PHOENIX GEOPHYSICS

MTU-2E   MTU-2H   MTU-3H   MTU-5

QUICK START MANUAL

DRAFT - 1998-Oct-15

CONTENTS

1. INTRODUCTION

To use V5-2000 MT System the following hardware system components and software packages are needed:

1. Data acquisition boxes

   A normal system for effecient routine MT survey consists of several MTU-2Es (from 4 to 30) for telluric measurement and a few MTU-2Hs (from 1 to 6) for local magnetic measurement and one MTU-2H for far remote referencing magnetic measurement.

The system configuration can also include the combination of MTU-2E, MTU-2H and MTU-5 units.

When delivered the MTU boxes are loaded with necessary software for self-calibration, coil calibration and data acquisition functions. A diskette for downloading these box-residence programs and PC host-residence programs are also provided with MTU box delivery.

2. Magnetic and Telluric Sensors

   The MTC-50 coils are used as sensors for magnetic components; one per channel.

   One pair of very low noise and stable PE-2 pots are used as electrodes for each telluric component.

3. MTUROBST Software Package

   This software processes with or without Robust scheme the time series data acquired by the MTU boxes. The processed and optimized output is Crosspower Files which is also called Plot Files.

4. TBS Software Package

   The Crosspower Files output from MTUROBST software can be displayed, plotted, editted (by discarding bad crosspower samples) or converted to standard EDI format for further processing with third party interpretation software packages.

Refer to MTUROBST Software Manual for Time Series Processing.

The TBS Software is self explanatory. For more detailed decriptions, refer to the documentation in the directory, TBS-DOC, on the MTU MANUAL DISKETTE.

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This manual describes the essential procedures needed to operate the Phoenix MTU series magnetotelluric receivers.

The MTU receiver logs signals from the sensors connected to it as time series synchronized to Universal Time Coordinated (UTC). It is available in several configurations which differ in the number and type of data channels which are recorded. These include:

- MTU-2E   Two channels of electric field data.
- MTU-2H   Two channels of magnetic field data.
- MTU-3H   Three channels of magnetic field data.

- MTU-5 Two channels of electric data and three channels of magnetic data.

All configurations are operated using the same software and procedures. The MTU-2E and MTU-5 must be connected to electric field sensors (porous pots), The MTU-2H, MTU-3H, and MTU-5 must be connected to magnetic field sensors (MTC-50 coils).

2. OPERATION

2.1 General

There are three essential operations that must be performed with the MTU.

- Box calibration. The MTU generates an internal test signal, measures its own amplitude and phase response, and stores the results in a file called *BOX.*CLB (where *BOX* is the box serial number, engraved on the outside panel of the MTU).
- Coil calibration (not required on MTU-2E). The MTU outputs a calibration signal to the MTC-50 magnetic sensors, measures their amplitude and phase response, and stores their results in a file called *COIL.*CLC (where *COIL* is the coil serial number).
- Data acquisition. The MTU stores magnetic and electric signals as time series in files called *filename*.TSL and *filename*.TSH (where filename is a file name specified by the operator, or automatically generated by the MTU).

All three operations require the use of a GPS antenna connected to the MTU. The GPS antenna must have a clear view of the sky. The coil calibration also requires that the MTC-50 coils be connected the MTU and the equipment must be located in a magnetically quiet area far from buildings and power lines.

An MTU can be programmed to perform these functions in two different ways.

- Online control. A host computer (running WIndows 95) is connected to the MTU through its parallel port and accessed using a program called WINHOST.EXE. This program allows the user to put the MTU into any of its operation modes and control any of its parameters. The host computer can be disconnected from the MTU and reconnected later if necessary. This method is typically used to perform box calibrations and coil calibrations. Data acquisition can also be started this way. An MTU can always be connected to a host computer for online control, even if offline setup was used to start it up, unless it is in INTERSVR mode.
- Offline setup. A file called STARTUP.TBL is created on a computer using a program called WINTABED.EXE. The file is loaded into the MTU. The MTU is then powered off and ready for field data acquisition. The next time that the MTU is powered on, the STARTUP.TBL file is read and the MTU performs the functions that have been programmed. This is the method normally used to perform data acquisition. Box calibration and coil calibration can also be performed this way.

Both the online control and offline setup modes function by setting values in the MTU Parameter Table. A list of the MTU parameters appears in Appendix B. The WINHOST.EXE and WINTABED.EXE provide a user-friendly method for setting the parameters.

This “Quick Start” manual contains instructions for performing calibrations using online control, and data acquisition using offline setup.

