MT TIME SERIES PROCESSING

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INTRODUCTION

The MTU Time Series Reprocessing program and its support files are saved in a compress file MS-ROBST.EXE. The program supports two modes of processing. The first mode is similar to the manner in which the V-5 has processes the data in real time. The advantage is the executable time is much shorter then the second mode that uses a ROBUST method to select DFT samples to process. Minimum requirement of 600 Kbytes of free RAM for DOS is needed to run either program mode.

The second program mode has a coherence ROBUST routine added to the function of reprocessing. However, to keep the executable within the 640 K-byte DOS boundary temporary results are written out to a mass storage device. The program speed will depend on the access time to read and write these files. A RAMDISK is recommended (4-6 Mbytes) or fast access hard disk or San-disk.

To explode the files do the following.

1) Create a directory, MTUROBST, on your hard disk.

2) Copy the file MS-ROBST.EXE into that directory.

3) Change current directory to MTUROBST and execute MS-ROBST.

The executable files and the utility files are exploded into the directory. Files needed for MTU ROBUST reprocessing are:

```
MTU-SITE.BAT  <= BATCH FILE to call MT-ROBST for multiple sites.
MT-ROBST.BAT  <= BATCH FILE to call MTROBUST.EXE with *.SYS files.
MTUROBST.EXE  <= PROCESSING ROUTINE called from BATCH FILE
MTUROBST.SYS  <= ROBUST CONSTANTS READ BY PROCESSING PROGRAM
MTU-V5TS.EXE  <= A PROGRAM TO CONVERT MTU (*.TSH, *.TSL, *.TBL) TIME
                 SERIES DATA TO “*.TSR” (for V5-16 COMPATIBLE;
                 high/low range sequential) or  “*.TSD” (for MTUs
                 only with simultaneous high/low range data) FORMAT
                 FOR PROCESSING.
```

You need to know the pathname to the Time Series data and the number of channels in each TIME SERIES file. You can reprocess a single file or up to four files that were recorded in clock synch mode. Due to the limitation of DOS, a maximum of seven (7) channels [Ex Ey Hx Hy Hz Rx Ry] can be used in the reprocessing program. You can make a valid selection for these channels from any of the Time Series data files. These options are selected and stored in the MTUROBST.SYS file.

PROGRAM OPTIONS:

There are three options for running the reprocessing program.

I) Execute batch file, MT-ROBST.BAT, without any parameters. The reprocessing program will generate a default set of process control parameters that the user can edit. These parameters are then stored in the system parameter file MTUROBST.SYS

Execute: MT-ROBST.bat

The MT-ROBST.BAT program does the following operations:

i) Delete the old MTUROBST.SYS file

ii) RUN reprocessing program MTUROBST.EXE which then READ the parameters in MTUROBST.SYS file and continues to READ and process the Time Series data accordingly.

iii) Create a new MTUROBST.SYS file

II) Run the batch file, MT-ROBST.BAT, with a set of parameters saved in the file, MTUROBST.nnn. This option will have the reprocessing program read the saved parameter file and allow the user an option to edit the parameters.

Execute: MT-ROBST nnn where nnn is the number used to call the site where the time series data was acquired and the parameters are prepared and saved in MTUROBST.nnn.

The MT-ROBST.BAT program does the following operation:

i) Copy MTUROBST.nnn to MTUROBST.SYS

ii) RUN the reprocessing program MTUROBST.EXE which then READ the parameters in MTUROBST.SYS file and continues to READ and process the Time Series data accordingly.

iii) Copy the MTUROBST.SYS to MTUROBST.nnn

III) Run the batch file, MTU-SITE.BAT, with several parameter files prepared for Time Series acquired from several MT sites.

Execute: MTU-SITE.bat MT-ROBST nnn mmm ... xxx
where nnn, mmm, ..., xxx are the site numbers for the time series data. This program does the operation of II, sequentially, with parameters from the files,
MTUROBST.nnn, MTUROBST.mmm, ..., MTUROBST.xxx.

Note that the batch option needs to be set in each parameter file. If “Batch : **1**” then the input parameters are just READ and NOT EDITED such that the reprocessing program can execute without user input. Example of MTU-site batch process for 3 Time Series sets: “MT-ROBST 501 502 503” with 3 sets of parameters prepared and saved in the files, MTUROBST.501, MTUROBST.502, MTUROBST.503

MTUROBST OUTPUT:

The output of MTUROBST processing program are multiple crosspowers that are stored in the file of name with suffix .MT, such as 1033-220.MT. The file name is read from the Header File (the first 4 and last 4 characters of STN Number), which is transferred directly from V5-16 or output from MTU-V5TS.EXE conversion program. If the MTUROBST processing is repeated for the same Time Series data set, the results will be stored in 1033-220.MT1, 1033-220.MT2, and so on. To stop the MTUROBST.exe during the processing, hit **Q** key (capital letter Q) and the program will store the processed results up to the point when **Q** is hit. Do not use CTRL_C, which could stop the process without saving the results. These XXXXXXXX.MT output files are called Plot Files. The information of the Plot Files can be displayed, edited or plotted using Phoenix's TBS software package. It can also be converted to standard EDI format or other ASCII format for input to interpretation SW.

The following is an example and explanation of the MTUROBST.SYS file. Note the characters after ":" are parameters entered by the user and explanation after "<=". This set of parameters is for processing 2 time-series files acquired with one MTU-5 (local station with Ex, Ey, Hx, Hy, Hz) and one MTU-2H (remote reference station for RHx, RHy).

