KMS Technologies	USER MANUAL		
	ORIGINATED BY: **Ying Liu**	REVISION DATE: **02/23/11**	DOCUMENT NUMBER: **13-0012-800**
SUBJECT: **MT processing software supplement**			REVISION: **1.0**

KMS-200

MT PROCESSING SOFTWARE SUPPLEMENT

Rev.	ECO	Description	By	Date	Approved
1.0	N/A	Original Issue	Ying	2/3/11	John

TABLE OF CONTENTS

TABLE OF FIGURES

1.0 OVERVIEW

The processing software is based on the robust processing developed by Gary Egbert for a single MT site with remote reference. These routines have been used by many MT working groups at different universities worldwide and are proven as an excellent robust processing for MT data. The estimation of the transfer functions in the processing is done in 2 steps:

1. Estimation of Fourier coefficients with short time segments. To achieve this short time window (128 samples) a very broad frequency band, down sampling techniques are applied with user defined decimation factors program: **kms_dnff.exe**
2. Robust estimation of the transfer functions with the cross- and auto spectra program: **kms_tranmt.exe**

The original routines have been modified and converted to Windows platform. The default input data format is the binary format of the KMS820 acquisition system but, the structure of the program, the input/output file formats and folder structure are kept original. The transfer functions with the error estimation given by Gary Egbert can be converted with a third program called **zss2edi.exe** to standard EDI-format which can be read by other commercial software like WinGlink®. Also a simple ASCII file with apparent resistivity and phase is given for plotting applications. The quick start section gives the easiest introduction to the handling of the procedures. More detailed information is given in the documents by Gary Egbert and Markus Eisel. User can use MT data processing tool included in KMS820 Acquisition System software which provides simple graphical interface and generates necessary files for the processing. But the user can also run the process under command line based on manually edited configuration files. The following provides background to understand the process.

2.0 FOLDER STRUCTURE

The software needs a certain folder structure for data, configuration files, system parameters as calibration files and output of the processing. The easiest way is to keep the complete survey under one folder and keep the structure inside the folder as shown below:

Mandatory subfolders are:

1. Input information:

Data	:Data files of the survey (.bin)
CF	:Configuration files (.cfg)
SP	:System parameter files (.sp)
sensors	:Calibration files of sensors (.cal)

2. Output information:

FC	: Fourier coefficients of kms_dnff.exe as input for kms_tranmt.exe
MT	: Impedances from kms_tranmt.exe
EDI	: Impedances in .edi and .apr format

The example has two (2) additional folders:

DOC	: Additional documentation for the software
RESULTS	: Results of the synthetic data example

The folder structure is defined in the configuration file “paths.cfg” which must be in the working directory of the program, as shown in Figure 1.