2.2 INTERSVR mode

1. The MTU can be accessed in “INTERSVR mode”. In this mode the host computer can access the MTU internal memory as if it were a disk drive on the host computer. The host computer must be set up with the “INTERLNK” driver in DOS or Windows 95 to make this possible. The MTU disk will typically appear as drive D: or E: on the host computer. See Appendix A.

2. In some versions of the MTU software, INTERSVR mode is entered automatically if any *.TSL time series files are present in the MTU memory. These files must be transferred to the host and deleted from the MTU before the MTU can be used again. The data transfer and file deletion should be performed using INTERSVR with the host computer in DOS mode.

3. With the MTU under online control using the WINHOST.EXE program, the MTU can be placed in INTERSVR mode by pressing the “MTU exit to DOS now” button on the host computer display.

4. INTERSVR mode must be used to transfer time series files or calibration files from the MTU, and can also be used to transfer a STARTUP.TBL file to the MTU. When transferring large data files from the MTU, the host should be running MS-DOS, not Windows 95, or transfer may be slow and errors may occur. Calibration files (.CLB, .CLC) and STARTUP.TBL files may be transferred with the host running Windows 95.

5. The MTU can exit INTERSVR mode only by disconnecting the battery. Do not disconnect the battery while reading or writing MTU files from the host.

6. INTERSVR mode will be eliminated in future versions of the MTU software. The “MTU File Utilities” button on the WINHOST.EXE program will be used to perform the file transfer function.

2.3 Online control

1. Connect the MTU to a battery.

2. Connect the MTU to the host computer using an MTU parallel cable.

3. Power on the host computer (if not already powered on) and run the WINHOST.EXE program.

4. Power on the MTU.

5. Wait for the MTU LED indicator to begin flashing at least every 12 seconds. This normally requires less then 3 minutes but can be as much as 30 minutes depending on last GPS lock location. See Appendix C.

6. Press the “Get Settings” button on the host computer display. If an “Error” box or “Time out” box appears, wait 1 minute and try again, until a “Message: Settings Retrieved” box is displayed. Online help is available for some fields by pressing <F1>.

7. Additional information about the MTU status can be obtained by pressing the “Display MTU Status” button.

8. The MTU can be powered down when required by pressing the “Shutdown” button on the host computer display. Allow at least 20 seconds for the MTU to shut down before disconnecting the MTU battery.

2.4 Offline setup

1. Power up the MTU, connect it to the host, and place it in INTERSVR mode, using WINHOST.EXE. Exit WINHOST.EXE.

2. Run the WINTABED program on the host computer.

3. Set the parameters to the required values. Online help is available for some fields by pressing <F1>.

4. Save the file as STARTUP.TBL in the \DATA directory of the MTU.

5. Disconnect power from the MTU.

6. Install the MTU at the survey site.

7. Power on the MTU. It will read the parameter values from STARTUP.TBL and operate accordingly.

2.5 Box calibration

1. Connect the MTU to a GPS antenna with a clear view of the sky.

2. Set up the MTU for online control as described in Section 2.3.

3. Select the “Line Frequency” appropriate to the survey area.

4. In “System Request” select “Box Calibration” mode.

5. Press “Display MTU Status”.

6. Monitor the progress of the box calibration. Initially the “Calibration Status” will contain the message “Box calibration in progress”. The MTU must acquire “4 GPS satellites” before it will begin calibration. Then calibration requires about 10 minutes. When calibration is complete, the “Calibration Status” will contain the message “Box calibration file on disk”.

7. If the calibration fails, the “Calibration Status” will contain the message “Box calibration failed”. If this happens, in “System Request” select “Setup” mode. Then return to step 4.

8. When calibration is complete, the MTU may be powered off; or another operation may be performed (e.g. coil calibration or data acquisition); or INTERSVR mode may be entered and the calibration file copied from the MTU. The calibration file is located in the \CAL directory on the MTU, and is named *nnnn*.CLB where *nnnn* is the box serial number.

2.6 Coil calibration

1. Connect the MTU to a GPS antenna with a clear view of the sky.

2. Connect the MTU to the MTC-50 sensors (if a coil calibration is to be performed).

3. Set up the MTU for online control as described in Section 2.3.

4. Select the “Line Frequency” appropriate to the survey area.

5. Enter the “Hx Coil Serial Number”,“Hy Coil Serial Number”, and “Hz Coil Serial Number” in the format “COILnnnn” where nnnn is the four digit serial number of the coil. If any channels do not have coils connected to them, make sure that the corresponding coil serial number is blank.

