMAP Line A model AMOD-1.00 - AMOD-30.00
```

4.2 File on Other Media

Even though magnetic tape and IBM 3480 compatible tape cartridges are the only media specified in this standard, many contractors and oil companies have computer systems which can exchange files using other media. Often the use of other media is more efficient than the use of magnetic tape. By mutual agreement, other media may freely be used for the exchange of EDI files. The device drivers which read and write logical records must, of course, use the same conventions for separation of records. Regardless of the media, the size of a logical record is not to exceed 128 bytes.

Once again, we point out that an EDI file is analogous to the source code file for a program. Its contents do not depend on the physical media or any file system organization on which it resides. Its meaning depends only upon the characters within the file which are organized according to a fixed set of rules.

For archival purposes, however, 9 track 1/2" magnetic tape recorded at 1600 BPI is the only allowed media.

4.3 Data Communications Channel

The exchange of EDI files need not be limited to physical media. Most computer systems now support the exchange of files over data communication links. EDI files can be transmitted from one computer to another using a mutually agreed upon protocol. It is highly recommended that any protocol used for the transmission of EDI files include a mechanism for error checking. As with physical media, the logical record length is not to exceed 128 bytes.

5.0 Geophysical Definitions, Conventions. and Units

5.1 Angles. Distances. and Locations

All azimuthal angular measurements are in degrees. Absolute angles, such as those in the measurement definition section, are relative to true north. Positive angles represent clockwise rotation and negative angles represent counterclockwise rotation. Angles are always to be reduced to the range of -180 degrees to +180 degrees. Note that impedance phase angles (see Section 5.5), however, are always measured counterclockwise in the complex plane.

The default units for lengths and distances are meters. However, any data block which specifies lengths or distances will include a UNITS=option. Use of the UNITS=FT option indicates that lengths and distances within that block are in feet rather than meters.

Absolute locations are expressed in terms of latitude, longitude, elevation, and (optionally) a brief textual description. Latitudes and longitudes are expressed as DEG:MIN:SEC. North and East are considered positive and South and West are considered negative. Elevations are relative to sea level with positive being upward. Unless the UNITS=FT option is specified, elevations are in meters. The recommended accuracy for latitudes and longitudes (for typical latitudes) is .01 seconds. Textual descriptions might refer to an intersection of two roads, or some other landmark.

5.2 Time Series Data

Because of the system dependent nature of data acquisition, there are no standard units for time series data. Generally, units are integers representing raw data before system response has been removed. If time series data sections are included within an EDI file, a full explanation of the nature of the data MUST be included within the >INFO section. This explanation should adequately describe the response of the measurement and recording system used for acquiring the data.

Because of the tremendous data volume, and its system dependent nature, time series data are not usually included with delivered data. It is only delivered when special reprocessing requirements preclude the use of another form of the data such as power spectra.

5.3 Power Spectra

Average power spectra estimates are often used to represent "raw" MT or EMAP data. Because most processing is done in the frequency domain, they are a convenient representation, and are much more compact than time series.

Power spectra are to be expressed in terms of standard units. Auto and cross power spectra for two electric field measurements are to be in units of ((mV/km)^2) / Hz. Auto and cross power spectra for two magnetic field measurements are to be in units of nT^2 / Hz. Cross power spectra for mixed measurements are to be in units of (nT(mV/km)) / Hz. All spectra are to be normalized for system response and number of samples. Unless specified otherwise by the ROT option, they are assumed to correspond to the measurement directions as defined in the >DEFINEMEAS section.

A >SPECTRA data block contains estimates of all the auto and cross power spectra for a set of measurements for a given frequency and bandwidth. These average spectra estimates are the result of averaging a number of independent spectra estimates. They may be independent in time (e.g. cascade decimation), or in frequency (e.g. FFT), or a combination. These data blocks usually represent the final averages, although the SEGNUM option allows delivery of smaller segments also.

5.4 Impedances

For tensor MT the surface impedance tensor has four components: ZXX, ZXY, ZYX, and ZYY which satisfy the impedance relations:

Ex = ZXX Hx + ZXY Hy
Ey = ZYX Hx + ZYY Hy

For EMAP, where only one component of the electric field is measured, it has only two: ZXX and ZXY which satisfy the impedance relation:

Ex = ZXXHx + ZXYHy

It is possible to compute the 4 MT impedance tensor estimates (ZXX, ZXY, ZYX, ZYY) from a set of spectra (in a least-squares sense), in a number of ways depending upon the reference fields used. The reference measurements (Rx, Ry) may be local or remote. For EMAP, impedances may be computed using the H component parallel to the line (ZXX) and using the H component perpendicular to the line (ZXY). For synthetic modeling applications, only ZXY may be required. However, in field acquisition where the line is not completely straight, both impedances must be provided.

For both MT and EMAP data, the option list for the data section will give the electric and magnetic field measurements from which the impedances were computed along with the reference measurements used. Impedances are normally assumed to be least-squares estimates using either local or remote reference measurements. In this case, 6 measurement ID's - Ex, Ey, Hx, Hy, Rx, and Ry must be specified. If another estimation technique has been used (such as L1 norm or averaging several least=squares estimates) it should be indicated using the TYPE option.

Unless specified otherwise by the ROT option, the impedances are assumed to be computed for the measurements in the measurement directions as defined in the >DEFINEMEAS section.

To allow reprocessing of tensor MT data from impedance estimates, the real and imaginary parts of all four impedances should be delivered. Although they may be provided in the measurement directions, it is often more convenient to rotate all of the impedances to either true north or to the strike angle. In the first case the ROT option should specify ROT=NORTH. Alternatively, a >ZROT data block may be included which indicates the rotation angle for each frequency relative to true north, and the ROT option should specify ROT=ZROT.

For EMAP data, the real and imaginary parts for the in-line and perpendicular impedances: ZXX and ZXY, should always be delivered. The spatially filtered impedances, FZXX and FZXY, should also be delivered. Because EMAP impedances are assumed to correspond to the measurement directions, the default ROT option (ROT=NONE) should always be used.

In order to provide rigorous error estimates for the surface impedance tensor elements, one must calculate the variance for the real part, the variance for the imaginary part, and a covariance. This is done in the usual manner for a finite number of estimates of the real and imaginary parts, which are clearly independent functions. This defines an error "ellipse" about the impedance tensor element in the complex plane. The >Z**R.VAR, >Z**I.VAR, and >Z**.COV (where ** is XX, XY, YX, or YY) keywords are provided for the real variance, imaginary variance, and covariance, respectively, for each tensor element. (Section 13.0).

However, the usual practice is to calculate a simplified "variance" as defined by Gamble, 1978, pp. 66-72. This is a real number (an estimate of the average of the variances of the real and imaginary parts) that is the radius of a circle about the tensor element in the complex plane. This circle approximates the error ellipse and for most purposes is an adequate estimate of the statistical uncertainty. The >Z**.VAR keyword is provided (Section 13.0) for this parameter. This is typically the only error estimate provided for impedance tensor components.

5.5 Apparent Resistivities and Phases

Apparent resistivities are given as:

$$\text{apparent resistivity(ij)} = \frac{|Zij|^2}{mu * omega} \qquad i,j=x,y$$

(where mu is the permeability of free space and omega is the frequency in radians), and are in units of ohm-meters.

The impedance phases are given by:

$$\text{impedance phase(i,j)} = TAN^{(-1)} \frac{[\ Im\ Zij]}{Re\ Zij} \qquad i,j-x,y$$

and are in degrees measured counterclockwise from the positive real axis in the complex plane. A homogeneous earth requires E and H fields to be in phase. The in-phase condition becomes +45 degrees for ZXY and -135 degrees for ZYX for generally accepted sign conventions for E and H. Note that this differs from the convention followed for azimuthal angles as specified in Section 5.1.

Unless specified otherwise by the ROT option, the impedances are assumed to be computed for the measurements in the measurement directions as defined in the >DEFINEMEAS section.

To allow reprocessing using alternative rotations of apparent resistivities for tensor MT data, the apparent resistivity magnitudes and phases computed from all four tensor impedances should be included. Although they may be delivered in the measurement directions with no >RHOROT data block included, it is often more convenient to rotate all of the apparent resistivities to either true north or to the strike angle. In the first case the ROT option should specify ROT=NORTH. Alternatively, a >RHOROT data block may be included which indicates the rotation angle for each frequency relative to true north, and the ROT option should specify ROT=RHOROT.

In cases where no reprocessing is anticipated, a two-dimensional model is sometimes assumed and the apparent resistivities are rotated such that RHOXY is parallel to the geological strike (or to another agreed upon angle) and RHOYX is perpendicular. In this case, RHOXX and RHOYY are assumed to be negligible and are not included.

For EMAP data, the apparent resistivity magnitudes and phases derived from the impedances computed from the parallel H component (RHOXX and PHSXX), and from the perpendicular H component (RHOXY and PHSXY) should be delivered. The apparent resistivity magnitude and phase from the corresponding spatially filtered impedances: FRHOXY, FPHSXY, FRHOXX, and FPHSXX, should also be delivered.

5.6 Continuous 1D Inversion

Continuous, one-dimensional inversions can be computed from apparent resistivity data sets. The Bostick inverse is the most common. A continuous inverse consists of two data sets. One record must contain a set of values representing depths which are strictly increasing. The units for the depths are meters unless the UNITS option specifies UNITS=FT. The second record contains a set of resistivity values which correspond one-to-one with the depth values. It is always in units of ohm-meters.

Any continuous inversion data blocks in a data section are assumed to be derived from the preceding apparent resistivity data blocks. If this is not true, it should be clearly indicated in the >INFO section. Unless specified otherwise by the ROT option, the inversions are assumed to be computed for the measurements in the measurement directions as defined in the >DEFINEMEAS section.

For tensor MT data, continuous inversions may be delivered for up to four apparent resistivities, although inversions for only RHOXY and RHOYX are usually included. For EMAP data, continuous inversions for the apparent resistivities computed from both the unfiltered and spatially filtered perpendicular impedance (RES1DXY, DEP1DXY, FRES1DXY, and FDEP1DXY) should be delivered. Optionally, continuous inversions for the apparent resistivities computed from both the unfiltered and spatially filtered parallel impedance (RES1DXY, DEP1DXX, FRES1DXX, and FDEP1DXX) may also be delivered.

The TYPE option should clearly indicate the technique used for inversion. If additional explanation is indicated, it should be in the >INFO section. For Bostick inversion, the type should indicate whether the apparent resistivity amplitudes (TYPE=BOSTICK-AMP) or Hilbert transform of the phase (TYPE=BOSTICK-PHS) data was used for estimating the slopes used in the inversion.

5.7 Signal Amplitude and Coherencies

The signal amplitude and coherencies are used in evaluating data quality, and identifying the source(s) of noise in the data. For identifying the source(s) of noise in the data it is most useful to have these parameters in the direction of the acquisition sensors, and for evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities. The orientation of these parameters can be specified using the ROT option. This option may be ROT=NONE, meaning that the parameters correspond to the measurement directions, ROT=RHOROT, meaning that the parameters correspond to the rotation angles given in the >RHOROT block, or RHO=NORTH, meaning that the parameters have been rotated to true north. The default is ROT=NONE.

The signal amplitude or power spectral density for any measurement can be delivered using a SIGAMP data block. The signal level may be useful in diagnosing poor data. The default for SIGAMP data is amplitude spectra. However, the option AMPPWR=PWR can be used to provide auto-power spectra instead. The units are the same as those for >SPECTRA data blocks (see Section 5.3), except, of course, for the appropriate amplitude/power conversion. The EUNITS or HUNITS option (as appropriate) may be used to specify the units if other than the default.

The signal amplitude (or power spectral density) can either be calculated from the total field (including the noise amplitude) or estimated using a remote field to eliminate the noise amplitude (Gambel, 1978). The default for the signal amplitude is the total field; however, the option TYPE-SIGNAL or TYPE-NOISE can be used to deliver the estimated signal or estimated noise.

For any two measurements A and B (in the temporal frequency domain), the coherency between A and B is defined as:

$$\text{COH} = \frac{|\langle AB^* \rangle|^2}{\langle A\,A^* \rangle \langle B\,B^* \rangle}$$

A and B are commonly the orthogonal electric and magnetic fields.

One can use an estimate of the impedance tensor to compute predicted E's, PEx and PEy, from the measured H's as:

$$\begin{aligned} PEx &= ZXX\ Hx + ZXY\ Hy \\ PEy &= ZYX\ Hx + ZYY\ Hy \end{aligned}$$

In a similar manner, one can use an estimate of the admittance tensor to compute predicted H's, PHx and PHx from measured E's:

$$\begin{aligned} PHx &= YXX\ Ex + ZXY\ Ey \\ PHy &= YYX\ Ex + ZYY\ Ey \end{aligned}$$

The E-predicted coherency can be computed using the predicted E and the orthogonal measured H, or an H-predicted coherency can be computed using the predicted H and measured E.

5.8 Parameters Calculated for Surface Impedance Tensor and Tipper

The impedance principal direction or "strike" (see >ZSTRIKE in Section 18.0) can be defined in many ways. For example it can be defined as the angle which:

1) Maximizes |Z'xy + Z'yx| ^2,
2) Maximizes |Z'xy|^2 + |Z'yx|^2,
3) Minimizes |Z'xx|^2 + |Z'yy|^2, or
4) Minimizes |Z'yy – Z'xx|;

where Z'xx, Z'xy, Z'yx, and Z'yy are the impedances rotated to the impedance strike angle. The principal direction, A, may be determined by incrementally rotating the impedance tensor, or alternatively it may be calculated analytically from the maximization of |Z'xy+Z'yx|^2 (Sims and Bostick, 1969) as

$$A = 1/4 * \mathrm{ARCTAN}\left(\frac{2(R1R2+I1I2)}{(R1^2+I1^2-R2^2-I2^2)} \right)$$

where R1 = Re(Zxx-Zyy), I1 = Im(Zxx-Zxy), R2 = Re(Zxy+Zyx), and I2 = Im(Zxy+Zyx),

or from an eigenstate formulation (Eggers, 1982) (Section 5.10). For a perfect two-dimensional earth, the same angle will satisfy all of these relationships. In actual field data, typically a three-dimensional anisotropic environment, the different methods produce different principal directions. However, in most interpretable situations they are not significantly different. There is an inherent 90 degree ambiguity in the calculated principal directions which can only be resolved by interpreting the off-diagonal element (Z'xy or Z'yx) of the rotated impedance tensor best represents the E-parallel (TE) mode and which the E-perpendicular (TM) mode. In practice, this is sometimes attempted by the field data acquisition crew, but more often is an interpretation task done after the fact. In any case, the method used to calculate the principal directions and resolve its ambiguities (if attempted) should always be documented or referenced in the >INFO text.

The impedance skew (See >ZSKEW in Section 18.0) is usually defined as

$$\mathrm{ZSKEW} = \frac{|Z'xx+Z'yy|}{|Z'xy-Z'yx|}$$

where Z'xx, Z'xy, Z'yx, and Z'yy are the rotated impedance elements. Any departure from this definition should be documented in the >INFO text.

The impedance ellipticity (See >ZELLIP in Section 18.0) is usually defined as

$$\mathrm{ZELLIP} = \frac{|(Zxx-Zyy) * \mathrm{COS}(2A) + (Zxv+Zyx) * \mathrm{SIN}(2A)|}{|(Zxy+Zyx) * \mathrm{COS}(2A) + (Zxx-Zyy) * \mathrm{SIN}(2A)|}$$

where A is the calculated impedance principal direction. Any departure from this definition should be documented in the >INFO text.

The complex tipper components, Tx and Ty, satisfy the tipper relation:

$$Hz = Tx\,Hx + Ty\,Hy$$

The tipper relation above may be solved for Tx and Ty using either local or remote reference fields, Rx and Ry, as in the impedance ease. Thus, the computation of the tipper parameters, Tx and Ty (in a least-squares sense) can be described by specifying 5 measurements: Hx, Hy, Hz, Rx, and Ry, where Rx and Ry may be coincident with Hx and Hy (local reference) or may be other measurements (remote reference).

From Tx and Ty, the tipper magnitude and tipper phase can be defined as:

$$\mathrm{TIPMAG} = \mathrm{SQRT}(|Tx|^2 + |Ty|^2)$$

$$TIPPHS = \frac{|Tx|^2 * Phs(Tx) + |Ty|^2 * Phs(Ty)}{|Tx|^2 + |Ty|^2}$$

In a manner similar to the impedance principal direction, the tipper principal direction (see >TSTRIKE in Section 18.0) can be defined as the angle which:

1) Minimizes |T'x| ^2
2) Maximizes |T'y|^2 or
3) Maximizes |T'y|^2 + |T'x|^2

where T'x and T'y are the tipper components rotated to the tipper strike angle. However, this method has the same 90 degree ambiguity as the impedance principal direction defined earlier. An alternative, preferred method for defining the tipper principal direction, B, is given by Jupp and Vozoff, 1976:

$$B = \frac{(TxR^2+TyR^2) * ATN(Tyr/TxR) + (TxI^2+TyI^2\} * ATN(TyI/TxI)}{|Tx|^2 + |Ty|^2} +90$$

where TxR, TxI, TyR, and TyI represent the real and imaginary parts of Tx and Ty respectively, and B is measured clockwise from true north in the defined aximuthal coordinate system. This is the angle which maximizes the coherency between the vertical and horizontal magnetic field. It has an inherent ambiguity of plus or minus 180 degrees. However, one can choose the principal direction for which the phase of COH(Hz,H'x) (the coherency between the vertical magnetic field, Hz, and the horizontal field component, Hx, rotated to the chosen principal direction) falls between +90 degrees and -90 degrees from the real axis in the complex plane.

The tipper principal direction defined in this way is unambiguous for a perfect two-dimensional earth, that is, it always points toward the resistive side of the contact which induces the vertical magnetic field component. The preferred definition of keyword >TSTRIKE is then B plus 90 degrees. Again, the method for determining tipper strike should always be documented or referenced in the >INFO text.

5.9 Spatial Filter Parameters

The width of the spatial filters used for EMAP processing can be delivered for examination or for use in reprocessing. A filter parameter represents the length of a spatial filter which is applied to the impedances. This filter length may be expressed in terms of distance units (FILWIDTH) or in terms of equivalent dipole lengths (EQUIVLEN). For a non-straight BMAP line, a filter angle (FILANGLE) is also required.

5.10 Alternate Processing Techniques

Alternative methods for computation of apparent resistivities have been presented by Eggers (1982) and LaTorraca (1986). Data to be delivered if using these methods includes eigenvalues, principal axis directions for eigenvectors, eigenvectors (complex), appropriate ellipticities, skews, and the apparent resistivities corresponding to the eigenvalues.

Although no data blocks have been provided for this information, .EXP blocks can be used to deliver all of these parameters. The use of .EXP blocks should always be fully documented in the >INFO text.

6.0 Syntactic Definitions and Conventions

6.1 Context-Free Grammars and BNF Notation

For the syntactic specification of a data interchange file, we shall use a notation called a context-free grammar (or grammar, for short). This is also called a BNF (Backus-Naur Form) description. This notation has been borrowed from the designers of programming languages (Aho and Ullman, 1978). It has a number of advantages as a method of syntax specification:

(1) A grammar gives a precise, yet easy to understand, syntactic specification.

(2) An efficient parser can be constructed automatically from a properly designed grammar. Certain parser construction processes can reveal syntactic ambiguities and other difficult to parse constructs which might otherwise go undetected in the initial specification of the syntax.

(3) A grammar imparts a structure to a syntax that is useful for its translation into a usable form and for the detection of errors.

In general, our grammar is constructed from terminals, non-terminals, and productions. The basic elements which comprise our data interchange file are ASCII characters. These are our terminals. Non-terminals are special symbols such as <integer> which denote a set of particular terminals arranged in a particular way. Productions define the ways in which non-terminals may be built up from one another and from terminals.

The following symbols are meta-symbols belonging to the BNF formalism, and are not symbols (unless explicitly noted) in our syntax definition:

"A" A character inside of double quotes represents that ASCII character.

/nnn A slash followed by 3 decimal digits represents the ASCII character with the character code nnn. This is generally used for non-printing characters.

"" Two double quotes denote the empty terminal symbol, i.e., no character.

<string> A string enclosed in < > denotes a non-terminal.

::= Two colons and an equal defines a production. Read it as "is defined as".

| A vertical bar means "or".

"A".."Z" Two characters, specified by either of the two conventions above, separated by two periods is a shorthand notation for any one of the characters in the indicated range. (e.g. "A".."Z" ::= "A" |"B" | ... "Y" |"Z")

{ } A pair of curley brackets denote the repetition of the enclosed symbols zero or more times.

{ }+ A pair of curly brackets followed by a plus denote repetition of the enclosed symbols one or more times.

( ) Parentheses may be used to indicate precedence. Normally, concatenation (ordering) has the highest precedence, followed next by l, then finally {} and 0+, all being evaluated left to right.

6.2 Syntactic Definitions

6.21 Character Set

The following productions divide all of the 256 possible values for an 8 bit ASCII character code into various character sets. The nonterminals defined here will be used in later productions.