EXAMPLE 1 - MTUROBST parameter file

```
SETUP REPROCESSING PARAMETERS
Batch : 0                               <= Set to 1 for batch mode (No EDITING)
No. of Time Series (4 Max) : 2          <= 1,2,3 or 4 TS files to reprocess
No. of Chans to Process (7 Max): 7      <= number of channels.
Series File for Series # 1 : C:\TSERIES\TST-123a.TSD     <= TS#1 filename
Series File for Series # 2 : C:\TSERIES\1032218a.TSD     <= TS#2 filename
Series File for Series # 3 : C:\                  <= Path & file name for TS#3
Series File for Series # 4 : C:\                  <= Path & file name for TS#4
    See Note 1 for convention on TS file names & V5/MTU file conversion
Directory of MTrepro SITEs : C:\V5MT-16\MT-SITE         <=Results Pathname
Channel Names   : SEx1 SEy1 SHx1 SHy1 SHz1 RHx2 RHy2     <=Channel name.
Series Chan Map :  101  102  103  104 105  201  202      <=TS Channel ID
                    |    |    |    |    |    |    <= TS#2 channel 1 is RHy2,
                    |    |    |    |    |    <= TS#2 channel 2 is RHx2,
                    |    |    |    |    <= TS#1 channel 5 is Hz1,
                    |    |    |    <= TS#1 channel 4 is Hy1,
                    |    |    <= TS#1 channel 3 is Hx1,
                    |    <= TS#1 channel 2 is Ey1,
                     <= TS#1 channel 1 is Ex1,

  <= * See Note 2 for details of Channel Names & Chan Map
```

```
Azm of Ex1 : 0                <= Site layout rotation from True North
Azm of Hx1 : 0
Azm of Ex2 : 0
Azm of Hx2 : 0
XPRs (Max=20) : 20            <= Number of XPR files from reprocess data.
Time LIMIT (Y | N) : N        <= Was used with V-5 data. Not used with MTU.
Recorded Hrs. HI : 3.0        <= Total HI-RANGE data recorded in hours.
LO : 15.0                     <= Hours of LO-RANGE recorded.
Weight Type (1=No Wgt, 2=Rho Var, 3=Coherency): 2   <= XPR Weighting factor.
          Note: Try each weighting type to find best results.
Cutoff Value for Weight : 0.0  <= Normal set to 0.0 Used as a step function.
          Note: A value of 0.05 to 0.50 can be used for type 3 above.
Ref Type (1=Loc E, 2=Rem E, 3=Loc H, 4=Rem H) : 4   <= Type H/E in Rem/Loc mode
Rho Min Plot : 0.1            <= Min. RHO plot value for the plot scale
Stn 1:    Rotate to P. Axes (1=Y) : 0 <= Normally 0. P.Axis can be calculated
Rotation Angle : 0                    <= Normally 0 or can be measured axis.
Stn 2:    Rotate to P. Axes (1=Y) : 0 <= Second Station is NOT used in 7-chan.
Rotation Angle : 0                    <= Parameter for above option.
Drive for XPR Files : D:              <= Temporary storage for XPR files.
Video Type (Blank for Prompt) : I     <= Default is VGA

Robust (Y|N) : Y                      <= Turn Robust processing ON/OFF.
Drive for Robust Files : D:          <= RAMDISK DRIVE for ROBUST files
Maximize COH for Stn1 (Y|N) : Y       <= Need to optimize Stn1.
SQRT(S1*S2) Maximize COH for Stn2 (Y|N) : N      <= Always N for 1 Stn.
Type[1=2:M(Ex,H)*3:M(Ey,H),4=5:P(Ex,H)*6:P(Ey,H),7=M(Hx,R)*M(Hy,R),8=P(H,R)]: 7
                                              <= * See Note 3 for details
Exit COH Value to Maximize Scheme: .80        <= (from 0 to 1)
Rejection Fraction of Estimates: .35          <= (from 0 to 1)
 001 002  003  004  005  006  007  008  009  010  No.of Estimates to Process in Band:
 100  75   50   100  75   50  200  200  200  100  <=Band 1-10 Estimates to process.
 011 012  013  014  015  016  017  018  019  020  No.of Estimates to Process in Band:
 100  75   50   25   25   20   15   10    5    5  <=Band10-20 Estimates to process.
RHO Variance(Y|N): Y                          <= Turn ON 2nd Robust Scheme.
Exit Value: .75                               <= (from 0 to 1)
Rejection Fraction of Estimates: .25          <= (from 0 to 1)

  <========================================================>
```

*** Note 1: Time Series file names**

The MTUROBST.exe program recognizes the following 2 types of time series files by checking the suffix.

1) FileName.TSR
   We call this TSR file.
   TSR files are the V5-16 MT compatible time series data files.
   The TSR file contains the time series data and information relevant to the hardware setting of V5-16 and parameters set by the operator for data acquisition. The high (384 - 9 Hz) and low (6 Hz and lower) range time series are acquired sequentially.

2) FileName.TSD
   We call this TSD file.
   TSD files are time series files after format conversion from the files transferred from V5-2000 System MT receiver units, MTU-2E, MTU-2H, MTU-3H or MTU-5.
   The TSD file contains the 24-bit time series data and information relevant to the hardware setting of MTUs and parameters set by the operator for data acquisition. The high and low range time series are acquired simultaneously.

   The TSD files are converted by running MTU-V5TS.EXE program. Explanation and prompts will be displayed by executing MTU-V5TS.EXE and the information given will be stored in the file C:\MTU-FILE.PRM as default setting for the next run.

   Note:
   The first time the program is run, the following question is asked:

   Reprocess MTU data with V5-16 data? (Y/N)

   Answer **Y** if the time series files are from both MTUs and V5-16.
   Answer **N** if the time series files are from MTUs only.

This setting will be stored and used as default for the future run until you delete the file

C:\MTU-FILE.PRM.

For data acquisition using only the MTU receivers (combination of MTU-2E, MTU-2H & MTU-5) the time series files will be all TSD files (simultaneous high and low range time series acquisition). For data acquisition using both the V5-16 and MTU receivers (combination of V5-16, MTU-2E, MTU-2H & MTU-5) all time series files will be converted to TSR files to make compatible with V5-16’s data (sequential high and low range data acquisition and adjustment for system time delay).

*** Note 2: Channel Names and Series Chan Map.**

The following parameters are used to identify where to find specific Time Series data for each of the channels used in the reprocessing. The Channel Names are the same as that used in the V-5 format.

```
Channel Names : SEx1  SEy1  SHx1  SHy1  SHz1  RHx2  RHy2

XXx0
^^^^
||||_ Station number        0: unused       1: STN 1      2: STN 2
|||__ Component identifier  x: North-South  y: East-West  z: Vertical
||___ Component Type        E: Telluric     H: Magnetic   X: Unused
|____ Station Type          S: Station      R: Reference  X: Unused

Series Chan Map :  101   102   103   104   105   201   202
```

The Series Chan Map is used to identifier which Time Series channel to use for the Channel Names given just previous. The hundred-digit number is used to identify which TIME SERIES file (i.e. 100 for TIME SERIES #1 and 200 for TIME SERIES #2). The last two digits are used to identify the channel within the Time Series data to use for the given channel. This example is TS#1 from MTU-5 and TS#2 from MTU-2H systems.