6. In “System Request” select “Coil Calibration” mode.

7. Press “Display MTU Status”.

8. Monitor the progress of the coil calibration. Initially the “Calibration Status” will contain the message “Coil calibration in progress”. The MTU must first acquire “4 GPS satellites” before it will begin calibration. Then calibration typically requires about 1 hour. When calibration is complete, the “Calibration Status” will contain the message “Coil calibration files on disk”.

9. When calibration is complete, the MTU may be powered off; or another operation may be performed (e.g. data acquisition); or INTERSVR mode may be entered and the

calibration files copied from the MTU. The calibration files are located in the \CAL directory on the MTU, and are named *COILnnnn*.CLB where COIL denotes the type of sensor and *nnnn* is the sensor serial number entered by the user.

10. Note that when an MTU is powered up, the “Calibration Status” will state “Coil calibration not performed” even though valid coil calibration files may be present. This is because the MTU has no way to verify that different sensors have not been connected to it.

2.7 Data acquisition

1. Perform an offline setup as described in Section 2.4. The following parameters should be set:

- “System request” select “Record”.

- “E / H Coupling” select “AC Couple” for both E & H channels.

- “Line Frequency” select “50 Hz” or “60 Hz” depending on power line frequency of the survey area.

- “Sampling Schedule” select “V5-Compatible”. This will use the same sample rate and frequencies of acquisition as the V5 system. The other option “V5-2000” is not yet implemented.

- “Low pass filter” select a value appropriate to the survey area. “Weak” should be used in areas of high contact resistance (>5 kohms) and low noise. “Strong” should be used in areas of low contact resistance (<1 kohms) and high noise. When in doubt, select “Strong”. “Medium” being the normal setting.

- “Start Time” should be set to the desired UTC time at which acquisition is to be started, in the format hh:mm:ss. The MTU will start at the specified time if it is less than 12 hours after the time at which the MTU is powered up; it will start immediately if the specified time is less than 12 hours before the time at which the MTU is powered up. The user may optionally enter both date and time in the format yyyy/mm/dd hh:mm:ss (example: 1998/06/30 12:00:00).

- “End Time” should be set to the desired UTC date and time at which acquisition is to be ended, in the same format as the Start Time. If no date is specified, the End Time is assumed to be within the 24 hours after the Start Time.

- “High Start Time” and “High End Time” should be set to UTC dates and times (date optional) at which acquisition of high range data will begin and end. These times must fall within the overall “Start Time” and “End Time”. (“High range” refers to high frequency data. It is collected for only a part of the total acquisition time, typically 2 hours, to conserve MTU memory.) If “High Start TIme” and “High End Time” are both set to 00:00:00, high range data will be acquired for the entire acquisition time.

- Enter the azimuth in degrees of the Ex dipole and the Hx coil in “Ex Sensor Az” and “Hx sensor Az”. Enter the dipole lengths in meters in “Ex Dipole Length” and “Ey Dipole Length”. These values are not needed by the MTU but entering them at this time makes processing more convenient.

2. In INTERSVR mode, or using WINHOST.EXE, check that the \DATA subdirectory of the MTU has at least 27 Mbytes of free space. If it does not, copy all files in the \DATA subdirectory to the host using INTERSVR with the host in DOS mode, and then delete them; or delete them using the MTU File Utilities in WINHOST.EXE.

3. Power down the MTU.

4. Install the MTU and its sensors at the survey site. See Section 2.8 for details of magnetic sensor installation (MTU-2H, MTU-3H, MTU-5) and Section 2.9 for details of electric sensor installation (MTU-2E, MTU-5).

5. Power up the MTU.

6. Observe the MTU LED flashing. Wait for the MTU to acquire four GPS satellites. It will signal this by flashing 1 s on, 1 s off. Once the MTU has acquired GPS it is ready to acquire data, even if GPS is lost for intervals of up to 1 hour. When the MTU begins to acquire data (at "Start Time") the LED will flash 2 s on, 1 s off. See Appendix C.

7. If desired, the MTU can be connected to a host computer at any time with a parallel cable and the progress of the acquisition can be monitored using WINHOST.EXE.

8. When data acquisition is complete, (or sooner, if desired) power down the MTU by operating the "POWER" switch. Wait at least 20 seconds, until the LED is off. Disconnect the power.

9. When it is desired to copy the data files from the MTU to a host computer, put the MTU in INTERSVR mode (see Section 2.2), and put the host computer in DOS mode. Copy all the files in the \DATA subdirectory of the MTU to the host. Delete the files from the \DATA subdirectory of the MTU. (Note: it may take several minutes to delete a large file.)