```
<upc_letter>    ::=  "A" .. "Z"
<lwc_letter>    ::=  "a" .. "z"
<digit>         ::=  "0" .. "9"
<special>       ::=  ">"
<other>         ::=  "!" | """ | "#" | "$" | "%" | "&" | """ | "(" | ")" | "*" | "+" | "," | "-" | "." | "/" | ":"| ";" |"<"
```

| "=" | "?" | "@" | "[" | "\" | "]" | "^" | "_" | """" | "{" | "|" | "}" | "~"

<space> ::= " "

<null> ::= /000 | /010 | /013

<illegal> ::= /001 .. /009 | /011 .. /012 | /014 .. /031 | /127 .. /255

Alternatively, we could have used the/nnn form to represent all of our sets:

<upc_letter> ::= /065 .. /090

<lwc_letter> ::= /097 .. /122

<digit> ::= /048 .. /057

<special> ::= /062

<other> ::= /033 .. /047 | /058 .. /061 | /063 .. /064 | /091 .. /096 | /123 .. /126

<space> ::= /032

<null> ::= /000 | /010 | /013

<illegal> ::= /000 .. /009 | /011 .. /012 | /014 .. /031 | /127 .. /255

Spaces (/032) are preserved as data are read. Spaces may serve as delimiters, be used to enhance readablility, or can be used to pad logical records.

The syntax of an EDI file is based only upon a stream of characters, neither physical nor logical records have syntactic significance. The mechanism for separating both physical and logical records is implemented by the system's device drivers. No other explicit record terminators are to be added when writing an EDI file. With the exception of three characters described below, only printing characters may be in EDI files.

For magnetic tape (Section 4.1) or any other media (Section 4.2), the system device drivers define the mechanism for record separation. The mechanism used by the system for record separation should be transparent to an application program which simply calls the system's read and write record routines.

However, because different computer systems may be used for reading and writing interchange files, the device drivers could fail to remove all of the record separators. Carriage return (/013)and linefeed (/010) characters (sometimes used by systems as logical record separators) could in some cases appear as part of the data. In like manner, ASCII null (/000) characters (sometimes used for padding physical records) could in some cases appear as part of the data.

Therefore, the three ASCII characters: carriage return, linefeed, and null are tolerated within the data but are to be completely ignored. The presence of any other non-printing ASCII characters within an EDI file is considered to be an error.

6.22 Strings and Numbers

We can simply define non-terminals for strings, numbers, and other simple syntactic constructs as follows:

<letter> ::= <upc_letter> | <lwc_letter>

<legal_char> ::= <letter> | <digit> | <other>

<unsign_int> ::= { <digit> } +

<unsign_real> ::= <unsign_int> "." <unsign_int> | <unsign_int> "." | "." <unsign_int>

<sign> ::= "+" | "-"

```
<int>          ::=    ( <sign> | "") <unsign_int>
<real>         ::=    ( <sign> | "" ) <unsign_real>
<exp>          ::=    <real> ( "E" | "e" )<int>
<string>       ::=    { <legal_char> }+  | ( " " " { <legal_char> | "" } " " ")
<number>       ::=    <int> | <real> | <exp>
<date>         ::=    <digit> <digit> "/" <digit> <digit> "/" <digit> <digit>
<lat_long>     ::=    <int> ":" <unsign_int> ":" ( <unsign_int> | <unsign_real )
```

6.23 Data

Blocks of data values may be represented with one of two forms:

(1) An ASCII data set consists of the characters "//", followed by a count, followed by a set of data values. The count and all data values are represented by textual representations for <number>. (Section 6.22).

(2) A Binary data set is represented in an EDI file by one of three special sets of characters which mean "read binary data from the current position in the open binary data file". The three special character sets "/I/", "/R/", and "/D/" corresponding to the three forms of binary data: INTEGER (two's complement 16 bit integers), REAL (IEEE format 32 bit reals), and DOUBLE (IEEE format 64 bit reals).

An ASCII data set begins with two slash characters, "//". This is followed by a count, and then the actual data values. The actual data values MUST begin a new record (i.e. on a new line). The count is an integer in the range 0 to 32767. A count of zero means that the data set is empty. The number of data values must be EXACTLY the same as the count. Any or all of the data values may be represented with a special value meaning "there is no value for this data point". This value is determined by the EMPTY option in the >HEAD block (Section 8.0). If the option is not specified, its static default value is 1.00E+32.

In BNF notation, an ASCII data set is represented as:

```
<ascii_data_set>       ::=      "//" <unsign_int> { <number> }
```

EDI files are always ASCII files, made up of readable, printable characters. However, a mechanism is provided for a parallel binary file containing data values in binary form. The BINDATA option in the >HEAD block (Section 8.0) allows the EDI file to reference another file which must contain only binary data.

If the BINDATA option is the null string (null is the static default), then the EDI file must contain only ASCII data. If the BINDATA option is not null, then it assumed that some or all data values will be read from a parallel binary file. When reading an EDI file which references binary data, the user will have to tell the reading program the name of the binary file to be used. Sufficient information must be provided in the tape header or through other means for the user to relate binary files to EDI files.

The appropriate binary file will be opened and rewound at the time the EDI file is opened. The first item in the binary file is a 16 character file tag (written with a FORTRAN 16A image or equivalent) which identifies the data set. This file tag must exactly agree with the string in the BINDATA option in the >HEAD block or a mismatch error occurs.

Data sets will always be read sequentially from that current file pointer position in the binary file. A data set consists of a count and a set of data values. The count is a 16 bit two's-complement integer (FORTRAN INTEGER*16 or equivalent). It gives the number of values in the data set, 0 to 32767. A count of zero represents an empty data set. The data values which follow are in one of the three supported binary formats. The number of values must be EXACTLY equal to the value of count. Any or all of the data values may be represented with a special value meaning "there is no value for this data point". This value is determined by the EMPTY option in the >HEAD block

(Section 8.0). If the option is not specified, its static default value is 1.00E+32 (be careful to use a value which is exactly representable in the specified format).

In BNF notation, binary data are represented (in the EDI file) as:

<bin_data_set> ::= "/I/" | "/R/"| "/D/"

A measurement ID set is a special case of a data set. It cannot be a binary data set. Its elements must be unsigned integers or unsigned reals. In BNF notation it may be represented as:

<meas_ID_set> ::= "//" <unsign_int> { <unsign_int> | <unsign_real> }

In summary, the BNF notation for a data set is represented as:

<data_set> ::= <ascii_data_set> | <bin_data_set> | <meas_ID_set>

ASCII should be considered the primary method for data representation in an EDI file. A provision for handling binary data has been included to accommodate very large data sets such as time series where the more compact representation of data is absolutely necessary.

6.24 Option Lists

Option lists may be a part of many of the data blocks defined below. An option list is simply a sequence of option names followed by a corresponding option argument. The option name is an abbreviated mnemonic keyword such as NCHAN for number of channels or BW for bandwidth. The option argument may be a string, a number, a date, or a lat/long. All of these were syntactically defined in Section 6.22. The option name and option argument are always separated by an equals sign. In BNF notation:

<option_name> ::= <letter> { <letter>| <digit> }
<option_arg> ::= <string> | <number> | <date> | <real> | <lat long>
<option> ::= <option_name> "=" <option_arg>
<option_list> ::= { <option> }

A list of allowed options is given for each keyword in sections 8-20. Included in the list are any restrictions and defaults for each option. Default values for options are applied if an option is omitted from the option list. Options may be required, have static defaults, or have dynamic defaults. Dynamic defaults depend upon previously set values. The first block in a new section can define the dynamic defaults for some options. Then, any data block within the section can use the default value by not specifying that option or may specify a different value by specifying the option. There are nine defined dynamic defaults: HX, HY, HZ, EX, EY, RX, RY, NF, and NC.

6.25 Comments

Comments can be placed anywhere in an EDI file where a space could occur except within a data set. A comment begins with the two character sequence ">!. It is terminated by another exclamation point "!". Between these may be any number of legal characters (Section 6.22) except, of course, for "!". In non-standard annotated BNF notation:

<comment> ::= ">! { <legal_char> } "!"
(Where <legal_char> does not include "!" or ">")

Characters within a comment have no syntactic meaning; they are used simply for enhancing the readability of an EDI file. Comments may not appear within data sets. They cannot be nested. The characters within comments are read from logical records just as the other characters.

7.0 High Level Organization of Data Interchange Files

7.1 Overview

An EDI file is organized very much like the source file for a computer program. Its basic element is a data block (analogous to a program statement). Sometimes, contiguous data blocks are grouped into larger units called data sections (analogous to subroutines). All data blocks begin with a keyword. A keyword is the character ">" followed by 1 to 16 letters. As in a programming language, the type of data block and its semantics depend on what the keyword is. Special keywords, beginning with a right arrow character and an equal character ">=", indicate data blocks which define the beginning of a data section (analogous to SUBROUTINE statements). Following the keyword may be an option list (section 6.24), and following this may be a data set (section 6.23). Whether the option list and/or data set is required depends on the type of the data block. In BNF notation:

```
<keyword>        ::=    ">" ( <letter> | "=" ) { <letter> | <digit> | "." }
<data_block>     ::=    <keyword> |
                 ::=    <keyword> <option_list> |
                 ::=    <keyword> <data_set> |
                 ::=    <keyword> <option_list> <data_set>
```

It should be noted that the ">" character is also used to begin comments. Other than keywords and comments, the ">" character should not appear in an EDI file (i.e., not in the >INFO text or within comments). This restriction enables rapid scanning of EDI files.

An EDI file consists basically of the following elements:

1) A >HEAD block
2) An >INFO block
3) Info Text
4) A Define Measurements Section
5) One or More Data Sections of the following types
   a. Time Series Data
   b. Spectra Data
   c. MT Data
   d. EMAP Data
   e. Other Data
6) An >END block

Each of these elements is discussed in the sections which follow.

7.2 >HEAD Block

All EDI files must begin with a >HEAD block (analogous to a PROGRAM statement). The >HEAD block uses an option list (Section 6.24) to define a number of conventions which apply to the entire file. It has no data set.

```
<head_block>     ::=    ">HEAD" <option_list>
```

7.3 >INFO Block

Immediately after the >HEAD block, is an >INFO block. It also has an option list but no data set. Following the >INFO block is free-form text. This is the repository for all important notes regarding the acquisition and processing of the data within the file. The info text continues until the next keyword is encountered. In BNF notation:

```
<info_block>     ::=    ">INFO" <option_list>
```

<info_text> ::= { <legal_char> } (Note: legal character does not include ">")

7.4 >=DEFINEMEAS Section

Following the >INFO text, there must be a define measurements section which defines all of the measurements which will be referenced within the file. Each measurement is assigned a unique measurement ID by which it may later be referenced. It is analogous to the DIMENSION statements in a program. The section begins with a >=DEFINEMEAS block. The option list for this block defines the reference system to be used for sensor locations and other parameters. The block has no data set.

The rest of the define measurements section consists of a series of >EMEAS and >HMEAS data blocks, one for each electric or magnetic field measurement. A measurement references both a channel and a run to uniquely identify a particular set of data. The definition of a measurement includes a complete description of the sensor location(s) and configuration, sensor ID, filters, gain, acquisition channel, etc. (See Channel, Run, and Measurement ID under Terms and Definitions).

Each >EMEAS or >HMEAS block uses an option list to specify the location and orientation of the data sensor(s) as well as information pertaining to the run.

<emeas_block> ::= ">EMEAS" <option_list>
<hmeas_block> ::= ">HMEAS" <option_list>
<def_meas_section> ::= ">=DEFINEMEAS" <option_list> { <emeas_block> | <hmeas_block> }

7.5 Data Sections

Following the define measurement section may be one or more data sections. Five types of data sections are presently defined: time series data, spectra data, MT data, EMAP data, and other data. Data sections may be in any order and there may be more than one of a given type.

Although data sections are completely independent of one another, it is strongly recommended that the same set of frequencies (and their order) be used for all data sections pertaining to the same data set. For example, the frequencies for an >=MTSECT data section should be exactly the same as those for the corresponding >=SPECTRASECT data section.

7.51 Time Series Data Sections

If time series data are included in the EDI file, it is in one or more time series data sections. Each time series data section begins with a >=TSERIESSECT block. This block has an option list which defines the number of data measurements and other parameters. It also has a data set which contains an ordered list of the measurement ID's which define the set of measurements for which data are presented.

The rest of the section consists of one or more >TSERIES blocks. Each block has an option list which completely describes the organization of the time series data. This block has an option list which defines the number of data measurements and other parameters. It also has a data set which contains an ordered list of the measurement ID's which define the set of measurements for which data are presented. Following this is a data set which contains the actual time series data. In BNF notation:

<tseriessect_block> ::= ">=TSERIESSECT" <option_list> <meas_ID_set>
<tseries_block> ::= ">TSERIES" <option_list> <data_set>
<tseries_section> ::= <tseriessect_block> { <tseries_block> }

Because acquisition systems vary so much, it is very important that the acquisition hardware and system response be adequately documented or referenced in the >INFO section.

7.52 Spectra Data Sections

If power spectra data are included in the EDI file, it is in one or more spectra data sections. Each spectra data section begins with a >=SPECTRASECT block. This block has an option list which defines the number of data measurements and other parameters. It also has a data set which contains an ordered list of the measurement ID's which define the set of measurements for which data are presented.

The rest of the section consists of one or more >SPECTRA blocks, one for each frequency. Each spec data block has an option list which defines the frequency, bandwidth, and other parameters which characterize the possible auto and cross power spectra for the entire set of measurements. In BNF notation:.