Note: If the Hz data is not available then enter 000 and reduce the number of Channels by 1.

An Example for a 6 channel processing using 2 channels Ex & Ey from MTU-2E in TIME SERIES #1 and the two channels Hx & Hy of TIME SERIES #2 and the two channels Hx & Hy of TIME SERIES #3 where last two Time Series files are from MTU-5 systems.

```
Channel Names   : SEx1  SEy1  SHx1  SHy1  SHz1  RHx2  RHy2
Series Chan Map :  101   102   203   204   000   303   304
```

An Example for a 7 channel processing using the 5 channels of TIME SERIES #1 and the two channels Hx & Hy of TIME SERIES #2 where both Time Series files are from MTU-5 systems.

```
Channel Names   : SEx1  SEy1  SHx1  SHy1  SHz1  RHx2  RHy2
Series Chan Map :  101   102   103   104   105   203   204
```

An Example for a 5 channel processing using the 5 channels of TIME SERIES #1 recorded by a MTU-5 system.

```
Channel Names   : SEx1  SEy1  SHx1  SHy1  SHz1  RHx2  RHy2
Series Chan Map :  101   102   103   104   105   000   000
```

*** Note 3 For ROBUST processing:**

There are 8 types of COHERENCE ROBUST processing schemes.

```
1) 1=2*3   Combine the weighting factor of type 2 with that of type 3.

2) M(Ex,H) Use MULTIPLE COHERENCE of Ex with the total MAGNETIC field.

3) M(Ey,H) Use MULTIPLE COHERENCE of Ey with the total MAGNETIC field.

4) 4=5*6   Combine the weighting factor of type 5 with that of type 6.

5) P(Ex,H) Use PARTIAL COHERENCE of Ex with the total MAGNETIC field.

6) P(Ey,H) Use PARTIAL COHERENCE of Ey with the total MAGNETIC field.

7) M(Rx,H)*M(Ry,H)  Use the combine weighting factor of the
                    MULTIPLE COHERENCE of Rx with the total MAGNETIC field
          with the  MULTIPLE COHERENCE of Ry with the total MAGNETIC field.

8) P(Rx,H)*P(Ry,H)  Use the combine weighting factor of the
                    PARTIAL COHERENCE of Rx with the total MAGNETIC field
          with the  PARTIAL COHERENCE of Ry with the total MAGNETIC field.

 Type 7 is recommended when the reference site is in a cultural free area.
 Type 1 is recommended for 5 channel local reference.
 Type 0 will turn OFF this ROBUST scheme.
```

The two variables setup the threshold limits for the ROBUST routine. If the COHERENCE factor reaches this level then EXIT the routine otherwise continue to iterate the process until the limit of REJECTIONS is reach. This limit of rejection is set by the second variable. For a value of .50, up to 50% of the data may be rejected (NOT USED) if the COHERENCE limit is not reached.

```
 001 002 003 004 005 006 007 008 009 010 No. of Estimates to Process in Band:
 100  75  50 100  75  50 200 200 200 100
                                <= No. of estimates to process in Band 1 to 10
                                <= Limited to RAMDISK space

011  012  013  014  015  016  017  018  019  020  No. of Estimates to Process in Band:
100   75   50   25   25   20   15   10    5    5
                                <= No. of Estimates to process in Band10 to 20
                                <= 5 is a minimum
```

There are 20 bands of processing, each having two frequencies of the 8th and 6th harmonic for DFT coefficients. Here you set how many spectra to calculate before applying the ROBUST routine to select the best ones for calculating the XPR matrix. Care must be taken in selecting these numbers, as the number of spectra may be limited, especially in the lower frequencies of cascade decimation. The frequencies that have lots of data, the spectra count can be up to 200. Please note that the larger these number, the more temporary file space is required. The program will create these temporary files before starting the actual reprocessing. An error will occur of out of memory space if the RAMDISK space is not large enough. If this occurs, you can either reduce the number of spectra estimates for each BAND or use the HARD DISK, which has slower access time for READING AND WRITING these files, hence slower execution time for the reprocessing program.

There is also a second ROBUST scheme that can be turned ON/OFF. It uses the RHO Variance as the criteria for selecting spectra for XPR calculation. The input to this routine is the output from the above routine.

The input values are similar to the above routine.

Note that the COHERENCE routine will select the data that is coherence between the remote reference site and the survey site. So if the noise is COHERENCE between the two sites, then this routine should be turn OFF.

The RHO Variance routine will select from the COHERENCE output, the data which E & H is coherence to produce small error-bars in the RHO data.

Note that after the first MTUROBST.SYS files are created, then a text-editing program can be used to modify these files for other TIME SERIES files to be process in batch mode. The files must be saved in TEXT only format. For saving multiple copies of the system constant, replace the *.SYS extension with the site number used for the Time Series Files.

EXAMPLE 2 - MTUROBST parameter file

This set of parameters is for processing 3 time-series files acquired with one MTU-2E (local station with Ex, Ey), one MTU-3H (local Hx, Hy, no Hz) and one V5-16 (remote reference station use only 2 magnetic channels for reference RHx, RHy).
The time series data files,

```
Series File for Series # 1 : C:\TSERIES\1032218a.TSR <= Path\filename for TS#1
Series File for Series # 2 : C:\TSERIES\1030218a.TSR <= Path\filename for TS#2
```

are converted from MTUs' .TSH, .TSL & .TBL files by running MTU-V5TS.EXE for "Reprocessing MTU with V5-16".