2.8 Installation of MTU-2H, MTU-3H, and MTU-5 with magnetic sensors

The MTU-2H, MTU-3H and MTU-5 are used to receive signals from external magnetic sensors. The data quality will largely depend on the selection of sensor location. Since the magnetic plane wave is assumed to be homogeneous in nature, then moving the location a few hundred meters to few kilometers will not matter. Only in abrupt topographic changes will the H-field be distorted somewhat. Therefore it is suggested that a local H-site be close to the E-site(s) (< 1 kilometer) and second site be some distance away for remote reference. In the case of the MTU-5, the E-site and the H-site are the same location. A remote site should be an area where the cultural noise is sufficiently different to be uncorrelated from that of the survey area.

The two sensors Hx & Hy are to measure the horizontal components of the magnetic vector. Therefore placement will be at right-angles to each other. By standard convention, Hx is the NORTH oriented sensor and Hy is EAST oriented sensor. Note that the positive end of PHOENIX coils is away from the preamp end (where the cable connects). All directions can be implemented by restricting the azimuth of Hx from -45° to +45°. If you must rotate additional to these limits for ease of layout, then interchange sensor components and correct the polarity. To reduce cross talk between sensors, placement should be more then 10 meters separation. Run the sensor cables back to the MTU-2H box having any excess cable away from the sensors and NOT in a coiled formation. If the sensor placement is in the SOUTH or WEST quadrant then make sure the sensor cable DOES NOT lay next the sensor, but loop away from the sensor in its path to the MTU-2H box. Installation for MTU-3 and MTU-5, Hz component needs to be buried vertically. Select an open area, away from power lines and large vegetation. Note that if telluric lines are installed at the same site location (MTU-5) they can cross talk with magnetic sensors. The separation from telluric lines to horizonal sensors should be more then 3 meters and 10 meters from the vertical sensor.

For best sensor measurement results, select a culture free area. This area should be away from power lines, roadway with vehicle traffic and large vegetation such as tall grass, bushes and trees. Roots of such vegetation can cause micro-seismic noise on the sensor measurement.

1. Level the sensors and sighted for accuracy of direction.

2. Bury the sensors 30-50 cm in depth for stability to reduce induced wind noise.

3. Connect the 3-way adapter to the MAG INPUT on front panel of MTU box.

4. Connect the sensor cable to 3-way adapter (Cable Hx: 1ring, Hy: 2rings, Hz: 3 rings).

5. Connect the ground pot to the GND binding post.

6. In the case of the MTU-5, install the electric field sensors as described in Section 2.9.

7. Connect the GPS antenna and locate for clear view of the sky.

8. Connect the battery.

9. The gain setting is generally “Normal”. The selection of “High” or “Low” gain for the

magnetic channels depends on the natural signal strength and it remains relatively stable with time. See Appendix D for gain values of three options.

2.9 Installation of MTU-2E and MTU-5 with electric sensors

The MTU-2E and MTU-5 are used to receive signals from external telluric dipole sensors. The data quality will largely depend on the survey location. The cultural noise of a given area is generally not under the operator’s control. However, the resistivity data of a given location is totally dependent on the electrical field measured at that site. Therefore when doing a profile line or a grid array survey, the E-sites are already determined. Some leeway can be given to the direction of measurement (azimuth of Ex) and configuration of the dipole (X, T or L shape) and length of each dipole.

Select a configuration to minimize the effects of cultural noise sources. Since the resistivity changes from location to location by as much as 0.1 ohm-m to 10,000 ohm-m, the telluric signal will to change proportional to the square root of the resistivity. Therefore, the signal to noise ratio will change from area to area. Where resistivity is high, the telluric signal will be strong and conversely the signal will be weak in areas of low resistivity. For the same noise level, the signal-to-noise ratio will be different. In locations of low (< 10 ohm-m) resistivity extra caution is required to reduce noise.

Follow these guidelines when installing the MTU and its electrodes.

1, Keep wire contacts clean, dry and wrap them. Remove any oxidized wire or wire corrosion from wire ends before connecting together.

2. Place the dipole wires from electrode to MTU-2E box firmly on the ground. The wire should be laid out limply and covered. This is to prevent wind noise on the dipole signal. A conductor moving through the Earth’s magnetic field will induce current in that conductor and hence add noise to the measurement being made. This noise is dominant from 10 Hz to 0.1 Hz.