```
<spectrasect_block>     ::=     ">=SPECTRASECT" <option_list> <meas_ID_set>
<spectra_block>         ::=     ">SPECTRA" <option_list> ";" <data_set>
<spectra_section>       ::=     <spectrasect_block> { <spectra_block> }
```

7.53 MT Data Sections

It will often be most convenient to use a separate EDI file for each MT sounding. However, one or more MT soundings may be included in an EDI file, each in its own MT data section. Each of these MT data sections begin with an >=MTSECT data block. The option list for this block contains default measurement ID's for up to five MT components and two references. It has no data set.

If data for multiple rotations are to be presented, a separate >=MTSECT data section should be used for each rotation.

Following the >=MTSECT block must be a >FREQ data block. The data set with this block defines the frequency set for the sounding. Following the >FREQ block are data blocks for the sounding.

First are the impedance data blocks. If the impedances are not in the measurement directions, the first impedance block must be >ZROT. For MT, up to four Z components may be included: ZXX, ZXY, ZYX, and ZYY. For each component, there may be up to 6 data blocks. No provision has been made to include separate data sets for impedance polar diagrams because they can be calculated so easily from the four Z components.

Next are the apparent resistivity data blocks. If the impedances are not in the measurement directions, the first impedance block must be >RHOROT. For MT, up to four apparent resistivities may be included: RHOXX, RHOXY, RHOYX, and RHOYY. For each of these there are corresponding PHS and up to 6 other data blocks.

Next are the continuous 1D inverse data blocks. There may be up to four inversions corresponding to the four apparent resistivities above. For each of these there may be RES1D and DEPTH1D data blocks.

Finally, are all of the other data blocks for the MT sounding. These include coherencies, predicted coherencies, signal amplitudes, signal-to-noise, up to 8 tipper parameters, strikes, skews, ellipticities, and ".EXP" data blocks.

All of these data blocks are discussed in detail in the sections below. In BNF form, an MT data section can be represented as:

```
<mtsect_block>          ::=     ">=MTSECT" <option_list>
<mt_data_block>         ::=     <keyword> <option_list> <data_set>
<mt_section>            ::=     <mtsect_block> { <mtdata_block> }
```

7.54 EMAP Data Sections

An EMAP data section contains an EMAP profile or a section of an EMAP profile. Each of these EMAP data sections begin with an >=EMAPSECT block. This block has an option list which contains the default measurement ID's for the magnetic and reference components. The data set for this block contains an ordered list of measurement ID's which define the EMAP array.

Following the >=EMAPSECT block must be a >FREQ data block which defines the frequency set for the profile. Following the >FREQ block are data blocks for the profile.

First are the impedance data blocks. Impedances for an EMAP profile must be in the measurement directions. Therefore, an EMAP section can not have a >ZROT data block. For an EMAP profile, there are up to two Z components: ZXX and ZXY. There may also be spatially filtered components: FZXX and FZXY. For each component, there may be up to 6 data blocks. Therefore, there may be up to 24 data Z blocks for each dipole. All of the desired Z blocks for the first dipole (the first entry in the ordered list of measurement ID's) should be first, followed by the same set of blocks for the next dipole, and so on for all of the dipoles in the section.

Next are the apparent resistivity data blocks. Because the apparent resistivities for an EMAP profile correspond to the measurement directions, the default for the ROT option, ROT=NONE should be used. For an EMAP profile, up to four apparent resistivities may be included: RHOXX, RHOXY FRHOXX, and FRHOXY. For each of these there are corresponding PHS and up to 6 other data blocks (VAR, ERR, and FIT for both RHO and PHS). Therefore, there may be up to 32 apparent resistivity data blocks for each dipole. All of the desired apparent resistivity blocks for the first dipole (the first entry in the ordered list of measurement ID's) should be first, followed by the same set of blocks for the next dipole, and so on for all of the dipoles in the section.

Next are the continuous 1D inverse data blocks. There may be up to four inversions corresponding to the four apparent resistivities above. For each of these there may be RES1D and DEPTH1D data blocks. Therefore, there may be up to 16 data blocks for each dipole. All of the desired continuous inverse blocks for the first dipole (the first entry in the ordered list of measurement ID's) should be first, followed by the same set of blocks for the next dipole, and so on for all of the dipoles in the section.

Finally, are all of the other data blocks for the EMAP profile. These include coherencies, predicted coherencies, signal amplitudes, signal-to-noise, spatial filter information, and ".EXP" data blocks. All of the other data blocks for the first dipole (the first entry in the ordered list of measurement ID's) should be first, followed by the same set of blocks for the next dipole, and so on for all of the dipoles in the section.

All of these data blocks are discussed in detail in the sections below. In BNF form, an MT data section can be represented as:

<emapsect_block>	::=	">=EMAPSECT" <option_list> <meas_ID_set>
<emap_data_block>	::=	<keyword> <option_list> <data_set>
<emap_section>	::=	<emapsect_block> { <emap_data_block> }

7.55 Other Data Sections

For defined techniques such as MT and EMAP, data blocks have been ordered and restricted to simplify processing and assure consistent and reasonable data. However, the standard also includes a provision for the unrestricted inclusion data blocks for non-standard applications.

All of these data blocks are discussed in detail in the sections below. In BNF form, an MT data section can be represented as:

<othersect_block>	::=	">=OTHERSECT" <option_list> <meas_ID_set>
<data_block>	::=	<keyword> <option_list> <data_set>

```
<other_section>          ::=        <othersect_block> { <data_block> }
```

7.6 >END Block

Finally, the EDI file must conclude with an >END block. It has no option list and no parameters. In BNF notation, it is represented as:

```
<end_block>              ::=        ">END"
```

7.7 >BNF Representation of an EDI File

Using the non-terminals defined in Sections 7.1-7.6, we can represent the syntax of an EDI file as follows:

```
<edi file>               ::=        <head_block>
                                    <info_block>
                                    <info_text>
                                    <def_meas_section>
                                    { <tseries_section> | spectra_section> | <mt_section> |  <emap_section> |
                                       <other_section>  }
                                    <end block>
```

8.0 Head, Info, Frequency, Zrot, Rhorot, and End Blocks

8.1 >HEAD

Keyword	Description
>HEAD	The head block contains a series of options which (1) identify the data set, (2) describe when, where, and by whom it was acquired, and (3) describe when, how and by whom it was written.
Restrictions:	Exactly one >HEAD block is allowed per file. It must be the first block in the file.

Option Name	Description	Restrictions	Default
DATAID	Identifier for data set	String	Required
ACQBY	Name of contractor or other party	String	Required
HLEBY	Name of contractor or other party	String	Required
ACQDATE	Date of (start of) data acquisition	Date	Required
ENDDATE	Date of end of data acquisition	Date or ""	""
FILEDATE	Date EDI file was written	Date	Required
COUNTRY	Name of country of acq	String or ""	""
STATE	State(s) / Province(s) of acq	String or ""	""
COUNTY	County(s) of acq.	String or ""	""
PROSPECT	Name of associated prospect(s)	String or ""	""
LOC	Description of location of Acq	String or ""	""
LAT	Avg. (approx) latitude of Acq	Latitude or ""	""
LONG	Avg. (approx) longitude of Acq	Longitude or ""	""
ELEV	Avg (approx) elevation of Acq	Number or ""	""
UNITS	Units for elevation	"M" or "FT"	"M"
STDVERS	Version of EDI Format for this file	String	Required
PROGVERS	Version ID for prog writing file	String	Required
PROGDATE	Last Revision of prog writing file	String	Required
MAXSECT	Maximum data sections in EDI file	Integer> = 1	"16"
BINDATA	If not "", tag for binary data file	String or ""	"

EMPTY	Value which represents "no data"	Number	"1.0E32"

Data Set: None

Notes: The LAT, LONG, and ELEV options are required for measured data, but not for model data.

The BINDATA option is "" if there is no parallel binary data file. If one or more of the data blocks in the file refer to binary data, this is a tag which must appear at the very beginning of the binary data file. This assures proper matching of EDI and binary files (Section 6.23).

The EMPTY option defines a special value which represents an empty data value. When this value is encountered in any data record in the file, it is interpreted as "there is no value for this data point". Because of the limits in converting between real numbers and their textual representations, care should be taken in selecting this value.

8.2 >INFO

Keyword	Description
>INFO	The >INFO block indicates the beginning of free-form text. This text section is to contain all important notes concerning data acquisition and processing. Any non-standard practices used must be documented here. The text may not include any legal characters except for the character ">".

Restrictions: Exactly one >INFO block is allowed per file. It must be the second block in the file, immediately after the >HEAD block.

Option Name	Description	Restriction	Default
MAXINFO	Maximum number of text lines in info text (may be less).	Integer >= 1	"256"

Data Set: None

Notes: None

8.3 >FREQ

Keyword	Description
>FREQ	Data block containing a set of frequencies in Hz. It defines the frequency set for succeeding data within that data section which are functions of frequency.

Restrictions: Exactly one >FREQ block is required to immediately follow >=MTSECT or >=EMAPSECT blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
ORDER	Ordering of frequencies	"INC" or "DEC"	"DEC"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Must contain NFREQ values in strictly increasing or decreasing order as specified by the ORDER option. The values must be within the legal range for reals and >0. Empty data values and empty data sets (Section 6.23) are not allowed.

Notes: The dynamic default for NF was set by the NFREQ option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

8.4 >ZROT

Keyword	Description
>ZROT	Data block containing a set of rotation angles used for impedances.

Restrictions: One >ZROT block may optionally appear in an >=MTSECT data section. If present, the >ZROT block must immediately follow the >FREQ block. It may not appear in an >=EMAPSECT data section. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the rotation angles for the impedances at the corresponding frequencies. The values must be within the legal range for angles (Section 5. 1). The data set may not contain empty values (Section 6.23). It may not be an empty data set and may not contain binary data (Section 6.23).

Notes: The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

8.5 >RHOROT

Keyword	Description
>RHOROT	Data block containing a set of rotation angles used for apparent resistivities.

Restrictions: One >RHOROT block may optionally appear in an >=MTSECT data section. If present, the >RHOROT block must immediately follow the >FREQ block and any impedance blocks. It may not appear in an >=EMAPSECT data section. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the rotation angles for the apparent resistivities at the corresponding frequencies. The values must be within the legal range for angles (Section 5.1). The data set may not contain empty values (Section 6.23). It may not be an empty data set and may not contain binary data (Section 6.23).

Notes:	The dynamic default for NF was set by the NFREQ option in the first block of the section. The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

8.6 >END

Keyword	Description
>END	Denotes the end of an EDI File.

Restrictions: Exactly one >END block is allowed per file. It must be the last block in the file.

Option: None

8.7 >! Comment

Keyword	Description
>!	Begins a comment.

Restrictions: Comments may appear anywhere in an EDI file where a space may appear except within data sets. Any legal characters may appear within a comment except for "!" and ">".

Notes: >! is only a pseudo keyword which causes all following characters to be syntactically ignored until another exclamation character ! is encountered.

9.0 Measurement Definition Blocks

9.1 >=DEFINEMEAS

Keyword	Description
>DEFINEMEAS	Begins a Measurement Definition data section. Defines locations of sensors and parameters pertaining to runs for each measurement.

Restrictions: Exactly one instance of a >DEFINEMEAS data block can appear in an EDI file. It must immediately follow the >HEAD block, >INFO block, and info text.

Option Name	Description	Restrictions	Default
MAXCHAN	Maximum number of channels	Integer >=1	"16"
MAXRUN	Maximum number of runs	Integer >=0	"0"
MAXMEAS	Maximum number of measurements	Integer >=1	"64"
UNITS	Units for sensor offsets from reference	"M" or "FT"	"M"
REFTYPE	Type of offset from reference	"CART"	"CART"
REFLOC	Description of location of reference	String or ""	""
REFLAT	Latitude of reference	Latitude or ""	""
REFLONG	Longitude of reference	Longitude or ""	""
REFELEV	Elevation of reference	Number or ""	""

Data Set: None

Notes: MAXCHAN is the maximum channel number used in the EDI file. MAXRUN is the maximum run number used in the EDI file. Measurement IDs incorporate both channel number and run number. The integer part is the channel number. There may be a fractional part which gives the run number. The run number for the first run is always 0. Thus, there is no fractional part in the measurement ID's for the first (and often only) run in the file. The number of digits in the fractional part is 2, 3, or 4, depending on the value of the MAXRUN option in the >=DEFINEMEAS data block. If the value is 0 (default), then all measurement IDs are simply the channel number. If the MAXRUN <100, then all measurement IDs are chan num+(run num/100). If MAXRUN is >=100 and <1000 then all measurement IDs are chan num+(run num/1000). Finally, if MAXRUN is >=1000, then measurement IDs are chan num+(run num/10,000).

The REFLAT, REFLONG, and REFELEV options are required for measured data, but not for model data.

All sensor locations within the section are defined relative to an arbitrary reference location. Currently the only reference type allowed is CARTesian in which X, Y, and Z offsets relative to the reference define a sensor location. The offsets are in meters unless the UNITS=FT option is specified. Positive X, Y, and Z offsets correspond to true north, east, and up from the reference, respectively. Because such a coordinate system begins to deviate after 7-10 minutes of longitude, other reference types may be added to the standard in the future to handle more sophisticated specification of sensor locations.

9.2 >EMEAS

Keyword	Description
>EMEAS	Defines the electrode locations and run parameters for an electric field measurement.

Restrictions: Zero or more >EMEAS blocks can appear within the Define measurements section. One block must be included for each electrical field measurement which is used in the EDI file. Note that multiple runs using the same channel are considered to be separate measurements, each requiring an >EMEAS block.

Option Name	Description	Restrictions	Default
ID	Measurement ID	Number >=1	Required
CHTYPE	Type of E measurement	"EX" or "EY"	Required
X	X offset from ref for first electrode	Number	Required
Y	Y offset from ref for first electrode	Number	Required
Z	Z offset from ref for first electrode	Number or ""	""
X2	X offset from ref for 2nd electrode	Number	Required
Y2	Y offset from ref for 2nd electrode	Number	Required
Z2	Z offset from ref for 2nd electrode	Number or ""	""
ACQCHAN	Description of acq chan for run	String or ""	""
FILTER	Description of filter(s) for run	String or ""	""
GAIN	Gain used for run	Number >0 or ""	""
MEASDATE	Date of run	Date or ""	""

Data Set: None

Notes: The type is designated as EX or EY as appropriate.

Measurement IDs incorporate both channel number and run number. The integer part is the channel number. There may be a fractional part which gives the run number. The run number for the first run is always 0. Thus, there is no fractional part in the measurement ID's for the first (and often only) run in the file. The number of digits in the fractional part is 2, 3, or 4, depending on the value of the MAXRUN option in the >=DEFINEMEAS data block. If the value is 0 (default), then all measurement IDs are simply the channel number. If the MAXRUN <100, then all measurement IDs are chan num+(run num/100). If MAXRUN is >=100 and <1000 then all measurement IDs are chan num+(run num/1000). Finally, if MAXRUN is >=1000, then measurement IDs are chan num+(run num/10,000).

For MT soundings EX usually designates the dipoles most nearly oriented in the north-south direction and EY designates the corresponding orthogonal dipoles. For measurements of type EX, the first electrode is the southern-most of the pair. For measurements of type EY, the first electrode is the western-most of the pair. For EMAP lines, dipoles along the line are generally designated as EX, and any perpendicular dipoles are designated EY. Along the line, the first electrode should be defined consistently such that the first electrode of each dipole is coincident with the second electrode of the previous one.

All electrode locations are relative to the reference location defined in the >=DEFINEMEAS block. Currently the only reference type allowed is CARTesian in which X, Y, and Z offsets relative to the reference define an electrode location. The offsets are in meters unless the UNITS=FT option is specified in the >=DEFINEMEAS block. Positive X, Y, and Z offsets correspond to true north, east, and up from the reference, respectively. Because such a coordinate system begins to deviate after 7-10 minutes of longitude, other reference types may be added to the standard in the future to handle more sophisticated specification of sensor locations. The null string for the Z offsets indicate that they are not specified.

9.3 >HMEAS

Keyword	Description
>HMEAS	Defines the sensor location and orientation, and run parameters for a magnetic field measurement.
Restrictions:	Zero or more >HMEAS blocks can appear within the Define measurements section. One block must be included for each magnetic field measurement which is used in the EDI file. Note that multiple runs using the same channel are considered to be separate measurements, each requiring an >HMEAS block.

Option Name	Description	Restrictions	Default
ID	Measurement ID	Number >=1	Required
CHTYPE	Type of H measurement	"HX","HY", or "HZ"	Required
X	X offset from ref for sensor	Number	Required
Y	Y offset from ref for sensor	Number	Required
Z	Z offset from ref for sensor	Number or ""	""
AZM	Azimuth angle for sensor	Number	Required
DIP	Dip angle for sensor	Number	"0"
ACQCHAN	Description of acq channel for run	String or ""	""
FILTER	Description of filter(s) for run	String or ""	""
SENSOR	Description of sensor for run	String or ""	""
GAIN	Gain used for run	Number >0 or ""	""
MEASDATE	Date of run	Date or ""	""

Data Set: None

Notes: If the measurement is a vertical magnetic field measurement, its type should be HZ. Otherwise, it should be HX or HY as appropriate.

For MT soundings, HX usually designates the measurements most nearly oriented in the north-south direction, and HY designates the corresponding orthogonal measurements. For EMAP surveys, magnetic field measurements parallel to the line are generally designated as HX, and measurements perpendicular to the line are designated HY.

Measurement IDs incorporate both channel number and run number. The integer part is the channel number. There may be a fractional part which gives the run number. The run number for the first run is always 0. Thus, there is no fractional part in the measurement ID's for the first (and often only) run in the file. The number of digits in the fractional part is 2, 3, or 4, depending on the value of the MAXRUN option in the >=DEFINEMEAS data block. If the value is 0 (default), then all measurement IDs are simply the channel number. If the MAXRUN <100, then all measurement IDs are chan num+(run num/100). If MAXRUN is >=l00 and <1000 then all measurement IDs are chan num+(run num/1000). Finally, if MAXRUN is >=1000, then measurement IDs are chan num+(run num/10,000).

All sensor locations are relative to the reference location defined in the >=DEFINEMEAS block. Currently the only reference type allowed is CARTesian in which X, Y, and Z offsets relative to the reference define an electrode location. The offsets are in meters unless the UNITS=FT option is specified in the >=DEFINEMEAS block. Positive X, Y, and Z offsets correspond to true north, east, and up from the reference, respectively. Because such a coordinate system begins to deviate after 7-10 minutes of longitude, other reference types may be added to the standard in the future to handle more sophisticated specification of sensor locations. The null string for a Z offset indicates that it is not specified.

Azimuth angles are measured on a level plane, plus or minus 180 degrees relative to true north with positive angles being clockwise. Dip angles are plus or minus 90 degrees relative to that level plane. Loop type sensors should be treated like the equivalent coil; that is, a coil which is normal to, and in the center of the plane defined by the loop sensor.

10.0 Time Series Blocks

10.1 >=TSERIESSECT

Keyword	Description
>TSERIESSECT	Begins a time series data section. Defines the set of measurements for which time series data are presented.

Restrictions: One or more instances of a >=TSERIESSECT can appear in an EDI file. Each one begins a new time series data section. It may immediately follow the >HEAD block, >INFO block, and info text, or it may appear after any other data section is complete.

Option Name	Description	Restrictions	Default
SECTID	Identifying name for this section	String or ""	""
NCHAN	Number channels for time series data	Integer >=1	Required
MAXBLKS	Max number of data blocks in section	Integer >=1	"16"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NCHAN data values. Each value is a measurement ID for a measurement defined in the >=DEFINEMEAS section. The ordering of the channels in the data set is the order used for the time series data. The data set may not contain empty values (Section 6.23). It may not be an empty data set and may not contain binary data (Section 6.23).

Notes: All data blocks within the section will contain time series data for the set of measurements defined in this block.

The dynamic default for NC is set by the NCHAN option.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

Because time series data are highly system dependent, a thorough explanation of the data acquisition procedure and system response should be included in the >INFO block.

10.2 >TSERIES

Keyword	Description
>TSERIES	Single or multi-channel time series data.

Restrictions: Zero or more >TSERIES data blocks can appear within a time series data section. A time series data section must begin with a >=TSERIESSECT data block which defines the set of measurements for which time series data are given.

Option Name	Description	Restrictions	Default
SECTID	Identifying name for this section	String or ""	
NCHAN	Number of channels	Integer >=1	Dyn NC
NPTS	Number of points/channel	Integer >= I	Required
SR	Sample Rate (Hz)	Number >0	Required
MPX	Multiplex type	"TIME" or "CHAN"	"CHAN"
BAND	Name of frequency band	String or ""	""
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Exactly (NCHAN x NPTS) data values are to be included in the data set. The values must be within the legal range for reals. The special value for no data (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the mpx option is MPX=TIME, then the data values multiplexed in time. That is, they are ordered such that the first NCHAN values correspond to the first sample for each of the channels (in the order they appear in the >=TSERIESSECT data set). The next NCHAN values correspond to the second sample, and so on. If the mpx option is MPX=CHAN, then the data values are channel multiplexed. That is, the first NPTS values correspond to the time series data for the first channel, the next NPTS values correspond to the second channel, and so on.

The sample rate at which the data was acquired is in Hz. A name for the frequency band may be included using the band option. A complete discussion of the units, calibration, filters, etc. for the acquisition of time series data must be included in the >INFO text.

The dynamic default for NC was set by the NCHAN option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

11.0 Spectra

11.1 >=SPECTRASECT

Keyword	Description
SPECTRASECT	Begins a spectra data section. Defines the set of measurements for which spectra data are presented.

Restrictions: One or more instances of a >=SPECTRASECT can appear in an EDI file. Each one begins a new spectra data section. It may immediately follow the >HEAD block, >INFO block, and info text, or it may appear after any other data section is complete.

Option Name	Description	Restrictions	Default
SECTID	Identifying name for this section	String or ""	""
NCHAN	Number channels for spectra data	Integer >= 1	Required
NFREQ	Number frequencies for spectra data	Integer >= 1	Required
MAXBLKS	Max number of data blocks in section	Integer >=1	"16"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NCHAN data values. Each value is a measurement ID for a measurement defined in the >=DEFINEMEAS section. The ordering of the channels in the data set is the order used for the spectra data. The data set may not contain empty values (Section 6.23). It may not be an empty data set and may not contain binary data (Section 6.23).

Notes: All data blocks within the section will contain a complete set of all auto and cross power spectra for the set of measurements defined in this block.

The dynamic default for NC is set by the NCHAN option.

The dynamic default for NF is set by the NFREQ option.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

11.2 >SPECTRA

Keyword	Description
>SPECTRA	Auto and cross power spectra data.

Restrictions: Zero or more >SPECTRA data blocks can appear within a spectra data section. A spectra data section must begin with a >=SPECTRASECT data block which defines the set of measurements for which power spectra are given.

Option Name	Description	Restrictions	Default
NCHAN	Number of channels	Integer >= 1	Dyn NC
FREQ	Frequency (Hz)	Number > 0	Required
ROTSPEC	Rotation angle of spectra	Angle or ""	""
BW	Bandwidth (Hz)	Number > 0	Required
AVGT	Number of independent avgs in time	Number > 0	"1"
AVGF	Number of independent avgs in freq	Number > 0	"1"
BAND	Name of frequency band	String or ""	""
SEGNUM	Number identifying a partial spectra	Integer >= 0	"0"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Exactly (NCHAN x NCHAN) data values are to be included in the data set. The data set represents an estimate of the auto and cross power spectra for a set of NCHAN measurements over a particular frequency range. The values must be within the legal range for reals. The special value for empty data (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty. The values are packed as described in note below.

Notes: Crosspower matrices are Hermitian and can be packed as shown in the following example. The complex auto and cross power spectra for 4 channels A, B, C, and D:

	A	B	C	D
A	<AA*>	<AB*>	<AC*>	<AD*>
B	<BA*>	<BB*>	<BC*>	<BD*>
C	<CA*>	<CB*>	<CC*>	<CD*>
D	<DA*>	<DB*>	<DC*>	<DD*>

can be stored as follows:

	A	B	C	D
A	<AA*>	Imag<AB*>	Imag<AC*>	lmag<AD*>
B	Real<AB*>	<BB*>	Imag<BC*>	Imag<BD*>
C	Real<AC*>	Real<BC*>	<CC*>	lmag<CD*>
D	Real<AD*>	Real<BD*>	Real<CD*>	<DD*>

with the real part in the lower left triangle and the imaginary part in the upper right triangle. Note that the auto spectra are real. The only ambiguity is the sign of the imaginary values. This is defined such that the sign associated with the imaginary values is in the upper right triangle of the original matrix is preserved in the compressed matrix. The data set is this compressed matrix, read by row, e.g. <AA*>, Imag<AB*>, Imag<AC*>, ... Real<CD*>, <DD*>.

The ordered set of measurements for which spectra are being given is defined by the >=SPECTRASECT block. The ordered list of measurements corresponds to the ordered list "A,B,C,D" in the example above.

The value of the FREQ option gives the center frequency of the spectra estimates in Hz. The BW option specifies the bandwidth in Hz between the (half-power) cut-off frequencies.

The value of the AVGT option is the number of independent estimates in time which were averaged to make these spectra estimates. Cascade decimation averages constant percentage bandwidth spectra estimates which are independent in time. Weighted averaging can lead to a number of independent samples which is not an integer. The AVGF option is the number of independent estimates in frequency which were averaged to make these spectra estimates. Spectra estimates generated from an FFT are averaged in frequency to produce constant percentage bandwidth spectra. Note that if a number of FFT runs are averaged, both AVGT and AVGF can be greater than 1.

If the ROTSPEC option is omitted, the spectra are assumed to be in the measurement directions. If the option is included, it must be an angle representing the (average) rotation angle of the type Ex and Hx channels from true north and the type Ey and Hy channels from east. If sensor layouts are orthogonal, rotation transformations can be applied to all of the horizontal sensor pairs to rotate the spectra. However, if the sensors are not all laid out orthogonally, the meaning of ROTSPEC should be explained in the >INFO text.

If the SEGNUM option is omitted, or is zero, then the spectra are assumed to be final averages. The SEGNUM option allows delivery of partial spectra estimates, which can then be averaged as desired to effect a form of data editing. Note that delivery of spectra segments greatly increases the quantity of data.

The dynamic default for NC was set by the NCHAN option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

12.0 MT, EMAP and Other Section head blocks

12.1 >=MTSECT

Keyword	Description
>=MTSECT	Begins an MT data section. Defines the default measurements for an MT sounding.
Restrictions:	One or more instances of an >=MTSECT can appear in an EDI file. Each one begins a new MT data section. It may immediately follow the >HEAD block, >INFO block, and info text, or it may appear after any other data section is complete.

Option Name	Description	Restrictions	Default
SECTID	Identifying name for this section	String or ""	""
NFREQ	Number of frequencies	Integer >=1	Required
MAXBLKS	Maximum number of blocks in section	Integer >= 1	"64"
HX	Meas ID for Hx measurement	Def Meas ID or ""	""
HY	Meas ID for Hy measurement	Def Meas ID or ""	""
HZ	Meas ID for Hz measurement	Def Meas ID or ""	""
EX	Meas ID for Ex measurement	Def Meas ID or ""	""
EY	Meas ID for Ey measurement	Def Meas ID or ""	""
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	""
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	""

Data Set: None

Notes: The dynamic defaults for HX, HY, HZ, EX, EY, RX, and RY may be set by the >=MTSECT block. If any are not specified, the corresponding dynamic default is set to "". All of the data blocks within the section may use these dynamic defaults if the corresponding options are not specified. After application of any appropriate dynamic defaults, an option argument will be a defined measurement ID or it may be "", indicating no measurement.

Although no restrictions are enforced, all appropriate measurements should be defined for a given data block. For scalar MT, only one E and one H are required (e.g. Ey and Hx). For tensor MT, two E's and two H's are required. If tipper parameters are being computed, Hz must also be defined. If least- squares estimation of the impedances is used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

Under normal circumstances, the measurements for HX, HY, HZ, EX, EY, RX, and RY should be the same for all data blocks within an >=MTSECT data section.

The dynamic default for NF is set to the value of the NFREQ option.

12.2 >=EMAPSECT

Keyword	Description
>=EMAPSECT	Begins an EMAP data section. Defines the measurements which make up an EMAP line.

Restrictions: One or more instances of an >=EMAPSECT can appear in an EDI file. Each one begins a new EMAP data section. It may immediately follow the >HEAD block, >INFO block, and info text, or it may appear after any other data section is complete.

Option Name	Description	Restriction	Default
SECTID	Identifying name for this section	String or ""	""
NFREQ	Number of frequencies Integer >= 1	Required	
MAXBLKS	Maximum number of blocks in section	Integer >=1	"64"
NDIPOLE	Number of dipoles in the EMAP line	Integer >= 1	Required
TYPE	Descr of spatial filter type used	String or ""	""
HX	Meas ID for Hx measurement	Def Meas ID or ""	""
HY	Meas ID for Hy measurement	Def Meas ID or ""	""
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	""
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	""
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NDIPOLE data values. Each value is a measurement ID for a measurement defined in the >=DEFINEMEAS section. The ordering of the measurements in the data defines the measurements which make up the EMAP line. The type of all of the measurement ID's (as defined by the CHTYPE option in the corresponding >EMEAS block) should be EX, although this restriction is not enforced. The data set may not contain empty values; nor may it be an empty data set and or contain binary data (Section 6.23).

Notes: The dynamic defaults for HX, HY, RX, and RY may be set by the >=EMAPSECT block. If any are not specified, the corresponding dynamic default is set to "". All of the data blocks within the section may use these dynamic defaults if the corresponding options are not specified. After application of any appropriate dynamic defaults, an option argument will be a defined measurement ID or it may be "", indicating no measurement.

Although no restrictions are enforced, all appropriate measurements should be defined for a given data block. For synthetic EMAP only Hx is required for parallel parameters and only Hy is required for perpendicular parameters. However, for field data, where the line layout is not perfectly straight, both Hx and Hy are generally required. If least-squares estimation of the impedances is used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

Under normal circumstances, the measurements for HX, HY, EX, RX, and RY should be the same for all data blocks corresponding to a given span within the >=EMAPSECT data section.

The TYPE option gives the filter type for spatial filter used; for example, "HANNING". If explanation is required, it should be included in the >INFO section.

The dynamic default for NF is set to the value of the NFREQ option.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

12.3 >=OTHERSECT

Keyword	Description
>=OTHERSECT	Begins an OTHER data section. Defines default measurements and a set of ordered measurements.

Restrictions: One or more instances of an >=OTHERSECT can appear in an EDI file. Each one begins a new MT data section. It may immediately follow the >HEAD block, >INFO block, and info text, or it may appear after any other data section is complete.

Option Name	Description	Restrictions	Default
SECTID	Identifying name for this section	String or ""	""
NFREQ	Number of frequencies	Integer >=1	Required
MAXBLKS	Maximum number of blocks in section	Integer >=1	"64"
N	Number of meas ID's in the ordered set	Integer >=0	"0"
HX	Meas ID for Hx measurement	Def Meas ID or ""	""
HY	Meas ID for Hy measurement	Def Meas ID or ""	""
HZ	Meas ID for Hz measurement	Def Meas ID or ""	""
EX	Meas ID for Ex measurement	Def Meas ID or ""	""
EY	Meas ID for Ey measurement	Def Meas ID or ""	""
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	""
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	""
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly N data values, although N may be zero. Each value is a measurement ID for a measurement defined in the >=DEFINEMEAS section. The ordering of the measurements in the data defines the measurements which make up any ordered set of measurements such as an EMAP line. The type of all of the measurement ID's (as defined by the CHTYPE option in the corresponding >EMEAS or >HMEAS block) may be anything. The data set may not contain empty values; nor may it be an empty data set or contain binary data (Section 6.23).

Notes: The dynamic defaults for HX, HY, HZ, EX, EY, RX, and RY may be set by the >=OTHERSECT block. If any are not specified, the corresponding dynamic default is set to "". All of the data blocks within the section may use these dynamic defaults if the corresponding options are not specified. After application of any appropriate dynamic defaults, an option argument will be a defined measurement ID or it may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined for a given data block.

The dynamic default for NF is set to the value of the NFREQ option.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

13.0 Impedance Data Blocks

13.1 >ZXXR, >ZXXI, ZXXR.VAR, >ZXXI.VAR, >ZXX.VAR, >ZXX.COV

Keyword	Description
>ZXXR	Real component of impedance ZXX (Ex/Hx)
>ZXXI	Imaginary component of impedance ZXX (Ex/Hx)
>ZXXR.VAR	Variance of real component of impedance ZXX
>ZXXI.VAR	Variance of imaginary component of impedance ZXX
>ZXX.VAR	Variance of impedance ZXX
>ZXX.COV	Covariance of impedance ZXX

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT or >=EMAPSECT data section. Any impedance blocks in these sections must immediately follow the >FREQ block and the optional >ZROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Defaults
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Type of estimation used	String or ""	"LEASTSQ"
ROT	Type of rotation applied	"NONE", "NORTH" or "ZROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "ZROT" then the impedances are assumed to have been rotated to the angles indicated in the >ZROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only tensor impedances (see note below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each scalar impedance only one E and one H are required (e.g. Ex and Hx for ZXX). For tensor impedances, two E's and two H's are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

13.2 >ZXYR, >ZXYI, >ZXYR.VAR, >ZXYI.VAR, >ZXY.VAR, >ZXY.COV

Keyword	Description
>ZXYR	Real component of impedance ZXY (Ex/Hy)
>ZXYI	Imaginary component of impedance ZXY (Ex/Hy)
>ZXYR.VAR	Variance of real component of impedance ZXY
>ZXYI.VAR	Variance of imaginary component of impedance ZXY
>ZXY.VAR	Variance of impedance ZXY
>ZXY.COV	Covariance of impedance ZXY

Restriction: One instance of any or all of these data blocks can appear in an >=MTSECT or >=EMAPSECT data section. Any impedance blocks in these sections must immediately follow the >FREQ block and the optional >ZROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
TYPE	Type of estimation used	String or ""	"LEASTSQ"
ROT	Type of rotation applied	"NONE", "NORTH", or "ZROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "ZROT" then the impedances are assumed to have been rotated to the angles indicated in the >ZROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only tensor impedances (see note 2 below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each scalar impedance only one E and one H are required (e.g. Ex and Hy for ZXY). For tensor impedances, two E's and two H's are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM, if specified, option may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

13.3 >ZYXR, >ZYXI, >ZYXR.VAR, >ZYXI.VAR, >ZYX.VAR, >ZYY.COV

Keyword	Description
>ZYXR	Real component of impedance ZYX (Ey/Hx)
>ZYXI	Imaginary component of impedance ZYX (Ey/Hx)
>ZYXR.VAR	Variance of real component of impedance ZYX
>ZYXI.VAR	Variance of imaginary component of impedance ZYX
>ZYX.VAR	Variance of impedance ZYX
>ZYX.COV	Covariance of impedance ZYX

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any impedance blocks must immediately follow the >FREQ block and the optional >ZROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Type of estimation used	String or ""	"LEASTSQ"
ROT	Type of rotation applied	"NONE", "NORTH", or "ZROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "ZROT" then the impedances are assumed to have been rotated to the angles indicated in the >ZROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only tensor impedances (see note 2 below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each scalar impedance only one E and one H are required (e.g. Ey and Hx for ZYX). Nor tensor impedances, two E's and two H's are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

13.4 >ZYYR, >ZYYI, >ZYYR.VAR, >ZYYI.VAR, >ZYY.VAR, >ZYY.COV

Keyword	Description
>ZYYR	Real component of impedance ZYY (Ey/Hy)
>ZYYI	Imaginary component of impedance ZYY (Ey/Hy)
>ZYYR.VAR	Variance of real component of impedance ZYY
>ZYYI.VAR	Variance of imaginary component of impedance ZYY
>ZYY.VAR	Variance of impedance ZYY
>ZYY.COV	Covariance of impedance ZYY

Restriction: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any impedance blocks must immediately follow the >FREQ block and the optional >ZROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
TYPE	Type of estimation used	String or ""	"LEASTSQ"
ROT	Type of rotation applied	"NONE", "NORTH", or "ZROT"	"NONE"
HX	Meas ID for I-Ix measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or **	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or "*	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "ZROT" then the impedances are assumed to have been rotated to the angles indicated in the >ZROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only tensor impedances (see note 2 below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to ". All of these options (after application of dynamic defaults) may be ", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each scalar impedance only one E and one H are required (e.g. Ey and Hy for ZYY). For tensor impedances, two E's and two H's are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

13.5 >FZXXR, >FZXXI, >FZXYR, >FZXYI

Keyword	Description
>FZXXR	Real component of spatially filtered impedance ZXX (Ex/Hx)
>FZXXI	Imaginary component of spatially filtered impedance ZXX (Ex/Hx)
>FZXYR	Real component of spatially filtered impedance ZXY (Ex/Hy)
>FZXYI	Imaginary component of spatially filtered impedance ZXY (Ex/Hy)

Restrictions: One instance of any or all of these data blocks can appear in an >=EMAPSECT data section. They may not appear in an >=MTSECT data section. Any impedance blocks must immediately follow the >FREQ block. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
TYPE	Type of estimation used	String or ""	"LEASTSQ"
ROT	Type of rotation applied	"NONE", "NORTH", or "ZROT"	"NONE"
EX	Meas ID for Ex measurement	Defined Meas ID	Required
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes:	The dynamic defaults for HX, HY, RX, and RY were set by the >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each scalar impedance one E and one H are required (e.g. Ex and Hx for ZXX, Ex and Hy for ZXY). If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

For EMAP filtered impedances, the ROT option should be "NONE", indicating that the impedances correspond to the measurement directions.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

14.0 Apparent Resistivity and Phase Data Blocks

14.1 >RHOXX, >PHSXX, >RHOXX.VAR, >PHSXX.VAR, >RHOXX.ERR, >PHSXX.ERR, >RHQXX.FIT, >PHSXX.FIT

Keyword	Description
>RHOXX	Magnitude of apparent resistivity (ohm-m) computed from ZXX
>PHSXX	Phase angle of apparent resistivity (deg) computed from ZXX
>RHOXX.VAR	Variance of RHOXX computed from variances of real and imag parts of ZXX
>PHSXX.VAR	Variance of PHSXX computed from variances of real and imag parts of ZXX
>RHOXX.ERR	Logl0 error bar (in decades) assoc, with RHOXX
>PHSXX.ERR	Error bar (in degrees) assoc, with PHSXX
>RHOXX.FIT	Data values defining smoothed curve which fits the RHOXX data
>PHSXX.FIT	Data values defining smoothed curve which fits the PHSXX data

Restrictions:	One instance of any or all of these data blocks can appear in an >=MTSECT or >=EMAPSECT data section. Any apparent resistivity blocks in these sections must follow the >FREQ block, any impedance blocks, and the optional >RHOROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=l	Dyn NF
TYPE	Confidence % for .ERR data or fitting method for .FIT data	String or ""	""
ROT	Type of rotation applied	"NONE", "NORTH"or "RHOROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or"	Dyn RY

CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "RHOROT" then the apparent resistivities are assumed to have been rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only apparent resistivities computed from tensor impedances (see note 2 below) may be rotated. The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each apparent resistivity computed from a scalar impedance only one E and one H are required (e.g. Ex and Hx for RHOXX). For rotatable apparent resistivities two E's and two H's are required. If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

14.2 >RHOXY, >PHSXY, >RHOXY.VAR, >PHSXY.VAR, >RHOXY.ERR, >PHSXY.ERR, >RHOXY.FIT, >PHSXY.FIT

Keyword	Description
>RHOXY	Magnitude of apparent resistivity (ohm-m) computed from ZXY
>PHSXY	Phase angle of apparent resistivity (deg) computed from ZXY
>RHOXY.VAR	Variance of RHOXY computed from variances of real and imag parts of ZXY
>PHSXY.VAR	Variance of PHSXY computed from variances of real and imag parts of ZXY
>RHOXY.ERR	Log10 error bar (in decades) assoc, with RHOXY
>PHSXY.ERR	Error bar (in degrees) assoc, with PHSXY
>RHOXY.FIT	Data values defining smoothed curve which fits the RHOXY data
>PHSXY.FIT	Data values defining smoothed curve which fits the PHSXY data

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT or >=EMAPSECT data section. Any apparent resistivity blocks in these sections must follow the >FREQ block, any impedance blocks, and the optional >RHOROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Confidence % for .ERR data or fitting method for .FIT data.	String or ""	
ROT	Type of rotation applied	"NONE", "NORTH", or "RHOROT"	"NONE"

HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "RHOROT" then the apparent resistivities are assumed to have been rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only apparent resistivities computed from tensor impedances (see note below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each apparent resistivity computed from a scalar impedance only one E and one H are required (e.g. Ex and Hy for RHOXY). For rotatable apparent resistivities two E's and two H's are required. If least=squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

14.3 >RHOYX, >PHSYX, >RHOYX.VAR, >PHSYX.VAR, >RHOYX.ERR, >PHSYX.ERR, >RHOYX.FIT, >PHSYX.FIT

Keyword	Description
>RHOYX	Magnitude of apparent resistivity (ohm-m) computed from ZYX
>PHSYX	Phase angle of apparent resistivity (deg) computed from ZYX
>RHOYX.VAR	Variance of RHOYX computed from variances of real and imag parts of ZYX
>PHSYX.VAR	Variance of PHSYX computed from variances of real and imag parts of ZYX
>RHOXY.ERR	Log10 error bar (in decades) assoc, with RHOYX
>PHSXY.ERR	Error bar (in degrees) assoc, with PHSYX
>RHOXY.FIT	Data values defining smoothed curve which fits the RHOYX data
>PHSXY.FIT	Data values defining smoothed curve which fits the PHSYX data

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any apparent resistivity blocks in the sections must follow the >FREQ block, any impedance blocks, and the optional >RHOROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Confidence % for .ERR data or fitting method for .FIT data.	String or ""	""
ROT	Type of rotation applied	"NONE", "NORTH" or "RHOROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or"	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or"	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "RHOROT" then the apparent resistivities are assumed to have been rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only apparent resistivities computed from tensor impedances (see note 2 below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each apparent resistivity computed from a scalar impedance only one E and one H are required (e.g. Ey and Hx for RHOYX). For rotatable apparent resistivities two E's and two H's are required. If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

14.4 >RHOYY, >PHSYY, >RHOYY.VAR, >PHSYY.VAR, >RHOYY.ERR, >PHSYY.ERR, >RHOYY.FIT, >PHSYY.FIT

Keyword	Description
>RHOYY	Magnitude of apparent resistivity (ohm-m) computed from ZYY
>PHSYY	Phase angle of apparent resistivity (deg) computed from ZYY

>RHOYY.VAR	Variance of RHOYY computed from variances of real and imag parts of ZYY
>PHSYY.VAR	Variance of PHSYY computed from variances of real and imag parts of ZYY
>RHOYY.ERR	Log10 error bar (in decades) assoc, with RHOYY
>PHSYY.ERR	Error bar (in degrees) assoc, with PHSYY
>RHOYY.FIT	Data values defining smoothed curve which fits the RHOYY data
>PHSYY.FIT	Data values defining smoothed curve which fits the PHSYY data

<u>Restrictions:</u> One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any apparent resistivity blocks in the sections must follow the >FREQ block, any impedance blocks, and the optional >RHOROT block, if included. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Confidence % for. ERR data or fitting method for .FIT data.	String or ""	""
ROT	Type of rotation applied	"NONE", "NORTH" or "RHOROT"	"NONE"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

<u>Data Set:</u> Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

<u>Notes:</u> If the ROT option is "RHOROT" then the apparent resistivities are assumed to have been rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", they are assumed to be in the measurement directions. Only apparent resistivities computed from tensor impedances (see note 2 below) may be rotated.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each apparent resistivity computed from a scalar impedance only one E and one H are required (e.g. Ey and Hy for RHOYY). For rotatable apparent resistivities two E's and two H's are required. If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

14.5 >FRHOXX, >FPHSXX, >FRHOXX.FIT, >FPHSXX.FIT, >FRHOXY, >FPHSXY, >FRHOXY.FIT, >FPHSXY.FIT

Keyword	Description
>FRHOXX	Apparent resistivity (ohm-m) comp. from spatially filtered FZXX
>FPHSXX	Phase (deg) computed from spatially filtered FZXX
>FRHOXX.FIT	Data values defining smoothed curve which fits the FRHOXX data
>FPHSXX.FIT	Data values defining smoothed curve which fits the FPHSXX data
>FRHOXY	Apparent resistivity (ohm-m) comp. from spatially filtered FZXY
>FPHSXY	Phase (deg) computed from spatially filtered FZXY
>FRHOXY.FIT	Data values defining smoothed curve which fits the FRHOXY data
>FPHSXY.FIT	Data values defining smoothed curve which fits the FPHSXY data

Restrictions: One instance of any or all of these data blocks can appear in an >=EMAP data section. They may not appear in an >=MTSECT data section. Any apparent resistivity blocks in the sections must follow the >FREQ block, and any impedance blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
TYPE	Fitting method for .FIT data	String or ""	""
ROT	Type of rotation applied	"NONE", "NORTH" or "RHOROT"	"NONE"
EX	Meas ID for Ex measurement	Defined Meas ID	Required
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic defaults for HX, HY, RX, and RY were set by the >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each apparent resistivity, one E and one H are required (e.g. Ex and Hx for RHOXX, Ex and Hy for RHOXY). If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

For apparent resistivities derived from EMAP filtered impedances, the ROT option should be "NONE", indicating that the apparent resistivities correspond to the measurement directions.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

15.0 Continuous 1-D Inversion Data Blocks

15.1 >RES1DXX, >DEP1DXX, RES1DXY, >DEP1DXY

Keyword	Description
>RES1DXX	True resistivity (ohm-m) computed from RHOXX using 1-D cont. inverse
>DEP1DXX	Depth (units) computed from RHOXX using 1-D cont. inverse
>RES1DXY	True resistivity (ohm-m) computed from RHOXY using 1-D cont. inverse
>DEP1DXY	Depth (units) computed from RHOXY using 1-D cont. inverse

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT or >=EMAPSECT data section. Any continuous 1-D data blocks in these sections must follow the >FREQ block, any impedance blocks, and any apparent resistivity blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs used for inversion	Integer >=1	Dyn NF
TYPE	Type of inversion	String or ""	""
ROT	Type of rotation applied to Rho data	"NONE", "NORTH" or "RHOROT"	"NONE"
UNITS	Units for depth	"M" or "FT"	"M"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. There is a one-to-one correspondence between a depth block and its corresponding resistivity block. The values must be within the legal range for reals. Depth values are relative to the surface and increase with depth. Thus, they must be all greater than zero and strictly increasing. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "RHOROT" then the inversion is assumed to have been computed from apparent resistivities which were rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", the apparent resistivities are assumed to be in the measurement directions. Inversion of MT data in the measurement directions or rotated to true north is usually of little interest, so ROT=ROTRHO should almost always specified for inversion data blocks in an >=MTSECT data section. Only apparent resistivities computed from tensor impedances (see note 2 below) may be rotated.

For inversions derived from EMAP impedances, the ROT option should be "NONE", indicating that the impedances correspond to the measurement directions.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each continuous inversion derived from a scalar impedance only one E and one H are required (e.g. Ex and Hx for RESXX and DEP1DXX, or Ex and Hy for RESXY and DEP1DXY). For inversions computed from rotated apparent resistivities two E's and two H's are required. If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The type of inversion used may be BOSTICK or another technique. If applicable, the option should also indicate how the slope was derived (e.g. from amplitude differences or Hilbert transform of phase).

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

15.2 >RES1DYX, >DEP1DYX, RES1DYY, >DEP1DYY

Keyword	Description
>RES1DYX	True resistivity (ohm-m) computed from RHOYX using 1-D cont. inverse
>DEP1DYX	Depth (units) computed from RHOYX using 1-D cont. inverse
>RES1DYY	True resistivity (ohm-m) computed from RHOYY using 1-D cont. inverse
>DEP1DYY	Depth (units) computed from RHOYY using 1-D continuous inverse

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any continuous 1-D data blocks in these sections must follow the >FREQ block, any impedance blocks, and any apparent resistivity blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs used for inversion	Integer >=1	Dyn NF
TYPE	Type of inversion	String or ""	""
ROT	Type of rotation applied to Rho data	"NONE", "NORTH" or "RHOROT"	"NONE"
UNITS	Units for depth	"M" or "FT"	"M"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or"	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. There is a one-to-one correspondence between a depth block and its corresponding resistivity block. The values must be within the legal range for reals. Depth values are relative to the surface and increase with depth.

Thus, they must be all greater than zero and strictly increasing. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If the ROT option is "RHOROT" then the inversion is assumed to have been computed from apparent resistivities which were rotated to the angles indicated in the >RHOROT data block. If it is "NORTH", they are assumed to have been rotated to true north. If it is "NONE", the apparent resistivities are assumed to be in the measurement directions. Inversion of MT data in the measurement directions or rotated to true north is usually of little interest, so ROT=ROTRHO should almost always specified for inversion data blocks in an >=MTSECT data section. Only apparent resistivities computed from tensor impedances (see note 2 below) may be rotated.

For inversions derived from EMAP impedances, the ROT option should be "NONE", indicating that the impedances correspond to the measurement directions.

The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to ". Ail of these options (after application of dynamic defaults) may be ", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each continuous inversion derived from a scalar impedance only one E and one H are required (e.g. Ey and Hx for RESYX and DEP1DYX, or Ey and Hy for RESYY and DEP1DYY). For inversions computed from rotated apparent resistivities two E's and two Hs are required. If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The type of inversion used may be BOSTICK or another technique. If applicable, the option should also indicate how the slope was derived (e.g. from amplitude differences or Hilbert transform of phase).

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

15.3 >FRES1DXX, >FDEP1DXX, FRES1DXY, >FDEP1DXY

Keyword	Description
>FRES1DXX	True resistivity (ohm-m) computed using a l-D cont. inverse from apparent resistivity data derived from spatially filtered FZXX data
>FDEP1DXX	Depth (units) corresponding one-to-one with the FRES1DXX resistivities
>FRES1DXY	True resistivity (ohm-m) computed using a 1-D cont. inverse from apparent resistivity data derived from spatially filtered FZXY data
>FDEP1DXY	Depth (units) corresponding one-to-one with the FRES1DXY resistivities

Restrictions: One instance of any or all of these data blocks can appear in an >=EMAPSECT. They may not appear in an >=MTSECT data section. Any continuous 1-D data blocks in the sections must follow the >FREQ block, any impedance blocks, and any apparent resistivity blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs used for inversion	Integer >=1	Dyn NF
TYPE	Type of inversion	String or ""	""
ROT	Type of rotation applied to Rho data	"NONE", "NORTH" or "RHOROT"	"NONE"
UNITS	Units for depth	"M" or "FT"	"M"
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. There is a one-to-one correspondence between a depth block and its corresponding resistivity block. The values must be within the legal range for reals. Depth values are relative to the surface and increase with depth. Thus, they must be all greater than zero and strictly increasing. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT, >=EMAPSECT, or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For each continuous inversion derived from a scalar impedance one E and one H are required (e.g. Ex and Hx for FRESXX and FDEPXX, or Ex and Hy for FRESXY and FDEP1DXY). If least-squares estimation was used for the impedances, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

For inversions derived from EMAP filtered impedances, the ROT option should be "NONE", indicating that the impedances correspond to the measurement directions.

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The type of inversion used may be BOSTICK or another technique. If applicable, the option should also indicate how the slope was derived (e.g. from amplitude differences or Hilbert transform of phase).

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

16.0 Coherency and Signal Data Blocks

16.1 >COH

Keyword	Description
>COH	Ordinary coherency between any two measurements as a function of freq.

Restrictions: One or more instances of this data block can appear in an >=MTSECT data section, or an >=EMAPSECT data section. Any coherency data blocks in these sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs used inversion	Integer >=1	Dyn NF
MEAS1	Meas ID for the 1st meas.	Def Meas ID	Required
MEAS2	Meas ID for the 2nd meas.	Def Meas ID	Required
ROT	Rotation of measurements	"NONE", "NORTH" or "ROTRHO"	"NONE"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: If coherencies are being used in identifying the source(s) of noise in the data, it is most useful to have these parameters in the direction of the measurements (ROT=NONE). For evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities (ROT=ROTRHO or ROT=NORTH).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

16.2 >EPREDCOH

Keyword	Description
>EPREDCOH	Multiple coherency relationship between an E measurement, and a predicted E measurement derived from two H measurements and a tensor impedance Z.

Restrictions: One or more instances of this data block can appear in an >=MTSECT data section, or an >=EMAPSECT data section. Any coherency data blocks in these sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs for inversion	Integer >=1	Dyn NF
MEAS1	Meas ID for the 1st H meas.	Def Meas ID	Required
MEAS2	Meas ID for the 2nd H meas.	Def Meas ID	Required
EPRED	Meas ID for predicted E meas.	Def Meas ID	Required
ROT	Orientation of measurements	"NONE", "NORTH" or "ROTRHO"	"NONE"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set:	Data set must contain exactly NFREQ data values. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.
Notes:	If coherencies are being used in identifying the source(s) of noise in the data, it is most useful to have these parameters in the direction of the measurements (ROT=NONE). For evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities (ROT=ROTRHO or ROT=NORTH). The dynamic default for NF was set by the NFREQ option in the first block of the section. The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

16.3 >HPREDCOH

Keyword	Description
>HPREDCOH	Multiple coherency relationship between an H measurement, and a predicted H measurement derived from two E measurements and a tensor admittance Y.

Restrictions:	One or more instances of this data block can appear in an >=MTSECT data section, or an >=EMAPSECT data section. Any coherency data blocks in these sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any l-D inversion blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs for inversion	Integer >= 1	Dyn NF
MEAS1	Meas ID for the 1st E meas.	Def Meas ID	Required
MEAS2	Meas ID for the 2nd E meas.	Def Meas ID	Required
HPRED	Meas ID for predicted H meas.	Def Meas ID	Required
ROT	Orientation of measurements	"NONE", "NORTH" or "ROTRHO"	"NONE"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set:	Data set must contain exactly NFREQ data values. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.
Notes:	If coherencies are being used in identifying the source(s) of noise in the data, it is most useful to have these parameters in the direction of the measurements (ROT=NONE). For evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities (ROT=ROTRHO or ROT=NORTH). The dynamic default for NF was set by the NFREQ option in the first block of the section. The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care

should be exercised in writing and testing checksums.

16.4 >SIGAMP

Keyword	Description
>SIGAMP	Signal amplitude (or power) spectra for a measurement as a function of frequency.

Restrictions: One or more instances of this data block can appear in an >=MTSECT data section, or an >=EMAPSECT data section. Any signal data blocks in these sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs for inversion	Integer >= 1	Dyn NF
MEAS	Meas ID for the measurement.	Def Meas ID	Required
AMPPWR	Whether spectra is amp or power	"AMP" or "PWR"	"AMP"
EUNITS	Units for E spectra (amplitude).	"MV/KM" or "V/M"	"MV/KM"
HUNITS	Units for H spectra (amplitude)	"NT"	"NT"
ROT	Orientation of measurements	"NONE", "NORTH" or "ROTRHO"	"NONE"
TYPE	Total field, est. signal, or est. noise	"FIELD", "SIGNAL" or "NOISE"	"FIELD"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: Either the EUNITS option or the HUNITS option, as appropriate for the measurement, may be specified for documentation purposes, or if E spectra are not in default units. If the AMPPWR option is PWR, then the units are the squares of the amplitude units.

If signal amplitude (or power spectral density) is being used in identifying the source(s) of noise in the data, it is most useful to have these parameters in the direction of the measurements (ROT=NONE). For evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities (ROT=ROTRHO or ROT=NORTH).

The signal amplitude (or power spectral density) can either be calculated from the total field (TYPE=FIELD), from the estimated signal only (TYPE=SIGNAL), or from the estimated noise only (TYPE=NOISE). The estimated signal and noise can be computed using a remote reference (Gamble, 1978).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

16.5 >SIGNOISE

Keyword Description

>SIGNOISE	Signal-to-noise ratio for a measurement as a function of frequency.
Restrictions:	One or more instances of this data block can appear in an >=MTSECT data section, or an >=EMAPSECT data section. Any signal data blocks in these sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of freqs for inversion	Integer >=1	Dyn NF
MEAS	Meas ID for the measurement.	Def Meas ID	Required
ROT	Orientation of measurements	"NONE", "NORTH" or "ROTRHO"	"NONE"
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values. All data values must be >=0 and <=1. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The estimated signal and noise can be computed using a remote reference (Gamble, 1978). From these, signal/(signal + noise) can be computed.

If signal amplitude (or power spectral density) is being used in identifying the source(s) of noise in the data, it is most useful to have these parameters in the direction of the measurements (ROT=NONE). For evaluating data quality it is most useful to have these parameters in the direction of the apparent resistivities (ROT=ROTRHO or ROT=NORTH).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

17.0 Tipper Data Blocks

17.1 >TIPMAG, >TIPPHS, >TIPMAG.ERR, >TIPPHS.ERR, >TIPMAG.FIT, >TIPPHS.FIT

Keyword	Description
>TIPMAG	Magnitude of total tipper
>TIPPHS	Phase angle of total tipper
>TIPMAG.VAR	Variance of TIPMAG
>TIPPHS.VAR	Variance of TIPPHS
>TIPMAG.ERR	Error bar assoc, with TIPMAG
>TIPPHS.ERR	Error bar (in degrees) assoc, with TIPPHS
>TIPMAGFIT	Data values defining smoothed curve which fits the TIPMAG data
>TIPPHS.FIT	Data values defining smoothed curve which fits the TIPPHS data

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any tipper blocks in the section must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	Confidence % for .ERR data or fitting method for .FIT data.	String or ""	""
HX	Meas ID for Hz measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
HZ	Meas ID for Hz measurement	Def Meas ID or ""	Dyn EX
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic defaults for HX, HY, HZ, RX, and RY were set by the >=MTSECT or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For the total tipper, HX, HY, and HZ are required. If least-squares estimation was used for the tipper, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the first block of the section.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

18.0 Strike, Skew and Ellipticity Data Blocks

18.1 >ZSTRIKE, >ZSKEW, >ZELLIP

Keyword	Description
>ZSTRIKE	Impedance strike angle computed from the impedance tensor Z
>ZSKEW	Impedance skew computed from the impedance tensor Z
>ZELLIP	Impedance ellipticity computed from the impedance tensor Z

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any strike, skew, or ellipticity blocks in the section must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
TYPE	For ZSTRIKE, criteria for	String or ""	""

	determining strike angle		
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
EX	Meas ID for Ex measurement	Def Meas ID or ""	Dyn EX
EY	Meas ID for Ey measurement	Def Meas ID or ""	Dyn EY
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic defaults for HX, HY, EX, EY, RX, and RY were set by the >=MTSECT or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For tensor impedances, two E's and two H's are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

18.2 >TSTRIKE, >TSKEW, >TELLIP

Keyword	Description
>TSTRIKE	Tipper strike angle computed from the tipper tensor T
>TSKEW	Tipper skew computed from the tipper tensor T
>TELLIP	Tipper ellipticity computed from the tipper tensor T

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section. They may not appear in an >=EMAPSECT data section. Any strike, skew, or ellipticity blocks in the section must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >= 1	Dyn NF
TYPE	For TSTRIKE, criteria for determining strike angle	String or ""	""
HX	Meas ID for Hx measurement	Def Meas ID or ""	Dyn HX
HY	Meas ID for Hy measurement	Def Meas ID or ""	Dyn HY
HZ	Meas ID for Hz measurement	Def Meas ID or ""	Dyn HX
RX	Meas ID for Rx ref measurement	Def Meas ID or ""	Dyn RX
RY	Meas ID for Ry ref measurement	Def Meas ID or ""	Dyn RY
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic defaults for HX, HY, HZ, RX, and RY were set by the >=MTSECT or >=OTHERSECT block. If any were not specified, the corresponding dynamic default was set to "". All of these options (after application of dynamic defaults) may be "", indicating no measurement. Although no restrictions are enforced, all appropriate measurements should be defined. For a tipper, Hx, Hy, and Hz are required. If least-squares estimation was used, the reference measurements Rx and Ry must be indicated. This is true whether they are coincident with other measurements (local reference) or distinct (remote reference).

The dynamic default for NF was set by the NFREQ option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

19.0 Spatial Filter Blocks

19.1 >FILWIDTH, >FILANGLE, >EQUIVLEN

Keyword	Description
>FILWID	Length of spatial filter in meters (or feet if UNITS=FT)
>FILANGLE	Angle of spatial filter in degrees (relative to true north)
>EQUIVLEN	Length of spatial filter in equivalent dipole lengths

Restrictions: One instance of any or all of these data blocks can appear in an >=EMAP data section. They may not appear in an >=MTSECT data section. Any spatial filter width blocks in the section must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
NFREQ	Number of frequencies	Integer >=1	Dyn NF
UNITS	Units for filter/dipole lengths	"M" or "FT"	"M"
DIPLEN	Dipole lengths for EQUIVLEN	Number >0 or ""	""
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set must contain exactly NFREQ data values corresponding to the frequencies defined by the >FREQ block. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The dynamic default for NF was set by the NFREQ option in the section head block.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

20.0 Non-Standard Data Blocks

Keyword	Description
>____.EXP	Data of a type not specified by this standard

Restrictions: One instance of any or all of these data blocks can appear in an >=MTSECT data section or an >=EMAPSECT data section. Any .EXP blocks in the sections must follow the >FREQ block, any impedance blocks, any apparent resistivity blocks, and any 1-D inversion blocks. One or more of any or all may appear anywhere in >=OTHERSECT sections.

Option Name	Description	Restrictions	Default
String [1-16]	Any desired option	String or ""	""
CHKSUM	Checksum total for data values	Number or ""	""

Data Set: Data set may contain any number of values. The values must be within the legal range for reals. The special value for empty (Section 6.23) should be used to denote missing data values and the count should be set to zero (Section 6.23) if the data set is empty.

Notes: The use of .EXP data blocks require the consent of all parties. The definition of the data, the options, and the defaults for .EXP blocks should be in the >INFO text.

The CHKSUM option, if specified, may be used to detect errors in data writing, reading, or transmission. The value of the checksum is the exact sum of all of the data values in the block. For purposes of summing, the values represented by the output format are to be used. Empty values (Section 6.23) are summed as zeroes. Blocks with binary data sets may use the CHKSUM option. Because of the limits in formatting real numbers, care should be exercised in writing and testing checksums.

21.0 Future Extensions

The >OTHERSECT data section and the .EXP data blocks are intended to provide flexibility to handle cases not covered by this standard for limited applications or in an interim role. As new techniques and data types come into use, the standard should be revised to reflect these.

Appendix 1 - Terms and Definitions

ASCII Data Set

An ASCII data set consists of the character sequence "//", followed by a count, followed by zero or more data values. The data values must begin a new record (i.e. start on a new line). See section 6.23, Data Set, and Data Value.

Backus-Naur Form (BNF)

Backus-Naur form, or BNF, is a formal notation for precise syntax specification used in this standard. See section 6.1 for a description of the notation. It is described in detail by Aho and Ullman (1978). See section 6.1.

Binary Data Set

A binary data set is a special kind of data set for use with very large data sets where data compression is required. Binary data values are placed in a parallel binary file and are referenced by the EDI interchange file. When one of three special character sequences: "/I/", "/R/", or "/D/" (for Integer, Real, and Double=precision Real data respectively) is encountered, data is read from the binary data file. See section 6.23.

Channel

A channel refers to a particular sensor setup. For electric field channels, it is represented by a pair of X,Y, and Z offsets from the reference location, one for each electrode. For magnetic field channels it is represented by an X, Y, Z offset of the sensor from the reference location, and azimuth and dip angles of the sensor. See Measurement ID.

Comment

Comments may be freely embedded within an EDI file any place where a space can be except within a data set. A comment begins with the two characters >! and continues until another ! character is encountered. See section 6.25.

Data Block (or block)

Data blocks are the basic building blocks from which EDI files are constructed. Each consists of a keyword followed by an option list and a data set. The keyword is required, but the option list and the data set may or may not be present, depending on the keyword. A mechanism has been included for including non-standard data blocks. See section 7.1 and EXP. Data Block.

Data Set

A data set is a series of values. There are two kinds of data sets: ASCII data sets and binary data sets. A data set is indicated by "//" (ASCII), "/I/" (Binary integer), "/R/" (Binary real), or "/D/" (Binary double). If it is an ASCII data set it is followed by a count and zero or more data values. If it is a binary data set, the count and data values are read from a parallel binary file. See section 6.23, ASCII Data Set, and Binary Data Set.

Data Section

A data section is a group of contiguous blocks which are related. All data sections begin with a block whose keyword begins with >=. All EDI files must contain a >=DEFMEAS data section which defines the measurements used by the file. They may then contain one or more of the following optional data sections: >=TSERIESSECT, >=SPECTRASECT, >=MTSECT, >EMAPSECT, or >=OTHERSECT. Any of these optional sections can be processed independently of the others. See section 7.5.

Data Value

A data value is a single number in an ASCII data set. It is a set of ASCII characters which represent a valid number. It may be an integer, real, or floating point format. An empty data value is represented by a special value defined by the EMPTY option in the >HEAD block. See section 6.22, ASCII Data Set, and Empty Data Value.

Date

The correct syntactic form for a date is MM/DD/YY, where MM is the month 01 to 12, DD is the day 01 to 31, and YY is the last two digits of the year, 00 to 99. See section 6.22.

Dynamic Option Default

Some options have default values which depend upon previously set values. The first block in a new section can define the dynamic defaults for some options. Then, any data block within the section can use the default value by not specifying that option or may specify a different value by specifying the option. There are nine defined dynamic defaults: HX, HY, HZ, EX, EY, RX, RY, NF, and NC. When writing an option list, if the option value = default value, the option does not have to be written. When reading, the default value should be filled in if the option is not specified. See also section 6.24, and Option.

Electrical Data Interchange (or EDI) File

An ASCII data file whose format corresponds to the syntactic and semantic specifications set forth in this standard.

EMAP

An acronym for Electro-Magnetic Array Profiling, a recently developed geophysical exploration technique (Bostick, 1986), which uses magnetic field measurements and an array of contiguous electric field measurements to estimate the subsurface resistivity structure. See section 7.54.

EMAP Data Section

An EMAP data section is a group of data blocks in an EDI file which corresponds to an EMAP line, or a section of an EMAP line. It must begin with an >=EMAPSECT data block which lists the measurements used for the EMAP processing. Following are data blocks for frequencies, impedances (Z's), apparent resistivities (Rho's), one-dimensional continuous inversions, coherencies, signal parameters, and other data blocks. See section 7.54.

Empty Data Set

A data set (either ASCII or binary) is a count followed by a series of data values. When a data set is completely empty, the count should be set to zero, and no data presented. The use of a special representation is in lieu of filling the data set with some arbitrary data value such as zero to represent no data. See section 6.23 and Data Set.

Empty Data Value

When one or more, but not all (see Empty Data Set), of the values in a data set unknown, a special "empty value" is used to represent those values. The use of this special representation is in lieu of filling the data value with some arbitrary number such as zero. The empty value is defined by the EMPTY option in the

>HEAD block. The static default for the EMPTY option is 1.0E32. See section 6.23 and Data Value.

End Block

This data block has no option list and no data set. There is always exactly one in each EDI file and it is always the last block in the file.

EXP Data Block

A special mechanism has been included within this standard for handling data blocks within an EDI file other than those currently defined by the standard. This may be used to handle new types of data until they can be officially added to the standard, or may be used for conveying special data types. Encountering a data block with any keyword not included in the standard is normally considered to be an error. However, if the keyword ends with the extension ".EXP" the data block is considered to be EXPerimental or an EXcePtion. In this case it must be a syntactically correct data block, but no restrictions are enforced on its option list or data set. Any use of EXP data blocks should be by agreement of effected parties and should be documented in the >INFO section. See section 20.0

Head Block

The head block is always the first block in an EDI file. There is exactly one head block per file. It has an option list but no data set. Options describe when, where, and by whom the data was collected as well as when, where, and by whom the EDI file was written.

Integer

Integers are considered to be two's compliment 16 bit quantities. The range of integers is -32768 to 32767. See section 6.22, section 6.23, Binary Data Set.

Interchange Media

This standard addresses the interchange media on which an EDI file resides as a separate issue from the format of an EDI file. The only standardized media are 9 track 1/2" magnetic tape and IBM 3480 compatible tape cartridges, but any media acceptable to all concerned parties may be used for the interchange of EDI files. Only 1600 BPI 9 track tape is acceptable for archival purposes. See sections 4.1 and 4.2.

Keyword

All data block begin with a keyword. Keywords begin with the character ">". The current standard defines 119 keywords. Additionally, the .EXP extension allows non-standard keywords to be used within an EDI file. New keywords may be added to the standard in the future as required. See section 7.1, Data Block, EXP Data Block.

Info Block

The info block is the second block in an EDI file, immediately following the head block. There is exactly one info block per file. The info block has an option list with one option and no data set. Following the info block is text which continues until another keyword is encountered. This is a repository for important field comments, descriptions of data acquisition and processing, data quality tables, and any other relevant information.

Measurement

A measurement combines a channel and a run to uniquely identify a particular set of data. The definition of a measurement includes a complete description of the sensor location(s) and configuration, sensor ID, filters, gain, acquisition channel, etc. All measurements must be defined in the Define Measurement section. It may then be uniquely referred to by its measurement ID. See Channel, Run, Measurement ID.

Measurement ID (or ID)

A number which uniquely identifies one of the measurements defined in the Define Measurements section. Measurement IDs incorporate both channel number and run number. The integer part is the channel number. There may be a fractional part which gives the run number. The run number for the first run is always 0. Thus, there is no fractional part in the measurement ID's for the first (and often only) run in the file. The number of digits in the fractional part is 2, 3, or 4, depending on the value of the MAXRUN option in the >=DEFINEMEAS data block. If the value is 0 (default), then all measurement IDs are simply the channel number. If the MAXRUN <100, then all measurement IDs are chan num+(run num/100). If MAXRUN is >=I00 and <1000 then all measurement IDs are chan num+(run num/1000). Finally, if MAXRUN is >= 1000, then measurement IDs are chan num+(run num/10,000).

Magnetotellurics (or MT)

Magnetotellurics, or MT, is a geophysical exploration technique which uses relationship between the earth's electric and magnetic fields as measured at the surface to estimate the subsurface resistivity structure.

MT Data Section

An MT data section is a set of contiguous data blocks associated with an MT sounding. It always begins with a >MTSECT data block which defines the measurements associated with the sounding. Following this may be data blocks for frequencies, impedances (Z's), apparent resistivities (Rho's), one-dimensional continuous inversions, coherencies, signal parameters, and other data blocks. See section 7.53.

Option

An option is an option name, followed by the character "=", followed by an option argument. It is the component from which option lists are built. The type of the option is indicated by its option name. See section 6.24, Option Argument, Option List, Option Name, Dynamic Option Default, and Static Option Default.

Option Argument

An option argument is a string of 1 to 16 characters. Depending upon the option name, there may be syntactic or semantic restrictions on the option argument. Possible restrictions include valid measurement ID, valid date, valid latitude, valid longitude, integer >=0, integer >=1, number >0, number >=0, etc. These are given in the option tables in sections 8-20. See section 6.24, Option, Option List, Option Name, Dynamic Option Default, and Static Option Default.

Option List

An option list is a set of 0 or more options. They may appear only in data blocks. For a given data block type, there is a list of allowable options. Some are required, and some have default values and may be omitted. These are given in the option tables in sections 8-20. See section 6.24, option, Option Argument, Option Name, Dynamic Option Default, and Static Option Default.

Option Name

An option name consists of 1 to 16 characters. Option names define the type of an option just as keywords define the type of a data block. They are defined by the standard in the same way as keywords. For a given data block type there is an allowable set of options as given in sections 8-20. See section 6.24,Option, Option Argument, Option List, Dynamic Option Default, and Static Option Default.

Other Data Section

Both MT and EMAP data sections are made up of basically the same of data blocks. They both impose restrictions as to which data blocks may be included and on the ordering of the blocks. The OTHER section allows unrestricted inclusion of all of these data blocks. See section 7.55.

Real Number

Because the range and precision of real numbers is machine dependent, all real data values must be representable using a "least common denominator" definition. All real data values are to be within the range-1.0E-32 to -1.0E-32, the value 0.0, or within the range 1.0E-32 to 1.0+32. There may be from 1 to 16 significant figures.

Reference Location

All of the sensor locations in the define measurements section are given in terms of X, Y, and Z offsets from a reference location. The latitude, longitude, and elevation of the reference location are required in the option list for the define measurements data block See section 9.1 and Define Measurements Section.

Run

A "run" refers to the acquisition of one data set from a given set of channels. Each run represented in an EDI file has a unique run number. The first run has a run number of 0. The run number is included within a measurement ID. See Measurement ID.

Spectra Data Section

A Spectra data section consists of a series of contiguous data blocks which represent the cross and auto power spectra estimates for a given set of measurements. Each spectra data section begins with a >=SPECTRASECT data block which defines the set of measurements for which spectra are given. A series of >SPEC data blocks, one per frequency, contain the actual spectra estimates. See section 7.52.

Static Option Option

Some options have default values which are used when the option is not specified. A data block can use the default value by omitting that option from its option list, or may specify a different value by including the option. When writing an option list, if the option value=default value, the option does not have to be written. When reading, the default value should be filled in if the option is not specified. See section 6.24, Option, Option Argument, Option List, Option Name, and Dynamic Option Default.

Tseries Data Section

A time series data section is a series of contiguous data blocks which contain time series data for a given set of measurements. Each tseries data section begins with a >=TSERIESSECT data block which defines the set of measurements for which time series data are presented. A series of one or more >TSERIES data blocks contain the actual time series data.

Appendix 2 - Syntax Summary for EDI Files

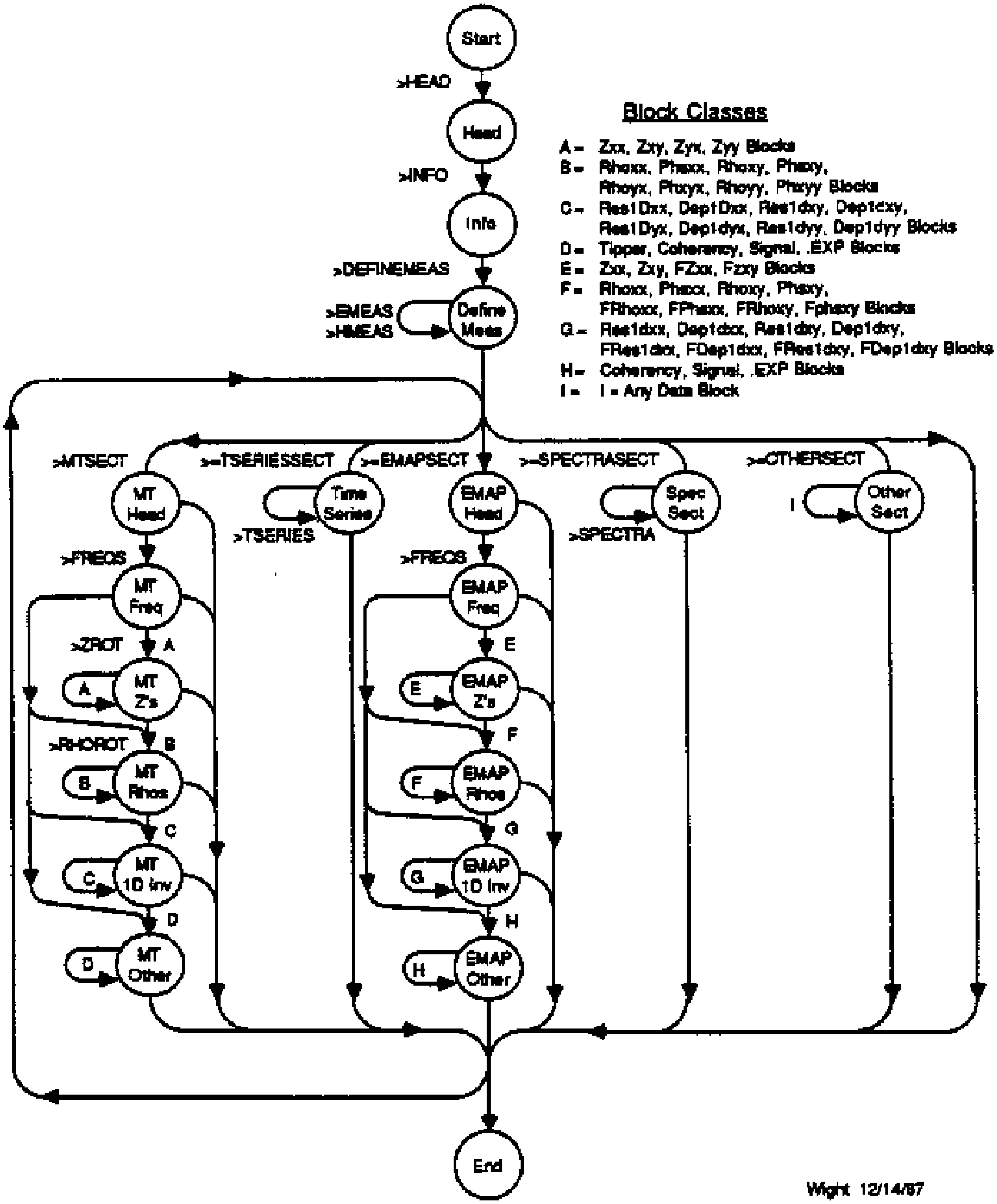
Refer to Section 6.1 for the notation used in the BNF (Backus-Naur Form) representation presented here.

Character Classes