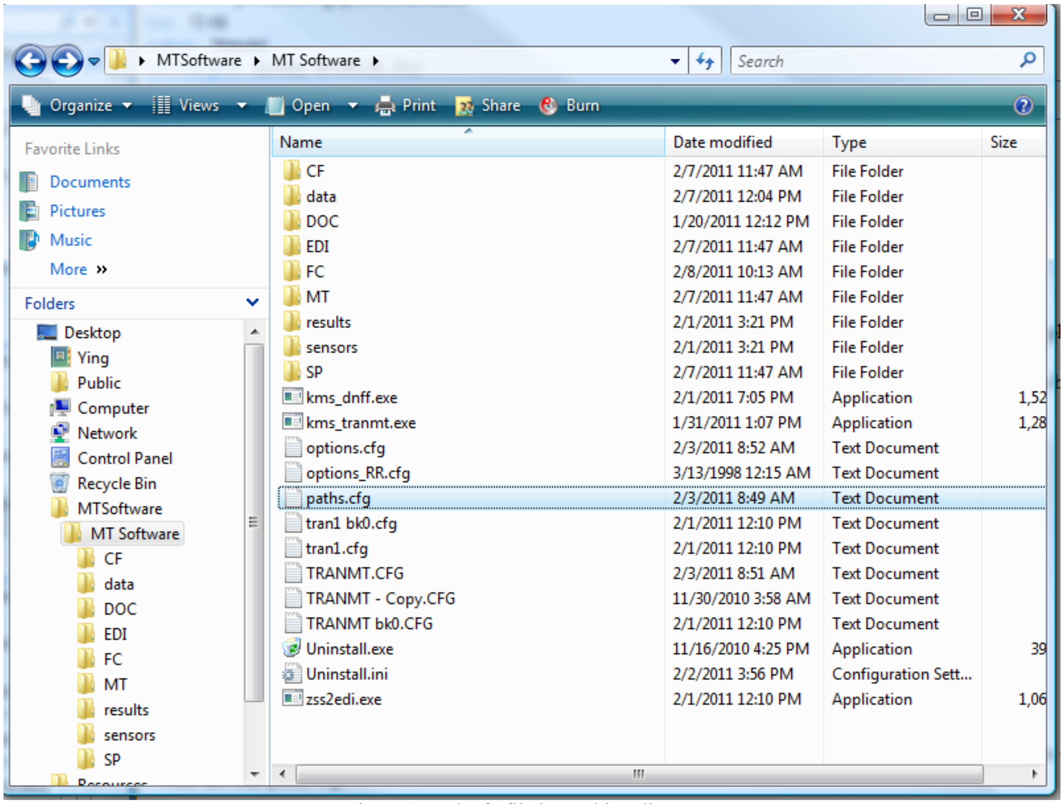

Figure 1: Path.cfg file in working directory

The example "paths.cfg" has a simple form where each line is defined as follows:

DATA – Folder containing data
SP – Folder containing system parameter files
DATA – Folder containing data information ????
CF\decset.cfg – Name and location of decimation setting configuration file
CF\pwset.cfg – Name and location of bandwidth settings configuration file
FC – Folder containing Fourier coefficients
SENSORS – Folder containing calibration files of sensors

Data files are usually large and may be placed on an external drive. Example of this path for both DATA files would be G:\subfolder_1\subfolder_2\DATA. The output EDI files can also be placed in a general location, such as G:\subfolder_1\subfolder_2\EDI.The other folder SP, CF, FC, SENSORS, and MT, should be kept in the default structure for each survey.

3.0 QUICK START WITH SYNTHETIC DATA

A walk-through of the processing with a simple synthetic data set for a homogeneous half-space (100 Ωohm.m) is the best way to demonstrate the process. The original data sets have been prepared by Gary Egbert. A slight modification has been done to adjust for the lowest sampling rate of 40 Hz used by the KMS-820 acquisition system.

In the subfolder DATA there are two binary files with the synthetic data: test1.bin and test 2.bin.The system parameters of these 2 data files are defined in the two ASCII files in the folder SP: test1.sp and test2.sp. The detailed explanations for the files are given in the section 1.4.

The processing is done in 3 steps with 3 programs:

1) Fourier coefficients calculation with **kms_dnff.exe**
2) robust impedance estimation with **kms_tranmt.exe**
3) EDI conversion and apparent resistivity and phase output with **zss2edi.exe**

3.1 Calculate Fourier coefficients

The first step is to calculate the Fourier coefficients with **kms_dnff.exe.**

When running the program, a prompt message will appear in the command window: “Enter input file name”. After user types in the file name “test1.bin”, the window as shown in Figure 2 will appear. The main parameter settings are shown in a table, such as the channel ID and the orientation of the sensors, etc. If the data file is invalid, the command window will disappear and theprocess ends.