3, Connect each E-line to its electrode. Make sure the wires are tightly wrapped together and covered by electrical tape. This connection must not touch the ground or become wet. Only the bottom of the electrode should make electrical contact with the earth.

4. Check the E-line for cuts and splices. Wrap them with black electrical tape to prevent any secondary contact(s) to ground. Such contacts will give capacitive discharges, adding noise to the telluric measurement.

5. Bury each electrode completely to provide a stable temperature environment for the measurement.

6. Reduce contact resistance at each to less then 1 kohm. Add salt (NaCl) water to the pot hole. Also adding driller's mud (Bentonite) mixed in salt water helps in gravel areas to lower contact resistance.

7. Check contact resistance, AC level, and DC level from each dipole. A reading of less then 1 kohm is good. A higher reading (2-5 kohm) is workable but the low pass filter (LPFR) setting may need to be changed.

8. To check the ground pot, measure the resistance from GND to the other four pots. All reading should be similar. If one or more readings are larger then the rest, check that electrode installation again. If all are higher then the N-S and E-W readings, then check the ground pot.

9. With a digital multimeter measure the AC signals voltage for N-S and E-W. This will determine if the correct gain (EGN) setting was selected. For levels > 50 mV, "Low "gain is best. Otherwise "Normal" gain should be used. "High" gain can be selected in areas of very low cultural noise (< 2mV) but generally a longer dipole works better in such cases.

See Appendix D for gain values of "Low", "Normal", and "High".

10. With a digital multimeter measure the DC signals N-S and E-W. This will give an indication if there is large self-potential (SP or DC offset) on the dipole. This can also indicate a bad electrode. Try replacing with another or moving the pot a few meters. A DC signal less then 50 mV is desirable but up to 100 mV should not effect the measurement.

11. Orient the MTU-2E box with the E binding post towards the East electrode location. This will align the other connection and reduce wires crossing over each other.

12. Connect the electrodes to the W, N, S, E, and GND binding posts of the MTU.

13. Connect the GPS antenna to the MTU.

14. Connect the battery.

Appendix A: Interlink setup procedure for MTU-Box

Phoenix Geophysics Limited
V5-2000 System
Interlink Setup Procedure for MTU-2E Box
MJM - Revised - 1997-October-21
Printed February 9, 2001

The following procedure describes how to set up both the MTU-box and a host PC running Windows '95 or DOS for use with the Interlink/Intersvr software.

1) In the config.sys of the PC (or laptop) place the following line:

```
device=C:\path\interlnk.exe  /drives:1  /noscan  /lpt1
```

where *path* is the directory where interlnk.exe can be found
/drives:1 sets up only one drive from the MTU
/noscan tells interlnk not to try to connect immediately. If this option is not used, interlnk will constantly try to establish communications with the MTU, which if turned off or not running intersvr.exe, will cause the PC to run dramatically slower.
/lpt1 forces use of the parallel port.

The PC must be rebooted to allow this change to take effect.

2) On the MTU, when you wish to connect to the PC, type the following at the DOS prompt:

```
intersvr c:  /X=a:
```

where *c:* is the drive to allow access to from the PC
/X=a: forces intersvr to skip the (non-existent) a: drive. Without this option, an a: drive is assumed to exist, and is setup by default, causing the interface to run more slowly.

Of course, you must be in the directory containing the intersvr.exe program when you run this command or have the directory listed in the PATH name. In the MTU software, there are two batch files setup for easy of useage. They are "i.bat" and SVR.bat.

3) If running DOS on the PC (or laptop), type the following at the DOS prompt (in the appropriate directory):

```
interlnk  /lpt1
```

where */lpt1* forces use of the parallel port.

You should now be able to access the c: drive on the MTU as a drive on the PC.

4) If running Windows ‘95, the job is slightly more complicated. If you try to run the interlnk command as above from the “Run” item on the “Start” menu, Windows will try to go into MS-DOS mode, which means Windows is no longer running.

Therefore, a “shortcut” to the interlnk.exe program should be created on the desktop with the appropriate parameters to prevent this from happening.

- Create the shortcut by copying an existing MS-DOS shortcut icon.
- Click on the icon with the right mouse button and select “Properties”.
- Select the “Program” tab of the shortcut.
- In the “Cmd line” box, place the following command:

  c:\path\interlnk.exe /LPT1

  where *c:\path* is the drive and path to interlnk.exe
  /LPT1 forces use of the parallel port.

  Leave the “Close on Exit” check box unchecked for now.

- Select the “Screen” tab of the shortcut.
- Set the “Usage” to “Window”.
- Select “OK”.
- Rename the icon to “Interlink” for ease of use.