Execute MTUROBST 500
Parameters in file C:\MTU-SITE\MTUROBST.500

```
SETUP REPROCESSING PARAMETERS
Batch : 0                               <= Set to 1 for batch mode (No EDITING)
No. of Time Series (4 Max) : 3          <= 1,2,3 or 4 Time Series files to reprocess
No. of Chans to Process (7 Max): 6      <= number of channels.
Series File for Series # 1 : C:\TSERIES\1032218a.TSR   <= Path & file name for TS#1
Series File for Series # 2 : C:\TSERIES\1030218a.TSR   <= Path & file name for TS#2
Series File for Series # 3 : C:\TSERIES\TST-003a.TSR   <= Path & file name for TS#3
Series File for Series # 4 :
Directory of MTrepro SITEs : C:\V5MT-16\MT-SITE        <= Pathname for Results
Channel Names   : SEx1 SEy1 SHx1 SHy1 SHz1 RHx2 RHy2
Series Chan Map :  101   102   201    202   000    303    304

  Where 101   <= TS#1 channel 1 is Ex1(from MTU-2E S/N 1032)
        102   <= TS#1 channel 2 is Ey1(from MTU-2E S/N 1032)
        201   <= TS#2 channel 1 is Hx1(from MTU-3H S/N 1030)
        202   <= TS#2 channel 2 is Ex1(from MTU-3H S/N 1030)
        000   <= SHz1 is not used
        303   <= TS#3 channel 3 is RHx2(from V5-16)
        304   <= TS#3 channel 4 is RHy2(from V5-16)

Azm of Ex1 : 0                    <= Site layout rotation from True North
Azm of Hx1 : 0
Azm of Ex2 : 0
Azm of Hx2 : 0
XPRs (Max=20) : 20                <= Number of XPR files from reprocess data.
Time LIMIT (Y | N) : N
Recorded Hrs. HI : 3.0            <= Total HI-RANGE data recorded in hours.
LO : 15.0                         <= Hours of LO-RANGE recorded.
Weight Type (1=No Wgt, 2=Rho Var, 3=Coherency): 2
Cutoff Value for Weight : 0.0
```

```
Ref Type (1=Loc E, 2=Rem E, 3=Loc H, 4=Rem H) : 4 <= Type of reference channels
Rho Min Plot : 0.1                                <= Min. resistivity plot
                                                  value; for setting plot scale
Stn 1:    Rotate to P. Axes (1=Y) : 0
Rotation Angle : 0
Stn 2:    Rotate to P. Axes (1=Y) : 0
Rotation Angle : 0
Drive for XPR Files : D:                     <= Temporary storage for ROBUST
Video Type (Blank for Prompt) : I            <= Default is VGA

Robust (Y|N) : Y                             <= Turn Robust processing ON/OFF.
Drive for Robust Files : D:                  <= RAMDISK DRIVE
Maximize COH for Stn1 (Y|N) : Y              <= Need to optimize Stn1.
SQRT(S1*S2) Maximize COH for Stn2 (Y|N) : N  <= Only if a Ex2 & Ey2.
Type[1=2:M(Ex,H)*3:M(Ey,H),4=5:P(Ex,H)*6:P(Ey,H),7=M(Hx,R)*M(Hy,R),8=P(H,R)]: 7
                                             <= * See Note 3 for details
Exit COH Value to Maximize Scheme: .80        <= (from 0 to 1)
Rejection Fraction of Estimates: .35          <= (from 0 to 1)
 001 002 003 004 005 006 007 008 009 010 No. of Estimates to Process in Band:
 100  75  50 100  75  50 200 200 200 100 <= No.of Estimates to process in Band 1 to 10
 011 012 013 014 015 016 017 018 019 020 No. of Estimates to Process in Band:
 100  75  50  25  25  20  15  10   5   5 <= No.of Estimates to process in Band10 to 20
RHO Variance(Y|N): Y                     <= Turn ON 2nd Robust Scheme.
Exit Value: .75                          <= (from 0 to 1)
Rejection Fraction of Estimates: .25     <= (from 0 to 1)
```

APPENDIX A: CALIBRATION FILE FORMAT   (*.MTC)

1.INTRODUCTION

The MTU calibration data (*.CLB & *.CLC) files have system response data at calibration harmonic frequencies. The program MTUCALD or SYSCAL is used to calculate the responses at data acquisition frequencies by extrapolating from the measured calibration data. The SYSCAL.exe was design for third party software and thus is NOT used by PHOENIX programs. See the document C0readme.txt file for instruction on how to use the MTUCALD.exe program.

2.PHOENIX CALIBRATION

A batch file MTULF-SN.bat is used to create CALIBRATION files for the PHOENIX software-reprocessing program. This program can be run using the following command line. Order of the parameters is important.

```
 MTULF-SN Lf Typ Fnm Drv

 where  Lf  is the Line Frequency [50 or 60]
        Typ is the calibration type [BOX or SEN]
               BOX is for MTU-BOX CAL data
               SEN is for SENSOR  CAL data
        Fnm is the input Filename (no extension) [1234 or coil4567]

            For BOX cal data the input is ssnn.CLB
                where ssnn is the serial number of the MTU box.

            For SEN cal data the input is COILssnn.CLC
                where ssnn is the serial number of the sensor.
        Drv is the Pathname of the input file.
```

The output file *.MTC is first saved in the BCAL directory and then copied to the input directory. A backup copy and ASCII file data from the batch program is placed in the CAL-DATA directory.

3.FILE FORMATS

3.1 BOX CALIBRATION

The output filename from the batch program MTULF-SN.bat is derive from the Line Frequency used, Box type and Serial Number.

LFt-ssnn.MTC

	Input	LF	type	ssnn	Output
Examples:	1234.CLB	50	MTU-5	1234	50U-1234.MTC
	1234.CLB	60	MTU-5	1234	60U-1234.MTC
	3456.CLB	50	MTU-3H	3456	50H-3456.MTC
	3456.CLB	60	MTU-3H	3456	60H-3456.MTC
	5678.CLB	50	MTU-2E	5678	50E-5678.MTC
	5678.CLB	60	MTU-2E	5678	60E-5678.MTC

Note that the same input file can be used for 50 or 60 Hz.

The output file is a random access file of record length 320 bytes.

The REC=1 entry is defined as follows:

```
 Gtag    70 Characters    Description of calibration parameters.
 Mtusn   12 Characters    Filename 'MTU-1234.MTC'
 Chan    2 byte Integer   Number of Channels in the CAL file.
 Smplrt  2 byte Integer   Array 3 elements Sample rate for Lv 3,4 & 5.
 Adrng   4 byte Integer Array 3 elements   AD range for Level 3,4 & 5.
 Lvadsf  4 byte REAL Array of 3 elements   AD Scale factor Lv:3,4 & 5.
 Fc      2 byte Integer   Filter setting of MTU box. 1:Wk 2:Md 3:Sg
 Ac      2 byte Integer   Input coupling: 1:AC  0:DC
```

An example of Gtag;
b.5GAINS SN:U1234 LF=50 EG=160 HG=048 LP=3AC DT=99/10/29 Ch5ExEyHxHyHz
where
SN: has Type and serial number of MTU box
LF= is the Line Frequency
EG= is the E-Gain used during calibration. (E Normalizing factor)
HG= is the H-Gain used during calibration. (H Normalizing factor)
LP= Fc setting and Ac setting
DT= is the date of the calibration.
Chn is the channel description where 'n' is the number of channels calibrated in this MTU box followed by the Channel Names.