```
<upc_letter>      ::=   "A" … "Z"
<lwc_letter>      ::=   "a" … "z"
<digit>           ::=   "0" … "9"
<special>         ::=   "%"
<other>           ::=   "!" | """ | "#" | "$" |"%" |"&" | "'" | "(" | ")" | "*"| "+"| ","| "-" | "."| "/"| ":" | ";"| "<"|
                        "=" | "?"| "@"| "[" | "\"| "]" | "^"| "_" | "`" | "{" | "|" | "}" | "~"
<space>           ::=   " "
<null>            ::=   /000 | /001 | /013
<illegal>         ::=   /001 … /009 | /011 … /012 | /014 … /031 | /127 … /255
<letter>          ::=   <upc_letter> | <lwc_letter>
<legal_char>      ::=   <letter> | <digit> | <other>
<unsign_int>      ::=   { <digit> }+
<unsign_real>     ::=   <unsign_int> "." <unsign_int> | <unsign_int> "." | "." <unsign_int>
<sign>            ::=   "+" | "-"
<int>             ::=   ( <sign> | "" ) <unsign_int>
<real>            ::=   ( <sign> | "" ) <unsign_real>
<exp>             ::=   <real> ( "E"|"e" )<int>
<string>          ::=   { <legal_char> }+l ( """ { <legal_char> | "" } """ )
<number>          ::=   <int> | <real> | <exp>
<date>            ::=   <digit> <digit> "/" <digit> <digit> "/" <digit> <digit>
<lat_long>        ::=   <int> ":" <unsign_int> ":" ( <unsign_int> | <unsign_real )
<ascii_data_set>  ::=   "//" unsign_int { <number> }
<bindata_set>     ::=   "/I/" | "/R/" | "/D/"
<meas_ID>         ::=   <unsign_int> | <unsign_real>
<meas_ID set>     ::=   "//" <unsign_int>  { <meas_ID> }
<data_set>        ::=   <ascii_data_set> | <bin_data_set> | <meas ID set>
<comment>         ::=   ">!" {<legal char> } "!"     (Where <legal. char> does not include "!" or ">")
<keyword>         ::=   ">" (<letter> | "=") { <letter> | <digit> | "." }
<option_name>     ::=   <letter> { <letter> | <digit> }
<option_arg>      ::=   <string> | <number> | <date> | <real> | <lat_long>
<option>          ::=   <option_name> "=" <option=arg>
<option_list>     ::=   { <option> }
```