Now, when you wish to establish communication with the MTU, double click on this icon. A DOS window will display some information from interlnk.exe indicating the drive letter setup. To remove the window, click on its ‘X’ tab. The shortcut properties can be set to close the window automatically by selecting “Close on Exit” in the “Program” tab.

If everything has worked properly, the MTU drive should appear as an additional drive when the “My Computer” icon is opened. Double click on the new drive letter (which will be different on every machine) to view the MTU c: drive in the Windows Explorer. File copying and editing can now be done as if the MTU drive were on the PC.

NOTES:
1) Once intersvr.exe is run on the MTU, it is not possible to exit the program. On a normal PC, the ALT-F4 combination accomplishes this, but this key combination cannot be sent through the serial keyboard interface to the MTU’s processor board. Therefore, the MTU must be turned off and rebooted to resume normal operation.

2) Do not run intersvr.exe on the MTU until you wish to perform file transfer operations.

3) Similarly, do not run interlnk.exe on the PC (or the shortcut in Win ‘95) until you wish to do file transfer. If interlnk.exe is run on the PC before intersvr.exe is run on the MTU, the PC will likely grind to a halt as it constantly tries to establish contact with the unreachable MTU drive.

4) The interlnk.exe program is both a device driver and a command line program and must be used in both places as described above.

Appendix B: MTU Parameter Table Specification

Phoenix Geophysics Limited
V5-2000 System
MTU Parameter Table Specification
DJD - Revised August 11, 1998
Printed February 9, 2001
* Denotes points for discussion
*** Denotes sections not yet written

Codes:

P - Essential for post processing (not encoded in .TS? files).

A - Do not update during acquisition.

F - Frequently updated

Mode parameter (updated by the MTU only):

MODE	integer	= 1 - Setup mode. = 2 - Recording mode. Level 5 data is logged continuously. Level 3 and 4 data is logged on a schedule specified by parameters HTIM, ETMH and HSMP. = 3 - Pot/coil check mode. = 4 - Pot impedance measurement mode. Generate test waveform at 16 Hz *** and stack, in various configurations of + and - test signal input and + and - pot connection, to allow the impedance of each pot to be calculated. Log the stacked waveforms to a .TSP file ***. = 7 - Box calibration mode. Generate test signals at three or four frequencies, analyze, and save frequency domain calibration to disk. = 8 - Magnetic sensor calibration mode. Generate test signals at three or four frequencies and log stacked waveforms to a .TSM file. = 9 - Shut down mode. Entered when the battery is low, the OFF switch is operated, when acquisition is complete and XDOS = 4, or when XDOS = 2. The MTU is powered down after a 10 s wait. = 10 - Fatal Error mode. Entered when a non-recoverable hardware configuration error occurs.

Mode transition matrix									
Final mode>	1 Setup	2 Record	3 Pot/coil	4 Pot Z	7 Box Cal	8 Coil cal	9 Shut down	10 Fatal Error
Initial mode								
1 Setup		RQST	RQST	RQST	RQST	RQST	RQST OFF,BAT	Hardware problem
2 Record	RQST						RQST OFF,BAT ETIM & XDOS=4	Hardware problem
3 Pot/coil	RQST						RQST OFF,BAT	Hardware problem
4 Pot Z	RQST						RQST OFF,BAT	Hardware problem
7 Box Cal	RQST						RQST OFF,BAT	Hardware problem
8 Coil cal	RQST						RQST OFF,BAT	Hardware problem
9 Shut down								
10 Fatal Error								

Parameters which are set by the host only:

RQST	integer		Requests the MTU to change MODE to the specified value if rules allow it.
V5SR	integer	A	Set to 0 for V5-2000 sample rates: 15, 300, 2,400 Hz. Set to 1 for V-5 compatible sample rates: 24, 320, 2,560 Hz if LFRQ = 50; 24, 384, 3,072 if LFRQ = 60.
LFRQ	integer	A	Line frequency, Hz. Valid entry: 50 or 60.
L3NS	integer		Level3 acquisition contiguous section in seconds. Starts on minutes which are odd multiples of HSMP. Valid entry: 0 to 2
L4NS	integer		Level4 acquisition contiguous section in seconds. Starts on minutes which are even multiples of HSMP. Valid entry: 0 - 16
HSMP	integer		Set the high range sample interval in minutes. Level 4 is sampled on the hour, Level 3 is sampled HSMP minutes later, and so on.
SGIN	integer		Sets the signal input source. 0=External, 1=Test signal, 2=Both.
EGN	integer	A?	Gain for “E” channels. Valid entries: 10, 40, 160.
HGN	integer	A?	Gain for “H” channels. Valid entries: 3, 12, 48.
ACDC	integer	A?	“E” channel coupling. Valid entries: 0 for DC , 1 for AC coupling.