Note 'Xx' denotes an unused channel.

This string will denote the type of channel used during acquisition.

The variable Smplrt has the Sample Rate used for the 3 levels of processing.

```
                                          LF=50       LF=60
            Level 3 [500 Hz to 50 Hz]    SR=2560     SR=3072
            Level 4 [ 50 Hz to 10 Hz]    SR=0320     SR=0384
            Level 5 [ 10 Hz to DC]       SR=0024     SR=0024
```

The variable Adrng has the AD range for the 3 levels of processing. For the MTU box, the same AD is used and thus the value is same for all levels. The MTU uses a 24-bit AD, thus the range is 2^23.

The variable Lvadsf has the AD Scale Factor for the 3 levels of processing. In MTU version B and later this value is the same at 6.40 Vdc for full analog range.

The other variables are self-explanatory.

The REC=2 entry is the system response data defined as follows:
A COMPLEX array of 40 elements is saved for channel 1.
(Cresp1(Frq), Frq=1,40)

The REC=3 entry is the statistics data defined as follows:
A COMPLEX array of 40 elements is saved for channel 1.
(Cstat1(Frq), Frq=1,40)

Addition records are added, if more then 1 channel of calibration data.

The REC=4 entry is the system response data defined as follows:
A COMPLEX array of 40 elements is saved for channel 2.
(Cresp1(Frq), Frq=1,40)

The REC=5 entry is the statistics data defined as follows:
A COMPLEX array of 40 elements is saved for channel 2.
(Cstat1(Frq), Frq=1,40)

The last 2 entries are repeated for each additional channel calibrated.

3.2 SEN CALIBRATION

The output filename from the batch program MTULF-SN.bat is derive from the Line Frequency used, SEN type and Serial Number.

```
        LFt-ssnn.MTC
                          Input   LF   type   ssnn      Output
        Examples:   coil1234.CLC  50   COIL   1234     50C-1234.MTC
                    coil1234.CLC  60   COIL   1234     60C-1234.MTC
                    loop5678.CLC  50   LOOP   5678     50L-5678.MTC
                    loop5678.CLC  60   LOOP   5678     60L-5678.MTC
```

Note that the same input file can be used for 50 or 60 Hz.

The output file is a random access file of record length 320 bytes.

The REC=1 entry is defined as follows:

```
Gtag    70 Characters    Description of calibration parameters.
Mtufil  12 Characters    Input Filename 'coil1234.CAL'
Cchan   2 byte Integer   Number of Channels in this calibration file.
Ugain   4 byte REAL      The Scale Factor for the sensor.
```

An example of Gtag;

```
a.5GAINS SN:C1234 LF=50 EG=000 HG=012 LP=3DC DT=99/10/29 Ch1HxXxXxXxXx
   where
   SN: has Type and serial number of the sensor.
   LF= is the Line Frequency
   EG= is the E-Gain used during calibration. (E channel not used)
   HG= is the H-Gain used during calibration. (H Normalizing factor)
   LP= Fc setting and Ac setting of the MTU box used for calibration.
   DT= is the date of the calibration.
   Chn where 'n' is the number of channels calibrated in this file
            followed by the Channel Name description.
            Note 'Xx' denotes an unused channel.
```

The variable Ugain has the Sensor Scale Factor for the 3 levels of processing. The factor is Volts to millivolts (1000) times the input attenuation factor of the MTU-box 1/4.3 or (1000*.233).

The REC=2 entry is the system response data defined as follows:

```
    A COMPLEX array of 40 elements is saved for channel 1.
                (Cresp1(Frq), Frq=1,40)
```

The REC=3 entry is the statistics data defined as follows:

```
    A COMPLEX array of 40 elements is saved for channel 1.
                (Cstat1(Frq), Frq=1,40)
```

APPENDIX B: XPR DATA FILE FORMAT   (.MT)*

The following document is written to explain the file format of the Phoenix *.MT file used for data storages of MT data. The original data file was written using a TBASIC run time complier. The TBASIC WRITE & READ statements defined the FORMAT.

The following statement is from the TBASIC Users Guide.
When a data file is created with the WRITE statement, the data is transferred in a "tagged binary format". A one-byte tag specifies the type of each data element. The three-byte tag for strings includes a two-byte string length. This allows better control over the data during transfer operations.

Note that the length of the data element tags must be taken into account when calculating the size of random records. The one-byte tag is an ASCII character defined as follows:

```
      Character String : 146  + 2-byte for length of string
      Integer Byte tag : 162
      Floating Byte tag: 168
```

For other compliers like FORTRAN or C or VB, this one byte Tag preceding each number in the data file, must be accounted for in your READ statement. A 1-byte data must be skipped, for INTEGER*2 and REAL*8 numbers and for a CHARACTER string, a 3-byte dummy must precede the CHARACTER variable.

The TAG-nnna.MT file is a RANDOM ACCESS file of record length 23040. Four types of data are stored in the file as follows:

1) Record 1 is the HEAD-INFO:	<- Has Site parameters and Gains info.
2) Record 2 is the XPWR-S#01:	<- Has XPR data for Time Segment 1.
....	<- Repeats for N XPR data segments.
Record N+1 is XPWR-S#nn:	<- Note nn has a maximum value of 20.
3) Record N+2 is OPLG-TIME:	<- Time of XPR recording + comments
4a) Record N+3 is PLOT-COMP:	<- Computed Plot File information.
4b) Record N+4 is XPWR-COMP:	<- Summed XPR data for Plot File.
5a) Record N+5 is PLOT-EDIT:	<- Computed Plot File information after EDITING.
5b) Record N+6 is XPWR-EDIT:	<- Summed XPR data for Plot File after EDITING.