```
<data_block>          ::=    <keyword> | <keyword> <option_list> | <keyword> <data_set> | <keyword>
                             <option_list> <data_set>
<head_block>          ::=    ">HEAD" <option_list>
<info_block>          ::=    ">INFO" <option_list>
<info_text>           ::=    { <legal_char> }  ( Where legal character does not include ">" )
<emeas_block>         ::=    ">EMEAS" <option_list>
<hmeas_hlock>         ::=    ">HMEAS" <option_list>
<def_meas_section>    ::=    ">=DEFINEMEAS" <option_list> { <emeas_block> | <hmeas_block> }
<tseriessect_block>   ::=    ">=TSERIESSECT" <option_list> <meas_ID_set>
 <tseries_block>      ::=    ">TSERIES" <option_list> <data_set>
<tseries_section>     ::=    <tseriessect_block> { <tseries_block> }
<spectrasect_block>   ::=    ">=SPECTRASECT" <option_list> <meas_ID_set>
<spectra_block>       ::=    ">SPECTRA" <option_list> ";" <data_set>
<spectra_section>     ::=    <spectrasect_block> { <spectra_block> }
<mtsect_block>        ::=    ">=MTSECT" <option_list>
<mt_data_block>       ::=    <keyword> <option_list> <data_set>
<mt_section>          ::=    <mtsect_block> { <mt_data_block> }
<emapsect_block>      ::=    ">=EMAPSECT" <option_list> <meas_ID_set>
<emap_data_block>     ::=    <keyword> <option_list> <data_set>
<emap_section>        ::=    <emapsect_block> { <emap_data_block> }
<othersect_block>     ::=    ">=OTHERSECT" <option_list> <meas_ID_set>
<data_block>          ::=    <keyword> <option_list> <data_set>
<other_section>       ::=    <othersect_block> { <data_block> }
<end_block>           ::=    ">END"
<edi_file>            ::=   <head_block>
                            <info_block>
                            <info_text>
                            <def_meas_section>
                            { <tseries_section> | spectra_section> | <mt_section> | <emap_section> |
                              <other_section> }
                            <end block>
```

Appendix 3 - Ordering of Data Blocks



Appendix 4 - Example EDI File for MT Site