ACDH	integer		"H" channel coupling. Valid entries: 0 for DC , 1 for AC coupling.
LPFR	integer	A?	LowPass Filter setting. Valid entries: 1, 2, 3 ***E/H
TBLF	string12		Change input parameter file to this file name from STARTUP.TBL. The .TBL extension is used regardless.
PTIM	datetime		Time to read more parameters from the STARTUP.TBL file.
WAIT	integer		Number of seconds to wait before reading next parameter. WAIT is set to 0 when the time expires and the next parameter is read.
SITE	string8	A?	Site ID. Recorded in the *.TBL file.
FILE	string8	A?	DOS compliant file name for the data files and the parameter files. Normally the site name TAG-nnnA where nnn is site No. ***
			The suffix is generated by the program. .TBL for parameter files, .TSL for level5 data, .TSH for level4 and level3 data files.
STIM	datetime	A	Start date/time of the data acquisition in UTC ***. If date is 0, then the date will be selected so that it is within ± 12 h of the present time.
HTIM	datetime	A	Start time to begin saving Level 3 & Level 4 data.
ETIM	datetime		End time of the data acquisition.
ETMH	datetime		End time of the high range data acquisition.
CMPY	string12		Name of company.
SRVY	string12		Survey ID.
EAZM	integer		Ex sensor azimuth from True North, deg. Range: +45 (E) to -45 (W)
EXLN	integer		Ex dipole length, m. Linear distance between N - S pots.
EYLN	integer		Ey dipole length, m. Linear distance between E - W pots.
HAZM	integer		Hx sensor azimuth from true north, deg. Range: +45 (E) to -45 (W) ***
HXSN	string8		Hx sensor Serial Number. If COIL is used : C-nnnn ***
HYSN	string8		Hy sensor serial number.
HZSN	string8		Hz sensor serial number. (What if air loop?***)
TXPR	integer		Period of Polarity signal output in seconds when MTU is used as transmitter controller (MTUTXC.HW).

Parameters which are initialized by the MTU and never changed:

SNUM	integer	The serial number of the MTU unit.
HW	string8	Hardware configuration of box.
VER	string8	Software version string.

CHEX	integer	Front end channel for EX. Initialized to 1 in MTU-2E. Set to 0 in MTU-3H/2H unit.
CHEY	integer	Front end channel for EY. Initialized to 2 in MTU-2E. Set to 0 in MTU-3H/2H unit.
CHHX	integer	Front end channel for HX. Initialized to 0 in MTU-2E. Set to 1 in MTU-3H/2H unit.
CHHY	integer	Front end channel for HY. Initialized to 0 in MTU-2E. Set to 2 in MTU-3H/2H unit.
CHHZ	integer	Front end channel for HZ. Initialized to 0 in MTU-2E. Set to 3 if Hz in MTU-3H unit.
ADFS	integer	A/D converter full scale, mV.
ADMX	integer	A/D converter max output corresponding to ADFS.
HATT	double	Gain of coil attenuator on interconnect board, mV/V.
TAMP	integer	Test signal square wave input, uV peak.
HAMP	double	Coil test waveform amplitude, nT.
HNOM	double	Coil nominal gain, mV/nT.
TCMB	integer	Type of comb filter. 1: a = 0.75, 1st order, odd in level 5, all in level 3 and 4.
TALS	integer	Type of aliasing filter: 1 - 5 th order sinc. 2 - Flat to 80% of folding frequency.
CCMN	double	Minimum acceptable coil corner frequency, Hz.
CCMX	double	Maximum acceptable coil corner frequency, Hz.
CFMN	double	Minimum acceptable corner frequency, Hz.
CFMX	double	Maximum acceptable corner frequency, Hz.
CCLT	integer	Coil cal time multiplier.

Parameters which are updated by the MTU only:

AQST	integer	Aquisition status. 0 = not acquiring, 1 = Setting up, 2 = Aquiring data, 3 = Aquisition done.
NSAT	integer	Number of GPS satellites acquired by the GPS receiver.