The following are F77 code used to define the variables in *.MT file from the Time Series Reprocessing Program:

```
c   ------------------------HEAD-INFO:---------------------------------
c
        WRITE (Ofile,REC=1) Tc,22,Taghdr(1:22),Tc,8,Fdate,Tc,16,Fdesc,
     &  Ti, Lfreq,Ti,Schan,(Tc,4,Schnam(J),J=1,7),(Ti,Stnref(J),J=1,7),
     &  Ti,Wghtyp,Tr,Ctoff,Ti,Reftyp,Ti,Pltest,(Tc,32,Rhead0(J),J=1,30)
     &  ,(Tc,32,Shead0(J,Stn),J=1,25),(((Tr,Syresp(Frq,I,J),J=1,2),
     &  I=1,7),Frq=1,40), (((Tr,Pcstat(J),J=1,2),I=1,7),Frq=1,40)
c
c   -------------------------XPWR-S#nn:--------------------------------
        Irec = 1 + Ixpr
        WRITE(Ofile,REC=Irec) Tc,22,Taghdr(1:22),Tc,8,Fdate,
     &  Tc,16,Fdesc,Ti,Schan,(Tc,4,Schnam(J), J=1,Schan),
     &  (((Tr,Stnxpr(Frq,I,J),J=1,Schan),I=1,Schan),Frq=1,40),
     &  (Tr,Stck7(Frq), Frq=1,40), (Tr,Wstk7(Frq),Frq=1,40)
c
c   -------------------------OPLG-TIME:--------------------------------
      Orec = 1 + Nxpr + 1
      WRITE (Ofile,REC=Orec) Tc,22,Taghdr(1:22), Ti,Oplin,
     &  Tc,47,Oplog(1)(1:47),Tc,43,Oplog(2)(1:43),Tc,32,Oplog(3)(1:32),
     &  Tc,35,Oplog(4)(1:35),Tc,43,Oplog(5)(1:43),Tc,76,Oplog(6)(1:76),
     &  (Tc,79,Oplog(I)(1:79),I=7,Oplin),(Tc,0,I=Oplin+1,50)
C
c   -----------PLOT-COMP:--or-- PLOT-CORR:--or--PLOT-EDIT:-------------
       Nrec = 1 + Nxpr + 2
       WRITE (Ofile,REC=Nrec) Tc,66,Taghdr(1:66),
     &  ((Tr,DBLE(Plots(Frq,I,Stn)),I=1,60),Frq=1,40),
     &  (Tr,Xstack(Frq),Frq=1,40),(Ti,Stnref(J),J=1,7)
C
c   -----------XPWR-COMP:--or-- XPWR-CORR:--or--XPWR-EDIT:-------------
       Nrec = 1 + Nxpr + 2
       WRITE(Ofile,REC=Nrec+1) Tc,45,Taghdr(1:45),Tc,8,Fdate,
     &  Tc,16,Fdesc,Ti,Schan,(Tc,4,Schnam(J), J=1,7),
     &  (((Tr,Stnxpr(Frq,I,J),J=1,7),I=1,7),Frq=1,40),
     &  (Tr,Xstack(Frq), Frq=1,40), (Tr,Wgts(Frq),Frq=1,40),
     &  ((Ti,Xmap(Frq,J),J=1,20),Frq=1,40)
C
C ---------------------------------------------------------------------
        where the variables Tc, Ti and Tr are defined as follows:
C
      CHARACTER*1 Tc, Ti, Tr
      Tc = CHAR(146)
      Ti = CHAR(162)
      Tr = CHAR(168)
C ---------------------------------------------------------------------
```