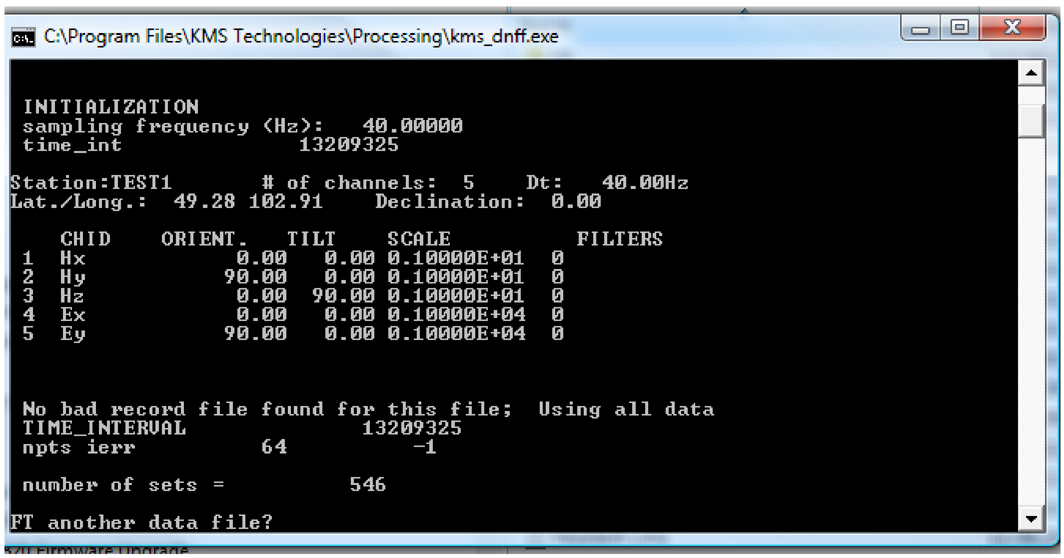

Figure 2: Prompt window for kms_dnff.exe

Then another prompt message appears: “FT another data file?” After user enters “yes” or “y”, the program will ask for the file name, then user enters “test2.bin”, as shown in Figure 3. When the program asks whether to process another file, user enters “no”, and the command window closes.

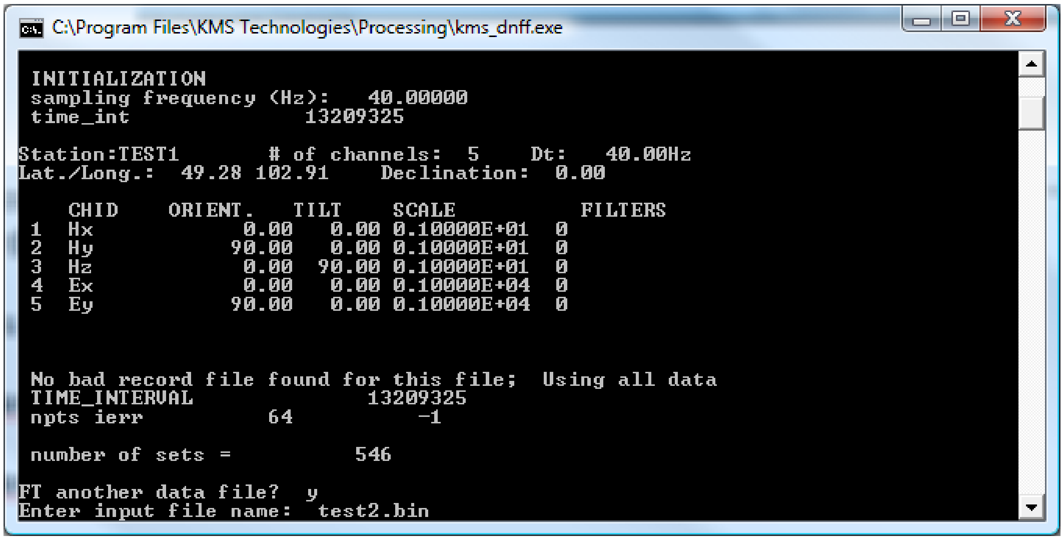

Figure 3: Enter the 2nd data file

User can also enter the file names in the command line: “**Kms_dnff -f:test1.bin”** and “**Kms_dnff -f:test2.bin”.**

The output of the processing will be generated in the FC folders, which are two binary files with the Fourier coefficients named “test1.f5” and “test2.f5”.

3.2 Robust estimation of the impedance

The second step is the robust estimation of the impedances from the Fourier coefficients. In this step, a configuration file named “TRANMT.cfg” with the parameters is used. The detailed description of this file is in section 1.4.