```
>HEAD

DATAID="MT SITE DEMO"
ACQBY="BIG OIL"
FILEBY="WSE ASSOCIATES"
ACQDATE=12/01/87
ENDDATE=12/02/87
FILEDATE=12/15/87
COUNTRY=USA
STATE=TEXAS
COUNTY=TRAVIS
LAT=30:20:34.4
LONG=-97:02:59.1
ELEV=508.5
UNITS=FT
STDVERS=1.0
PROGVERS="WSE 4.2"
PROGDATE=12/14/87

>INFO

 ....................................................................
                  SAMPLE EDI FILE - MT SITE

 THIS IS A FABRICATED EXAMPLE OF AN ELECTRICAL DATA INTERCHANGE (EDI)
 FILE FOR AN MT SITE. OUR HYPOTHETICAL SITE HAS 5 LOCAL COMPONENTS:
 HX, HY, HZ, EX, AND EY.  ADDITIONALLY THERE ARE 2 REMOTE H COMPONENTS:
 HXR AND HYR. THE E FIELDS MEASUREMENT WERE MADE WITH A 1000 FOOT DIPOLES
 IN AN L CONFIGURATION. THE AZIMUTH OF THE HX AND EX ARE 30 DEGREES EAST
 OF TRUE NORTH. THE SITE IS LOCATED EXACTLY 1 MILE EAST OF THE REFERENCE
 LOCATION FOR THE SURVEY. THE REMOTE SENSORS ARE LOCATED EXACTLY 1 MILE
 NORTH OF THE SITE.

 FOR ILLUSTRATION PURPOSES, DATA HAS BEEN COLLECTED FOR 14 FREQUENCIES.
 THIS FILE DELIVERS A TOTAL OF 56 DATA BLOCKS FOR THE SITE, INCLUDING
 Z'S, APPARENT RESISTIVITIES AND PHASES, CONTINUOUS 1D INVERSES,
 COHERENCIES, TIPPERS, STRIKES, SKEWS, AND ELLIPTICITIES.

 ....................................................................
>=DEFINEMEAS

MAXCHAN=7
MAXRUN=0
MAXMEAS=7
UNITS=FT

>!*****THE X,Y OFFSETS ARE RELATIVE TO THIS REFERENCE*****!
REFLAT=30:20:34.4
REFLONG=-97:02:59.1
REFELEV=508.5

>!****DEFINE MEASUREMENTS FOR MT SITE *****!
>HMEAS ID=1.0 CHTYPE=HX X=5280 Y=0 AZM=30 ACQCHAN=CH1
>HMEAS ID=2.0 CHTYPE=HY X=5280 Y=0 AZM=120 ACQCHAN=CH2
>HMEAS ID=3.0 CHTYPE=HZ X=5280 Y=0 AZM=0 ACQCHAN=CH3
>EMEAS ID=4.0 CHTYPE=EX X=5280 Y=0 X2=5780 Y2=866 ACQCHAN=CH4
>EMEAS ID=5.0 CHTYPE=EY X=5280 Y=0 X2=6146 Y2=-500 ACQCHAN=CH5

>!****DEFINE MEASUREMENTS FOR REMOTE REFERENCE *****!
>HMEAS ID=6.0 CHTYPE=HX X=5280 Y=5280 AZM=30 ACQCHAN=CH6
>HMEAS ID=7.0 CHTYPE=HY X=5280 Y=5280 AZM=120 ACQCHAN=CH7

>=MTSECT

SECTID="SITE 1"
NFREQ=14
```

```
>!****SET DYNAMIC DEFAULTS FOR MEASUREMENTS FOR THIS SITE ****!
HX=1
HY=2
HZ=3
EX=4
EY=5
RX=6
RY=7

>!****FREQUENCIES****!
>FREQ NFREQ=14 // 14
  3.600e+01  1.800e+01  9.000e+00  4.500e+00  2.250e+00  1.125e+00  5.625e-01
  2.813e-01  1.406e-01  7.031e-02  3.516e-02  1.758e-02  8.789e-03  4.395e-03

>!****IMPEDANCES****!
>ZXXR ROT=NORTH // 14
 -1.460e+00 -6.004e-01  9.271e-01 -2.435e-01 -1.769e-01 -8.976e-02  1.485e-02
 -2.583e-02  4.822e-02  1.004e-01  9.548e-02  2.335e-01  2.991e-01  2.882e-01
>ZXXI ROT=NORTH // 14
  1.056e-01 -1.112e+00 -8.492e-01  2.021e-01 -7.485e-02 -9.052e-02 -9.381e-02
 -1.848e-01 -3.187e-01 -1.946e-01 -5.313e-02  5.389e-02  6.311e-02  7.104e-02
>ZXX.VAR ROT=NORTH // 14
  4.017e+00  9.072e-01  2.231e-01  1.208e-01  4.502e-03  7.516e-03  1.504e-02
  5.770e-03  1.721e-03  1.116e-04  2.399e-05  1.629e-05  4.700e-05  3.670e-04
>ZXYR ROT=NORTH // 14
  2.907e+01  1.883e+01  1.240e+01  7.643e+00  4.724e+00  3.018e+00  2.142e+00
  1.626e+00  1.373e+00  1.116e+00  8.385e-01  5.322e-01  3.974e-01  3.221e-01
>ZXYI ROT=NORTH // 14
  6.419e+01  3.771e+01  2.180e+01  1.436e+01  8.614e+00  5.271e+00  3.221e+00
  1.884e+00  1.208e+00  9.069e-01  6.458e-01  5.228e-01  3.261e-01  2.436e-01
>ZXY.VAR ROT=NORTH // 14
  2.373e+00  4.877e-01  5.825e-02  6.964e-02  2.889e-03  4.747e-03  3.467e-03
  5.875e-03  1.498e-03  8.099e-05  2.402e-05  1.588e-05  6.335e-05  5.665e-04
>ZYXR ROT=NORTH // 14
 -3.535e+01 -2.521e+01 -1.534e+01 -1.001e+01 -6.155e+00 -3.987e+00 -2.796e+00
 -2.041e+00 -1.779e+00 -1.695e+00 -1.233e+00 -9.883e-01 -8.615e-01 -7.095e-01
>ZYXI ROT=NORTH // 14
 -7.948e+01 -4.757e+01 -2.797e+01 -1.794e+01 -1.151e+01 -6.989e+00 -4.180e+00
 -2.621e+00 -1.673e+00 -1.078e+00 -9.462e-01 -5.856e-01 -4.474e-01 -4.087e-01
>ZYX.VAR ROT=NORTH // 14
  1.170e+01  3.389e+00  6.290e-01  7.736e-01  2.270e-02  2.569e-02  3.570e-02
  3.284e-02  9.171e-03  4.002e-04  1.723e-04  4.835e-05  8.636e-05  8.556e-04
>ZYYR ROT=NORTH // 14
 -1.847e+00 -6.300e-01  2.994e-01  2.148e-01 -9.737e-02 -2.827e-02 -2.110e-01
 -3.100e-01 -1.617e-01  1.057e-01  2.474e-01  2.783e-01  3.500e-01  3.300e-01
>ZYYR ROT=NORTH // 14
 -1.847e+00 -6.300e-01  2.994e-01  2.148e-01 -9.737e-02 -2.827e-02 -2.110e-01
 -3.100e-01 -1.617e-01  1.057e-01  2.474e-01  2.783e-01  3.500e-01  3.300e-01
>ZYYR ROT=NORTH  // 14
 -1.847e+00 -6.300e-01  2.994e-01  2.148e-01 -9.737e-02 -2.827e-02 -2.110e-01
 -3.100e-01 -1.617e-01  1.057e-01  2.474e-01  2.783e-01  3.500e-01  3.300e-01

>!****ROTATION ANGLES****!
>RHOROT // 14
 -5.900e+01 -6.200e+01 -6.900e+01 -7.200e+01 -6.800e+01 -6.900e+01 -7.100e+01
 -7.300e+01 -5.500e+01 -4.400e+01 -4.600e+01 -7.300e+01 -8.400e+01 -8.800e+01

>!****APPARENT RESISTIVITIES AND PHASES****!
>RHOXY ROT=RHOROT // 14
  2.758e+01  1.974e+01  1.398e+01  1.176e+01  8.580e+00  6.559e+00  5.321e+00
  4.404e+00  4.758e+00  5.880e+00  6.372e+00  6.333e+00  6.013e+00  7.420e+00
>RHOXY.ERR ROT=RHOROT // 14
  1.803e-04  1.036e-04  3.491e-05  9.930e-05  1.129e-05  4.853e-05  8.737e-05
  3.578e-04  1.689e-04  1.478e-05  8.090e-06  1.076e-05  9.042e-05  1.311e-03
>RHOXY.FIT ROT=RHOROT // 14
  2.784e+01  1.932e+01  1.456e+01  1.119e+01  8.638e+00  6.467e+00  4.962e+00
  4.429e+00  4.818e+00  5.760e+00  6.148e+00  6.286e+00  6.129e+00  7.652e+00
>RHOYX ROT=RHOROT // 14
  4.204e+01  3.220e+01  2.262e+01  1.876e+01  1.514e+01  1.151e+01  8.992e+00
  7.848e+00  8.480e+00  1.148e+01  1.374e+01  1.502e+01  2.144e+01  3.051e+01
```

```
>RHOYX.ERR ROT=RHOROT // 14
  5.831e-04  4.411e-04  2.331e-04  6.913e-04  5.026e-05  1.496e-04  5.325e-04
  1.122e-03  5.802e-04  3.742e-05  2.691e-05  1.382e-05  3.457e-05  4.814e-04
>RHOYX.FIT ROT=RHOROT // 14
  4.102e+01  3.160e+01  2.362e+01  1.851e+01  1.470e+01  1.132e+01  8.786e+00
  7.773e+00  8.565e+00  1.086e+01  1.332e+01  1.568e+01  2.114e+01  3.071e+01
>PHSXY ROT=RHOROT // 14
  6.564e+01  6.346e+01  6.036e+01  6.197e+01  6.126e+01  6.021e+01  5.637e+01
  4.922e+01  4.134e+01  3.911e+01  3.760e+01  4.449e+01  3.937e+01  3.710e+01
>PHSXY.ERR ROT=RHOROT // 14
  7.844e-01  4.506e-01  1.519e-01  4.321e-01  4.912e-02  2.112e-01  3.802e-01
  1.557e+00  7.351e-01  6.431e-02  3.521e-02  4.684e-02  3.935e-01  5.704e+00
>PHSYX ROT=RHOROT // 14
 -1.140e+02 -1.179e+02 -1.187e+02 -1.192e+02 -1.181e+02 -1.197e+02 -1.238e+02
 -1.279e+02 -1.368e+02 -1.475e+02 -1.425e+02 -1.494e+02 -1.526e+02 -1.501e+02
>PHSYX.ERR ROT=RHOROT // 14
  2.538e+00  1.919e+00  1.014e+00  3.008e+00  2.187e-01  6.512e-01  2.317e+00
  4.884e+00  2.525e+00  1.628e-01  1.171e-01  6.014e-02  1.504e-01  2.095e+00

>!****CONTINUOUS 1D INVERSIONS****!
>RES1DXY ROT=RHOROT UNITS=FT // 14
  8.290e+00  7.877e+00  6.285e+00  5.159e+00  3.755e+00  2.638e+00  2.708e+00
  4.295e+00  7.512e+00  8.089e+00  6.925e+00  6.124e+00  7.645e+00  2.185e+01
>DEP1DXY ROT=RHOROT UNITS=FT // 14
  1.027e+03  1.210e+03  1.485e+03  1.841e+03  2.288e+03  2.799e+03  3.468e+03
  4.633e+03  6.834e+03  1.057e+04  1.544e+04  2.208e+04  3.083e+04  4.872e+04
>RES1DYX ROT=RHOROT UNITS=FT // 14
  1.811e+01  1.290e+01  1.041e+01  9.311e+00  7.039e+00  4.991e+00  4.775e+00
  7.442e+00  1.495e+01  2.227e+01  2.175e+01  2.951e+01  6.984e+01  7.954e+01
>DEP1DYX ROT=RHOROT UNITS=FT // 14
  1.246e+03  1.547e+03  1.892e+03  2.368e+03  2.984e+03  3.703e+03  4.614e+03
  6.138e+03  9.112e+03  1.451e+04  2.273e+04  3.487e+04  5.726e+04  9.761e+04