The following are F77 SUBROUTINES used to write the *.MT file from the Time Series Reprocessing Program:

```
C --------------------------------------------------------------------
C
        SUBROUTINE Wrthdr(Ofile,Stn,Fdate,Fdesc)
C
        INCLUDE 'mtrob.inc'
C
      CHARACTER Fdate*8, Fdesc*16
      COMPLEX   Savrsp,Gstdev
      REAL*8    Syresp(1:40,1:7,1:2), Pcstat(1:2), Ctoff
c
      INTEGER*2 Stn, Frq, Ofile
      INTEGER*2 Schan, Stnref(1:7), Pltest, I, J
      CHARACTER*1 Tc, Ti, Tr, Null, Site*8
      CHARACTER Taghdr*22, Schnam(1:7)*4
C
      Null = CHAR(0)
      Tc = CHAR(146)
      Ti = CHAR(162)
      Tr = CHAR(168)
      Schan = 7
      Pltest= 0
      Ctoff = Cutoff
      Site = "TAG-123a"
C
      DO 10 I = 1, 7
        Stnref(I) = 0
        IF (Reffld(I,Stn) .NE. 0) Stnref(I) = I
        Schnam(I) = 'XXx0'
        IF (Reffld(I,Stn) .NE. 0) Schnam(I) = Chnam(Reffld(I,Stn))
  10  CONTINUE
C
        DO 50 Frq = 1, 40
          DO 40 I = 1, 7
            J = Reffld(I,Stn)
            Syresp(Frq,I,1) = 0.0D0
            Syresp(Frq,I,2) = 0.0D0
            Pcstat(1) = 1.0D0
            Pcstat(2) = 0.0D0
            IF (J .NE. 0) THEN
              Savrsp = 1.0D0 / Gains(Frq,J)
              Gstdev = (1.0D0,0.0D0)
              Syresp(Frq,I,1) = REAL(Savrsp)
              Syresp(Frq,I,2) = AIMAG(Savrsp)
              Pcstat(1) = REAL(Gstdev)
              Pcstat(2) = AIMAG(Gstdev)
```

```
          END IF
  40      CONTINUE
  50    CONTINUE
        Taghdr = 'HEAD-INFO: ' // Shead0(2,Stn)(13:23)

        WRITE (Ofile,REC=1) Tc,22,Taghdr(1:22),Tc,8,Fdate,Tc,16,Fdesc,
     &  Ti, Lfreq,Ti,Schan,(Tc,4,Schnam(J),J=1,7),(Ti,Stnref(J),J=1,7),
     &  Ti,Wghtyp,Tr,Ctoff,Ti,Reftyp,Ti,Pltest,(Tc,32,Rhead0(J),J=1,30)
     &  ,(Tc,32,Shead0(J,Stn),J=1,25),(((Tr,Syresp(Frq,I,J),J=1,2),
     &  I=1,7),Frq=1,40), (((Tr,Pcstat(J),J=1,2),I=1,7),Frq=1,40)
c
      RETURN
      END
C
C ---------------------------------------------------------------------
C
        SUBROUTINE Wrtxpr(Ofile,Ixpr,Stn,Fdate,Fdesc)
C
        INCLUDE 'mtrob.inc'
C
      CHARACTER    Fdate*8, Fdesc*16
      INTEGER*2    Ofile, Ixpr, Irec
      REAL*8       Stck7(1:40),Wstk7(1:40),Stnxpr(1:40,1:7,1:7)
      COMPLEX      Xpr7(1:40,1:Nch,1:Nch)
C
      INTEGER*2 Stn, Frq, I, I1, J, J1
      INTEGER*2 Schan, Pltest
      CHARACTER*1 Tc, Ti, Tr, Null
      CHARACTER Taghdr*22, Schnam(1:7)*4
      EQUIVALENCE (Stck7,Cavg),(Wstk7,Cavgr),(Xpr7,Tmpxpr)
      EQUIVALENCE (Stnxpr,I4data)
C
      Null = CHAR(0)
      Tc = CHAR(146)
      Ti = CHAR(162)
      Tr = CHAR(168)
      Schan = 7
      Pltest= 0
C
      DO 100 I = 1, Schan
        Schnam(I) = 'XXx0'
        IF (Reffld(I,Stn) .NE. 0) Schnam(I) = Chnam(Reffld(I,Stn))
 100  CONTINUE
C
      DO 400 Frq = 1, 40
        DO 300 I = 1, Schan
          I1 = Reffld(I,Stn)
          DO 200 J = I, Schan
            J1 = Reffld(J,Stn)
```

```
            Stnxpr(Frq,I,J) = 0.0
            Stnxpr(Frq,J,I) = 0.0
            IF (I1.EQ.0 .OR. J1.EQ.0) GOTO 200
            Stnxpr(Frq,J,I) = AIMAG(Xpr7(Frq,I1,J1))
            Stnxpr(Frq,I,J) = REAL(Xpr7(Frq,I1,J1))
 200      CONTINUE
 300    CONTINUE
 400  CONTINUE
C
      Irec = 1 + Ixpr
      WRITE(Taghdr,9000) 'XPWR-S#',Ixpr,': ',Shead0(2,Stn)(13:23)
c
      WRITE(Ofile,REC=Irec) Tc,22,Taghdr(1:22),Tc,8,Fdate,
     &  Tc,16,Fdesc,Ti,Schan,(Tc,4,Schnam(J), J=1,Schan),
     &  (((Tr,Stnxpr(Frq,I,J),J=1,Schan),I=1,Schan),Frq=1,40),
     &  (Tr,Stck7(Frq), Frq=1,40), (Tr,Wstk7(Frq),Frq=1,40)
C
9000  FORMAT (A7,I2.2,A2,A11)
      RETURN
      END
C
C ----------------------------------------------------------------------
C
        SUBROUTINE Wrtopl(Ofile,Stn,Orec,Oplin)
C
        INCLUDE 'mtrob.inc'
C
        INTEGER*2  Stn, Ofile, Oplin, I, Orec
        CHARACTER*1 Tc, Ti, Tr, Null
        CHARACTER Taghdr*22, Oplog(50)*80
        EQUIVALENCE (Oplog,Bndrec)
C
      Null = CHAR(0)
      Tc = CHAR(146)
      Ti = CHAR(162)
      Tr = CHAR(168)
C
      Taghdr = 'OPLG-TIME: ' // Shead0(2,Stn)(13:23)
      WRITE (Ofile,REC=Orec) Tc,22,Taghdr(1:22), Ti,Oplin,
     &  Tc,47,Oplog(1)(1:47),Tc,43,Oplog(2)(1:43),Tc,32,Oplog(3)(1:32),
     &  Tc,35,Oplog(4)(1:35),Tc,43,Oplog(5)(1:43),Tc,76,Oplog(6)(1:76),
     &  (Tc,79,Oplog(I)(1:79),I=7,Oplin),(Tc,0,I=Oplin+1,50)
C
      RETURN
      END
```

```
C
C ----------------------------------------------------------------------
C
        SUBROUTINE Wrtplt(Ofile,Stn,Nrec,Fdate,Fdesc)
C
        INCLUDE 'mtrob.inc'
C
        CHARACTER    Fdate*8, Fdesc*16
        REAL*8       Wgts(1:40), Xstack(1:40), Stnxpr(1:40,1:7,1:7)
        INTEGER*2    Xmap(1:40,1:20)
        INTEGER*2    Stn, Ofile, Schan, Frq
        INTEGER*2    I, Nrec, Stnref(1:7)
        CHARACTER*1  Tc, Ti, Tr, Null
        CHARACTER    Taghdr*66,Wtype(1:4)*6,Rtype(1:5)*6, Schnam(1:7)*4
        EQUIVALENCE (Stnxpr,I4data),(Xmap,Gains)
C