When running **kms_tranmt.exe,** the program will ask for a file name. Enter “TRANMT.cfg”. Or user can type “**kms_tranmt -f:tranmt.cfg**” in the command line. The output will be written in the MT folder with the following extension --- “zss” for single site interpretation and “zrr” for remote reference if the remote reference configuration is in .cfg configuration file.

3.3 Convert to EDI output

The third step is to convert to EDI output with **zss2edi.exe.** When running this program, a prompt window will ask user to enter the paths for “.zss” file and “.edi” file, and also the file name. Since the paths for both “.zss” file and “.edi” file are default, user only needs to press “Enter”, as shown in Figure 4.

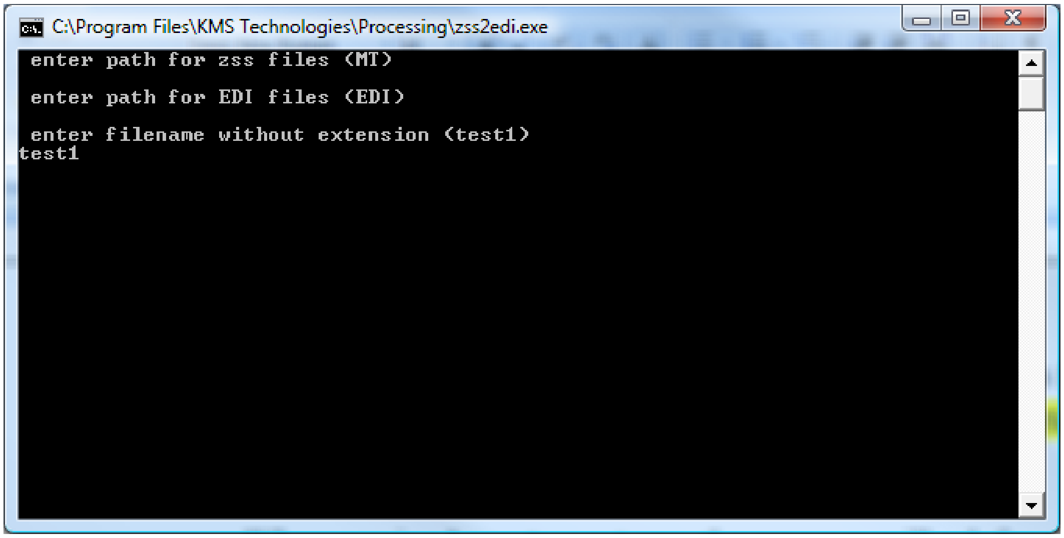

Figure 4: Prompt window for zss2edi.exe

The .apr and .edi output files will be generated in the EDI folder.

3.4 Configuration files

This section introduces the configuration files used in the processing software.

3.4.01 Main configuration file: tranmt.cfg

This file tells the program which Fourier coefficient files to process.
The example configuration file of 2 single site stations (test1 and test2) and a remote reference with local site (test1) and remote site (test2) called "tranmt.cfg" is shown as follows:

```
test1             //1st station file name: used for making output file name to MT folder or path defined
options.cfg       //options for single station processing (this run)
1                 //number of groups used for FC files
1  5              //for group 1: number of FC files and number of channels in group
test1.f5          //name of the 1st FC-file (line repeats if the number of FC files is more than 1)
y                 //query for another file? yes
test2             //2nd station file name: used for making output file name
options.cfg       //options for single site processing
1                 //number of groups used for FC files
1  5              //for group 1: number of FC files and number of channels in group
test2.f5          //name of the 2nd file with Fourier coefficients
y                 //query for another file? yes
test2r1           //output filename for remote reference
options_RR.cfg    //options for remote reference (test2)
2                 // number of channel groups (station 1 & station 2)
1    5            //for station 1: number of FC files and number of channels
test1.f5          // FC file name of station 1
1    5            //for station 2: number of FC files and number of channels
test2.f5          //FC file name of station 2 (remote reference station)
n                 // not continue with another set, if yes entry 'y'. If "y" is entered, certain lines should be repeated
                  // following the format explained above.
```

Note: If user wants to modify the configuration file, make sure in each line, the comments are located after the 40th character; otherwise the file can be corrupted.