>!****COHERENCIES****!
>COH MEAS1=1 MEAS2=5 // 14
  9.279e-01  9.346e-01  9.604e-01  9.202e-01  9.225e-01  9.229e-01  9.176e-01
  9.280e-01  9.852e-01  9.921e-01  9.797e-01  8.994e-01  7.829e-01  8.757e-01
>COH MEAS1=2 MEAS2=4 // 14
  8.199e-01  8.721e-01  8.995e-01  7.882e-01  7.776e-01  8.154e-01  7.543e-01
  8.853e-01  9.622e-01  9.058e-01  9.423e-01  9.756e-01  9.613e-01  9.390e-01
>COH MEAS1=1 MEAS2=6 // 14
  9.119e-01  9.272e-01  9.674e-01  9.144e-01  9.251e-01  9.201e-01  9.094e-01
  9.278e-01  9.901e-01  9.646e-01  9.289e-01  9.906e-01  9.895e-01  9.828e-01
>COH MEAS1=2 MEAS2=7 // 14
  7.492e-01  8.516e-01  8.899e-01  7.888e-01  7.795e-01  8.234e-01  7.775e-01
  8.910e-01  9.791e-01  9.192e-01  9.150e-01  9.966e-01  9.969e-01  9.882e-01
>EPREDCOH MEAS1=1 MEAS2=2 EPRED=4 // 14
  8.236e-01  8.730e-01  9.008e-01  7.904e-01  7.815e-01  8.208e-01  7.554e-01
  8.866e-01  9.769e-01  9.917e-01  9.965e-01  9.984e-01  9.974e-01  9.923e-01
>EPREDCOH MEAS1=1 MEAS2=2 EPRED=5 // 14
  9.282e-01  9.349e-01  9.612e-01  9.233e-01  9.232e-01  9.231e-01  9.181e-01
  9.303e-01  9.865e-01  9.977e-01  9.981e-01  9.974e-01  9.938e-01  9.940e-01
>HPREDCOH MEAS1=4 MEAS2=5 HPRED=1 // 14
  9.296e-01  9.368e-01  9.614e-01  9.236e-01  9.248e-01  9.256e-01  9.212e-01
  9.297e-01  9.861e-01  9.979e-01  9.985e-01  9.977e-01  9.952e-01  9.909e-01
>HPREDCOH MEAS1=4 MEAS2=5 HPRED=2 // 14
  8.277e-01  8.805e-01  9.045e-01  7.923e-01  7.856e-01  8.238e-01  7.755e-01
  8.970e-01  9.790e-01  9.933e-01  9.970e-01  9.979e-01  9.960e-01  9.933e-01

>!****AMPLITUDE SPECTRA AND SIGNAL/NOISE!
>SIGAMP MEAS=1 // 14
  5.296e-05  6.686e-05  1.186e-04  7.894e-05  1.099e-04  2.516e-04  4.995e-04
  1.039e-03  4.297e-03  5.704e-02  1.131e-01  2.492e-01  4.599e-01  6.086e-01
>SIGAMP MEAS=2 // 14
  3.931e-05  6.079e-05  8.574e-05  7.050e-05  8.688e-05  1.994e-04  3.249e-04
  1.102e-03  3.827e-03  2.668e-02  7.907e-02  2.794e-01  5.413e-01  7.225e-01
>SIGAMP MEAS=3 // 14
  4.685e-06  6.066e-06  1.022e-05  9.450e-06  1.773e-05  6.080e-05  2.197e-04
  6.953e-04  2.246e-03  1.568e-02  3.994e-02  9.877e-02  3.027e-01  9.606e-01
>SIGAMP MEAS=4  // 14
```

```
  2.753e-03  2.755e-03  2.305e-03  1.206e-03  9.632e-04  1.401e-03  1.336e-03
  3.290e-03  8.926e-03  4.448e-02  1.043e-01  3.242e-01  5.582e-01  5.126e-01
>SIGAMP MEAS=5 // 14
  3.773e-03  2.836e-03  2.963e-03  1.246e-03  1.097e-03  1.518e-03  1.889e-03
  2.644e-03  9.188e-03  9.717e-02  1.459e-01  2.292e-01  3.116e-01  3.945e-01
>SIGNOISE MEAS=1 // 14
  8.839e-01  9.031e-01  9.550e-01  8.760e-01  8.918e-01  8.805e-01  8.820e-01
  9.128e-01  9.895e-01  1.000e+00  9.988e-01  9.995e-01  9.988e-01  9.943e-01
>SIGNOISE MEAS=2 // 14
  6.991e-01  7.946e-01  8.377e-01  6.752e-01  6.778e-01  7.316e-01  6.757e-01
  8.361e-01  9.726e-01  9.939e-01  9.960e-01  9.991e-01  9.982e-01  9.985e-01
>SIGNOISE MEAS=3 // 14
  6.645e-01  7.779e-01  8.256e-01  3.934e-01  1.755e-01  5.915e-02  7.106e-02
  2.716e-02  3.156e-02  6.086e-01  4.838e-01  3.265e-01  1.226e-01  4.700e-02
>SIGNOISE MEAS=4 // 14
  9.812e-01  9.759e-01  9.786e-01  9.255e-01  9.114e-01  9.251e-01  8.641e-01
  9.533e-01  9.839e-01  9.913e-01  9.983e-01  9.975e-01  9.963e-01  9.831e-01
>SIGNOISE MEAS=5 // 14
  9.783e-01  9.716e-01  9.680e-01  9.704e-01  9.583e-01  9.710e-01  9.559e-01
  9.445e-01  9.836e-01  9.955e-01  9.982e-01  9.954e-01  9.898e-01  9.930e-01

>!****TIPPER PARAMETERS****!
>TIPMAG // 14
  7.868e-02  8.121e-02  7.657e-02  7.961e-02  7.335e-02  6.844e-02  1.120e-01
  1.463e-01  1.434e-01  2.327e-01  2.435e-01  2.346e-01  2.314e-01  3.499e-01
>TIPMAG.ERR // 14
  1.568e-05  4.497e-06  1.083e-06  1.583e-05  5.274e-06  3.319e-05  1.919e-04
  2.361e-03  4.919e-03  1.116e-03  1.061e-03  1.934e-04  2.570e-03  1.751e-02
>TIPPHS // 14
 -1.928e+01 -1.000e+01 -1.766e-02  7.753e+00  1.609e+01  2.944e+01  6.685e+00
  7.514e+01  1.134e+02  1.509e+02 -5.234e+01 -1.506e+02 -1.478e+02 -1.204e+02
>TIPPHS.ERR // 14
  1.526e+03  2.795e+02  3.401e+02  5.752e+02  2.511e+03  1.312e+04  8.978e+03
  2.597e+05  8.453e+06  8.796e+02  3.031e+02  6.890e+02  8.801e+04  2.209e+04

>!****STRIKE, SKEW, AND ELLIPTICITY PARAMETERS****!
>ZSTRIKE // 14
 -5.900e+01 -6.200e+01 -6.900e+01 -7.200e+01 -6.800e+01 -6.900e+01 -7.100e+01
 -7.300e+01 -5.500e+01 -4.400e+01 -4.600e+01 -7.300e+01 -8.400e+01 -8.800e+01
>ZSKEW // 14
  2.101e-02  2.449e-02  3.252e-02  3.496e-03  1.586e-02  1.541e-02  2.274e-02
  6.819e-02  1.092e-01  1.253e-01  1.749e-01  2.920e-01  4.405e-01  5.082e-01
>ZELLIP // 14
  2.412e-02  1.906e-02  1.024e-01  1.249e-01  3.665e-02  3.118e-02  2.283e-01
  3.854e-01  4.535e-01  1.922e-02  4.999e-01  6.752e-01  3.796e-01  2.396e-01
>TSTRIKE // 14
  1.274e+02  9.790e+01  1.046e+02  9.981e+01  9.965e+01  1.076e+02  9.595e+01
  8.752e+01  1.259e+02 -1.513e+02 -1.025e+02 -9.677e+01  1.492e+01  1.338e+01
>TSKEW // 14
  2.097e-01  8.216e-02  1.054e-01  1.554e-01  3.523e-01  5.739e-01  1.549e-01
  8.763e-01  8.543e-01  3.189e-01  3.353e-01  9.722e-02  1.869e-01  8.438e-01
>TELLIP // 14
  2.765e-01  2.598e-01  1.274e-01  1.618e-01  2.747e-01  3.163e-01  2.421e-01
  7.723e-01  1.189e+00  1.877e+00  1.351e+00  4.430e-01  9.644e-02  6.656e-01

>END
```

Appendix 5 - Example EDI File for EMAP Line

```
>HEAD

DATAID="EMAP DEMO"
ACQBY="BIG OIL"
FILEBY="WSE ASSOCIATES"
ACQDATE=12/01/87
ENDDATE=12/02/87
FILEDATE=12/15/87
COUNTRY=USA
STATE=TEXAS
COUNTY=TRAVIS
LAT=30:20:34.4
LONG=-97:02:59.1
ELEV=508.5
UNITS=FT
STDVERS=1.0
PROGVERS="WSE 4.2"
PROGDATE=12/14/87

>INFO

 ...................................................................
                EXAMPLE EDI FILE - EMAP DATA LINE

 THIS IS A FABRICATED EXAMPLE OF AN ELECTRICAL DATA INTERCHANGE (EDI)
 FILE FOR AN EMAP LINE. OUR HYPOTHETICAL SURVEY IS ONLY 6 DIPOLES LONG.
 EACH DIPOLE IS 1000 FEET LONG AND HAS AN AZIMUTH OF 45 DEGREES (EAST
 OF TRUE NORTH). OUR REFERENCE LOCATION CORRESPONDS THE SOUTHWEST-MOST
 ELECTRODE ON OUR LINE (DIPOLE 1). ALL OFFSETS ARE MEASURED RELATIVE TO THAT
 REFERENCE. WE MEASURED HX AND HY USING SENSORS LOCATED AT THE REFERENCE
 LOCATION. REMOTE-REFERENCE PROCESSING WAS NOT USED.

 THE LINE WAS ACQUIRED USING 2 RUNS. THE FIRST RUN, DESIGNATED  RUN 0,
 CONSISTS OF 5 CHANNELS: E1, E2, E3, HX, AND HY.  THE SECOND RUN,
 DESIGNATED RUN 1, CONSISTS OF 5 CHANNELS: E4, E5, E6, HX, AND HY.

 FOR ILLUSTRATION PURPOSES, DATA HAS BEEN COLLECTED FOR 14 FREQUENCIES.
 THIS FILE DELIVERS 4 COMPONENTS FOR EACH FREQUENCY FOR EACH DIPOLE:
 ZXXR, ZXXI, ZXYR, AND ZXYI.

 ...................................................................

>=DEFINEMEAS

MAXCHAN=5
MAXRUN=1
MAXMEAS=10
UNITS=FT

>!*****THE X,Y OFFSETS ARE RELATIVE TO THIS REFERENCE*****!
REFLAT=30:20:34.4
REFLONG=-97:02:59.1
REFELEV=508.5

>!****DEFINE MEASUREMENTS FOR RUN 0 *****!
>EMEAS ID=1.0 CHTYPE=EX X=0 Y=0 X2=707 Y2=707 ACQCHAN=CH1
>EMEAS ID=2.0 CHTYPE=EX X=707 Y=707 X2=1414 Y2=1414 ACQCHAN=CH2
>EMEAS ID=3.0 CHTYPE=EX X=1414 Y=1414 X2=2121 Y2=2121 ACQCHAN=CH3
>HMEAS ID=7.0 CHTYPE=HX X=0 Y=0 AZM=45 ACQCHAN=CH4
>HMEAS ID=8.0 CHTYPE=HY X=0 Y=0 AZM=135 ACQCHAN=CH5

>!****DEFINE MEASUREMENTS FOR RUN 1 *****!
>EMEAS ID=4.1 CHTYPE=EX X=2121 Y=2121 X2=2828 Y2=2828 ACQCHAN=CH1
>EMEAS ID=5.1 CHTYPE=EX X=2828 Y=2828 X2=3536 Y2=3536 ACQCHAN=CH2
>EMEAS ID=6.1 CHTYPE=EX X=3536 Y=3536 X2=4243 Y2=4243 ACQCHAN=CH3
>HMEAS ID=7.1 CHTYPE=HX X=0 Y=0 AZM=45 ACQCHAN=CH4
>HMEAS ID=8.1 CHTYPE=HY X=0 Y=0 AZM=135 ACQCHAN=CH5
```

```
>=EMAPSECT

SECTID="LINE 1"
NFREQ=14
MAXBLKS=256
NDIPOLE=6

>!***** THIS DATA SET (6 MEASUREMENT ID'S) DEFINES THE EMAP LINE *****!
// 6
    1.0    2.0    3.0    4.1    5.1    6.1

>!*****FREQUENCIES *****!
>FREQ // 14
    100.0000     50.0000     20.0000     10.0000      5.0000      2.0000      1.0000
      0.5000      0.2000      0.1000      0.0500      0.0200      0.0100      3.3250

>!*****DIPOLE 1 *****!
>ZXXR HX=7 HY=8 EX=1 RX=7 RY=8 // 14
       1.585       1.086       1.211       1.617       2.197       2.341       2.059
       1.693       1.243       1.157       1.414       1.704       2.000       3.418
>ZXXI HX=7 HY=8 EX=1 RX=7 RY=8 // 14
       3.814       2.431       2.134       2.590       3.323       3.376       2.548
       1.620       0.334      -0.245      -0.420      -0.229       0.243       8.164
>ZXYR HX=7 HY=8 EX=1 RX=7 RY=8 // 14
      35.430      32.150      27.040      23.440      19.070      16.870      15.100
      14.400      13.550      12.640      10.720       9.120       6.910      53.170
>ZXYI HX=7 HY=8 EX=1 RX=7 RY=8 // 14
      33.360      30.360      25.760      22.400      17.850      14.960      11.570
       9.720       7.979       7.417       7.362       7.487       7.304      52.170

>!*****DIPOLE 2 *****!
>ZXXR HX=7 HY=8 EX=2 RX=7 RY=8 // 14
       1.605       1.210       1.537       2.084       2.802       2.963       2.592
       2.131       1.579       1.494       1.860       2.256       2.660       0.535
>ZXXI HX=7 HY=8 EX=2 RX=7 RY=8 // 14
       3.955       2.215       2.040       2.830       4.047       4.246       3.243
       2.036       0.331      -0.444      -0.676      -0.414       0.242       0.970
>ZXYR HX=7 HY=8 EX=2 RX=7 RY=8 // 14
      47.430      43.660      37.620      33.250      27.700      24.660      21.790
      20.380      18.630      17.180      14.610      12.590       9.740       6.990
>ZXYI HX=7 HY=8 EX=2 RX=7 RY=8 // 14
      44.900      40.400      33.980      29.530      23.710      20.100      15.940
      13.690      11.550      10.800      10.550      10.530      10.040       6.829

>!*****DIPOLE 3 *****!
>ZXXR HX=7 HY=8 EX=3 RX=7 RY=8 // 14
       0.220       0.120       0.138       0.213       0.326       0.361       0.323
       0.266       0.193       0.180       0.222       0.271       0.321       6.734
>ZXXI HX=7 HY=8 EX=3 RX=7 RY=8 // 14
       0.459       0.248       0.233       0.336       0.491       0.517       0.393
       0.243       0.033      -0.061      -0.083      -0.047       0.038      17.410
>ZXYR HX=7 HY=8 EX=3 RX=7 RY=8 // 14
       5.921       5.222       4.271       3.664       2.976       2.651       2.411
       2.328       2.217       2.073       1.747       1.472       1.097      17.930
>ZXYI HX=7 HY=8 EX=3 RX=7 RY=8 // 14
       6.016       5.444       4.533       3.863       2.976       2.442       1.868
       1.580       1.327       1.247       1.231       1.235       1.184      21.290

>!*****DIPOLE 4 *****!
>ZXXR HX=7.1 HY=8.1 EX=4.1 RX=7.1 RY=8.1 // 14
       4.976       4.249       3.605       3.311       2.978       2.766       2.492
       2.315       2.098       1.973       1.833       1.743       1.604       2.205
>ZXXI HX=7.1 HY=8.1 EX=4.1 RX=7.1 RY=8.1 // 14
      12.230       9.344       6.374       4.902       3.498       2.844       2.199
       1.835       1.410       1.163       0.885       0.743       0.627      15.160
>ZXYR HX=7.1 HY=8.1 EX=4.1 RX=7.1 RY=8.1 // 14
      13.850      11.520       9.031       7.753       6.506       5.923       5.383
       5.111       4.763       4.467       3.930       3.481       2.782      31.850
>ZXYI HX=7.1 HY=8.1 EX=4.1 RX=7.1 RY=8.1 // 14
```

```
      16.690      13.860      10.460       8.460       6.218       5.014       3.823
       3.296       2.881       2.731       2.620       2.565       2.459      39.530

>!*****DIPOLE 5 *****!
>ZXXR HX=7.1 HY=8.1 EX=5.1 RX=7.1 RY=8.1 // 14
       0.841       0.758       1.362       1.958       2.545       2.721       2.735
       2.643       2.457       2.341       2.228       2.159       2.037       2.923
>ZXXI HX=7.1 HY=8.1 EX=5.1 RX=7.1 RY=8.1 // 14
      10.480       7.842       5.230       4.001       2.888       2.389       1.879
       1.548       1.118       0.850       0.548       0.397       0.290      18.440
>ZXYR HX=7.1 HY=8.1 EX=5.1 RX=7.1 RY=8.1 // 14
      25.820      22.610      19.400      17.690      15.580      14.220      12.570
      11.620      10.420       9.566       8.266       7.282       5.833      44.640
>ZXYI HX=7.1 HY=8.1 EX=5.1 RX=7.1 RY=8.1 // 14
      30.840      25.690      19.890      16.650      13.040      11.050       8.953
       7.878       6.832       6.352       5.912       5.666       5.268      56.630

>!*****DIPOLE 6 *****!
>ZXXR HX=7.1 HY=8.1 EX=6.1 RX=7.1 RY=8.1 // 14
       0.875       0.512       0.981       1.635       2.466       2.868       3.156
       3.173       3.055       2.959       2.863       2.796       2.658       0.000
>ZXXI HX=7.1 HY=8.1 EX=6.1 RX=7.1 RY=8.1 // 14
      13.190      10.070       6.765       5.091       3.496       2.760       2.036
       1.617       1.119       0.820       0.483       0.319       0.218       0.000
>ZXYR HX=7.1 HY=8.1 EX=6.1 RX=7.1 RY=8.1 // 14
      36.840      32.170      26.700      23.600      20.300      18.580      16.750
      15.700      14.310      13.250      11.540      10.210       8.232       0.000
>ZXYI HX=7.1 HY=8.1 EX=6.1 RX=7.1 RY=8.1 // 14
      45.930      39.170      30.690      25.470      19.310      15.820      12.180
      10.490       9.035       8.447       7.943       7.670       7.194       0.000

>END
```

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