      DATA Wtype/' NO WT ','RHOVAR','ORDCOH','PARCOH'/
      DATA Rtype/'LOC E  ','REM E ','LOC H ','REM H ','NONSTD'/
C
      Null = CHAR(0)
      Tc = CHAR(146)
      Ti = CHAR(162)
      Tr = CHAR(168)
      Schan = 7
C
      DO 100 I = 1, 7
        Stnref(I) = 0
        IF (Reffld(I,Stn) .NE. 0) Stnref(I) = I
        Schnam(I) = 'XXx0'
        IF (Reffld(I,Stn) .NE. 0) Schnam(I) = Chnam(Reffld(I,Stn))
 100  CONTINUE
C
      DO 200 Frq = 1, 40
         Xstack(Frq) = Stack(Frq)
         Wgts(Frq) = Wt(Frq)
  200 CONTINUE
C
      WRITE(Taghdr,9050) 'PLOT-COMP: ',Shead0(2,Stn)(13:23),
     &  ',WGT=',Wtype(Wghtyp), ',CUT=',Cutoff, ',REF=',Rtype(Reftyp),
     &  ',ROT= 0 DEG.'
       WRITE (Ofile,REC=Nrec) Tc,66,Taghdr(1:66),
     &  ((Tr,DBLE(Plots(Frq,I,Stn)),I=1,60),Frq=1,40),
     &  (Tr,Xstack(Frq),Frq=1,40),(Ti,Stnref(J),J=1,7)
C
      DO 450 Frq = 1, 40
        DO 420 I = 1, 7
          I1 = Reffld(I,Stn)
          DO 410 J = I, 7
```

```
            J1 = Reffld(J,Stn)
            Stnxpr(Frq,I,J) = 0.0
            Stnxpr(Frq,J,I) = 0.0
            IF (I1.EQ.0 .OR. J1.EQ.0) GOTO 410
            Stnxpr(Frq,J,I) = AIMAG(Sum(Frq,I1,J1))
            Stnxpr(Frq,I,J) = REAL(Sum(Frq,I1,J1))
 410      CONTINUE
 420    CONTINUE
 450  CONTINUE
C
      WRITE(Taghdr,9060) 'XPWR-COMP:',(Schnam(J), J=1,7)
      WRITE(Ofile,REC=Nrec+1) Tc,45,Taghdr(1:45),Tc,8,Fdate,
     &  Tc,16,Fdesc,Ti,Schan,(Tc,4,Schnam(J), J=1,7),
     &  (((Tr,Stnxpr(Frq,I,J),J=1,7),I=1,7),Frq=1,40),
     &  (Tr,Xstack(Frq), Frq=1,40), (Tr,Wgts(Frq),Frq=1,40),
     &  ((Ti,Xmap(Frq,J),J=1,20),Frq=1,40)
C
9050  FORMAT (A11,A11,A5,A6,A5,F4.2,A5,A6,A12,1X)
9060  FORMAT (A10,7(1X,A4))
      RETURN
      END
C
```

```
C2345&7890123456789012345678901234567890123456789012345678901234567890123456789012
2
C######################################################################
#
C#  INCLUDE file for MTROBUST.FOR         DATE:  (1992 Jan.15)
#
C#                                    REVISION:  (1998 Feb.05)
#
C######################################################################
#
        PARAMETER (Nsermx=4,Nch=7,Ntsch=8,Nchmx=15,Nstnmx=2)
C
C... COMMON ...
        INTEGER*2       Nser
        CHARACTER       Tdrv*2
        COMMON /Ntser/Nser,Tdrv
C
        CHARACTER*32    Rhead0(30),Shead0(25,2)
        COMMON  /Head/  Rhead0,Shead0
C
        INTEGER*2       Chan0
        CHARACTER*4     Chnam(Nch)
        INTEGER*2       Reffld(7,Nstnmx)
        INTEGER*2       Rtate(Nstnmx)
        DIMENSION       Rotang(Nstnmx)
        REAL            Map(Nch,2)
        INTEGER*2       Mxstn
        COMMON  /Challc/Chan0,Chnam,Reffld,Rtate,Rotang,Map,Mxstn
C
        COMPLEX         Gains(40,Nch)
        COMMON  /Gainsc/Gains
C
        INTEGER*2               Wghtyp,Reftyp,Lfreq
        COMMON  /Type/  Wghtyp,Reftyp,Cutoff,Lfreq
C
        COMPLEX         D328 ( 32),D326 ( 32)
        COMMON  /Dcoef2/D328,D326
C
        INTEGER*4       Stack(40),Tmpstk(40),Minstk(20)
        DIMENSION       Wt(40)
        COMMON  /Stkwt/ Stack,Tmpstk,Minstk,Wt
C
        INTEGER*4       Chsat(Nch),Satalw(20)
        INTEGER*4       Satlev(3:5,1:Nch),Satmax(1:Nch)
        COMMON  /Sat/   Chsat,Satalw,Satlev,Satmax
C
        DIMENSION       Fhz(40)
        COMMON  /Freqhz/Fhz
```

```
C
      INTEGER*2       Sermap(Nch),Cmap(Nchmx,Nsermx)
      INTEGER*4       I4data(1:1024,1:Ntsch)
      DIMENSION       Isat(Nsermx)
      INTEGER*2               Lev,Lstlev,Ibuf,Bsize(Nsermx)
      COMMON  /Tser/I4data,Isat,Lev,Lstlev,Sermap,Cmap,Ibuf,Bsize
C
      INTEGER*4       Satcnt(20),Recrdy(7:20),Index0(20),Index1(20)
      INTEGER*4       Satppt(32),Tmpsat(Nch),Satdet(32,Nch)
      INTEGER*4       Lowrec
      REAL*8          Series(32,Nch)
      REAL*8          Bndrec(32,Nch,7:20)
      COMMON  /Casdec/Satcnt,Recrdy,Index0,Index1,
     &                Satppt,Tmpsat,Satdet,
     &                Lowrec,Series,Bndrec
      INTEGER*2       Ixprh,Ixprl
      COMMON  /Ixpr/  Ixprh,Ixprl
C
      COMPLEX         Eighth(Nch),Sixth(Nch)
      COMPLEX         Dft(Nch),Dftp(Nch)
      COMPLEX         Sum(40,Nch,Nch)
      COMPLEX*16      Cavg(Nch,Nch),Cavgr(Nch,Nch)
      COMPLEX         Tmpxpr(40,Nch,Nch)
      REAL*8          Avgs
      COMMON  /Xpr/   Eighth,Sixth,Dft,Dftp,Sum,Cavg,Cavgr
     &                                ,Tmpxpr,Avgs
      CHARACTER*16    Hitim, Lotim, Hstar, Lstar, Ltstim
      COMMON /Xprtim/ Hitim, Lotim, Hstar, Lstar, Ltstim
C
      DIMENSION       Plots(40,60,Nstnmx)
      COMMON /Plotsx/ Plots
C
      CHARACTER       Rbst*1,Rdrv*2,Rbvar*1
      COMPLEX         Rbxpr(Nch,Nch)
      INTEGER*2       Rbstk(40), Nrbstk(20)
      INTEGER*2       Ntype,Stn1,Stn2
      REAL*4          Prej,Thresh,Vrej,Vwgt
      COMMON  /Robst/ Rbst,Rdrv,Rbxpr,Rbstk,Nrbstk,Ntype,Stn1,Stn2,
     &                Prej,Thresh,Rbvar,Vrej,Vwgt
C
C###  END of INCLUDE FILE ###
_
```