3.4.02 Options configuration file: option.cfg

There are 2 option files: one for single site and the other for multiple stations with remote reference.

The settings for the configuration files are the standard settings used by Gary Egbert and his group for many years. The 2 example option files have been proven to be the best settings. The coherent settings parameters are for experiments but have not shown any improvement.

Example 1: option file for single site (file: **options.cfg**)

Robust Single station

```
FC                  //input folder
MT                  // output folder
CF/bs_test.cfg      // full path name for band setup file which will be discussed in next section
y                   // y for robust and n for least squares
n                   // n for single station and y for remote reference
n                   // n for magnetic field  as reference and y for electrical field as reference
n                   //output coherence v.s. set number (always leave it as no)
 0. 0. 0. 0. 0      //coherence sorting parameters (recommended by Gary Egbert to leave them all zeros)
1                    // number of rotations (not in use by Gary Egbert, leave it as 1)
0                    //rotation angles (not in use by Gary Egbert, leave it as 0)
```

Example 2: option file for remote reference (file: **options_RR.cfg**)

Robust Remote Reference EMAP

```
FC                  //input folder
MT                  //output folder
CF/bs_test.cfg      //full path name for band setup file
y                   //robust
y                   // remote reference
n                   // n for magnetic field  as reference and y for electrical field as reference
n                   //output coherence v.s. set number. (always leave it as no)
0. 0. 0. 0. 0       //coherence sorting parameters as recommended by G. Egbert
1                   //number of rotations (not in use by Gary Egbert, leave it as 1)
0                   //rotation angles (not in use by Gary Egbert, leave it as 0)
```

3.4.03 Band setup file

This file tells the program to produce estimates for which frequency band. The frequency band's order is from the highest to the lowest with no overlap. A reasonable decimation level has been chosen for each frequency band. User doesn't have to modify this file. An example of band setup file is shown as follows:

```
25
1 25 30
1 20 24
1 16 19
1 13 15
1 10 12
```

1 8 9
1 6 7
1 5 5
2 14 17
2 11 13
2 9 10
2 7 8
2 6 6
2 5 5
3 14 17
3 11 13
3 9 10
3 7 8
3 6 6
3 5 5
4 18 22
4 14 17
4 10 13
4 7 9
4 5 6

3.4.04 External system parameter file: *.sp

The system parameters are given by the binary header in the data file. The parameters include sampling rate, sensor orientations, electrode line length, instruments specific analogue filter corrections and factors for conversion of data from counts to physical units. In some occasion, header information may be corrupted or the operators in the field don't enter the parameters correctly. To avoid this problem, user can manually create an external ASCII file "*.sp" with the system parameters and place the file in the SP folder.

To force the program to read the external ASCII file, user needs to add a suffix "-sp" or "-SP" to when running "**kms_dnff.exe**". For example: enter "kms_dnff.exe f:test1.bin -SP:test1.sp" in the command window will force the program to use test1.sp file.

The structure of the sp- file is shown in the following examples.

First example: test1.sp. This is the system parameter file for the synthetic data example. Notice that there are no gain factors and no filter characteristic and induction coil response.

```
test1            // file name
49.28   102.91   //latitude & longitude in degree
0.0              //geomagnetic declination of the site
5                //number of channels enabled
0.025            //sampling rate in seconds
0.  0.           //clock offset & linear drift with the default value of 0
Hx               //measurement of CH1
                 //Hx/Hy/Hz is the X/Y/Z direction of magnetic field
0.  0.           //sensor orientation & vertical tilt degrees of the sensor in CH1
                 //for Hx, this line is 0. 0., for Hy, this line is 90. 0, for Hz, this line is 0., 90.
1.0   0          //gain of CH1 & number of filter (0 means no filter)
Hy               //measurement of CH2
90.  0.          //sensor orientation & vertical tilt degrees of the sensor in CH2
1.0   0          // gain of CH2 & number of filter
```

```
Hz                      //measurement of CH3
0.  90.                 // sensor orientation & vertical tilt degrees of the sensor in CH3
1.0   0                 //gain of CH3 & number of filter
Ex                      //measurement of CH4
                        //Ex/Ey is the X/Y direction of electrical field
1.0  0.  0.   1.0       //line distance between electrodes in meters, angle, tilt, pre-amplification gain
                        //for Ex, the angle and tilt is 0&0, for Ey, the numbers are 90&0.
                        //the pre-amplification gain of electrode should always be 1.
1.0  0                  // gain of CH4 & number of filter
Ey                      // measurement of CH5
1.0  90.  0   1.0       // line distance between electrodes in meters, angle, tilt, pre-amplification gain
1.0  0                  // gain of CH5 & number of filter
```

Example 2: data_40_1.sp. In this example, different channels have different gain settings, LEMI-120 coils and electrodes are connected to the unit, and a Bessel low- pass filter (LP) with cut-off frequency of 10 Hz is applied to all the channels.

```
data_40_1               //file name
30.21108   -95.99404    //latitude & longitude in degree
0.0                     //geomagnetic declination of the site
5                       //number of channels enabled
0.025                   //sampling rate in seconds
0.  0.                  //clock offset & linear drift
Hx                      //measurement of CH1: Hx component
0.  0.                  //sensor orientation & vertical tilt degrees of the sensor in CH1
8.0   2                 //gain of CH1 & number of filter*
AP                      // amplitude phase filter of CH1.**
Lemi-120.rsp            //calibration file name for the sensor used in CH1
PZ                      //filter type used in CH1. If a low-pass filter is used, the line should be PZ(pole-zero).
LPbessel_10Hz.rsp       //calibration file name for the filter used in CH1
Hy                      // measurement of CH2: Hy component
90.  0.                 // sensor orientation & vertical tilt degrees of the sensor in CH2
4.0   2                 //gain of CH2 & number of filter
AP                      // amplitude-phase filter of CH2
Lemi-120.rsp            //calibration file name for the sensor used in CH2
PZ                      //filter type used in CH2.
LPbessel_10Hz.rsp       //calibration file name for the filter used in CH2
Hz                      //measurement of CH3: Hz component
0.  0.                  //sensor orientation & vertical tilt degrees of the sensor in CH1
 8.0   2                // gain of CH3 & number of filter
AP                      // amplitude-phase filter of CH3
Lemi-120.rsp            //calibration file name for the sensor used in CH2
PZ                      //filter type used in CH3
LPbessel_10Hz.rsp       //calibration file name for the filter used in CH3
Ex                      // measurement of CH4: Ex component
 79.0  0.  0.   1.0     //line distance between electrodes in meters, angle, tilt, pre-amplification gain
40.0  1                 // gain of CH4 & number of filter
PZ                      //filter type pole-zero for LP Bessel in CH4
LPbessel_10Hz.rsp       //calibration file name for the filter used in CH4
Ey                      // measurement of CH5: Ey component
 73.0  90.  0   1.0     // line distance between electrodes in meters, angle, tilt, pre-amplification gain
160.0  1                // gain of CH5 & number of filter
PZ                      //filter type pole-zero for LP Bessel in CH5
```

LPbessel_10Hz.rsp //calibration file name for the filter used in CH5

*: Number of filters is depending on how many filter characteristics should be considered. For magnetic field, at least one filter is applied, which is the induction coil calibration file. Also, there may be low-pass filters applied to the channels. For example, for a channel applied with a low-pass filter and connected with a coil, this number should be 2. For a channel applied with a low-pass filter and connected with an electrode, the number of filters should be 1. For each filter, there are 2 lines to identify the filter characteristics:

1) line 1: A 2-character string to identify the filter type
   a. "PZ" for the analogue low pass filters (Pole-Zero)
   b. "AP" for coil calibration files (Amplitude-Phase)
2) line 2: calibration file name for parameters definitions

**: This line is only valid if in the previous line the number of filters is larger than 0. For the coil calibration file, it is "AP" (Amplitude-Phase).

4.0 COPYRIGHT STATEMENT

KMS Technologies –KJT Enterprises Inc.
6420 Richmond Ave, Suite 610
Houston, TX 77057
USA

Kurt@kmstechnologies.com