CLST	integer	Clock Status = 0 if time is uninitialized, = 1 if time is based on CPU RTC, = 2 if synchronization to GPS is in progress (but MINCLK not synch'd) = 3 if time is based on a crystal oscillator which was initialized by GPS, = 4 if clock is locked to GPS.
NUTC	datetime	UTC time of most recent 1 Hz pulse. This is always an integral second.
TERR	integer	Error in sample time, us. + for late, - for early. Normally zero, will be non-zero during recovery from GPS dropout.
LFIX	datetime	UTC time of last GPS fix.
OCTR	integer	Oscillator control register value. The program sets it during tracking the 1 PPS signal of the GPS. Range: 0-255. *** We should raise some kind of caution flag when it approaches limits to allow for readjustment.
ELEV	integer	Elevation of site, m received from GPS.
LATG	string12	Latitude from GPS, degrees and minutes. Format "4348.519,N,".
LNGG	string12	Longitude from GPS, degrees and minutes. Format "07920.277,W".
SRL3	integer	Sample rate for level 3, Hz. Set based on V5SR and LFRQ.
SRL4	integer	Sample rate for level 4, Hz. Set based on V5SR and LFRQ.
SRL5	integer	Sample rate for level 5, Hz. Set based on V5SR and LFRQ.
EXR	integer	Ex pot resistance between N - S expressed in ohms.
EXAC	integer	Ex AC measurement between N - S expressed in mV.
EXDC	integer	Ex DC measurement between N - S expressed in mV.
EYR	integer	Ey pot resistance between E - W expressed in ohms.
EYAC	integer	Ey AC measurement between E - W expressed in mV.
EYDC	integer	Ey DC measurement between E - W expressed in mV.
TOTL	integer	Total count of data records level3, level4 and level5 combined. ***
BADR	integer	Count of records flagged bad (not including saturations)
SATR	integer	Count of records containing saturations.
BAT1	integer	Battery #1 voltage in mV. (Input voltage pin A-D)
BAT2	integer	Battery #2 voltage in mV. (Input voltage pin B-C)
BAT3	integer	Battery #3 voltage in mV. (Internal Backup voltage)
TEMP	integer	Internal operating temperature (degrees C) of MTU unit

DISK	integer	Free disk space, bytes.
GFPG	integer	Return code from the FPGA loader for the GPS board. 0 = successful, -1 = not loaded, >0 = error.
FFPG	integer	Return code from the FPGA loader for all Front End boards. 0 = successful, -1 = not loaded, >0 = error.
DSP	integer	Return code from the DSP loader for all Front End boards. 0 = successful, -1 = not loaded, >0 = error.
CALS	integer	Box calibration status: 0 = calibration file is on disk, 1 = no calibration on disk, 3 = calibration is in progress, 4 = calibration failed.
CCLS	integer	Coil calibration status: 0 = calibration file is on disk, 1 = no calibration on disk, 3 = calibration is in progress, 4 = calibration failed.
XDOS	integer	1 = Exit to DOS. 4 = Shutdown at end of acquisition. Initialized to 0. ***

Note:

"datetime" data type is based on the AMX time data type (8 bytes: s, min, h, day, month, year, day of week , century)

"integer" data type is a 32 bit signed integer.

"string12" data type consists of up to 12 ASCII characters followed by a null terminator.

"string8" data type consists of up to 8 ASCII characters followed by a null terminator.

"double" data type is a double precision (8 byte) floating point number.

Appendix C: MTU LED Status

Phoenix Geophysics Limited
V5-2000 System
LED Message Pattern
MJM - Revised - 1998-February-18
Printed February 9, 2001

The following document describes the message indicated by the LED flashing pattern on the MTU box:

No GPS satellites: LED stays on continuously.

Prior to Data Acquisition: LED flashes 1 second on/1 second off per satellite, up to a maximum of 4 on/4 off. e.g. if 3 satellites are in use, the pattern would be 1 sec. on, 1 sec. off, 1 sec. on, 1 sec. off, 1 sec. on, 1 sec. off.

During Data Acquisition: LED flashes 1 second on/2 seconds off per satellite, up to a maximum of 4 on/8 off. e.g. if 3 satellites are in use, the pattern would be 1 sec. on, 2 sec. off, 1 sec. on, 2 sec. off, 1 sec. on, 2 sec. off.

After Data Acquisition: LED flashes 1 second on/5 seconds off continuously.

In all cases, the pattern repeats every 12 seconds.

The MTUP.EXE program must be running to control the LED. Since the LED is connected to the speaker port of the CPU board, it will flash briefly during power up as a normal part of the CPU's POST.

Also, if the MTUP.EXE program is set to exit or power down after completion of data acquisition (using the XDOS parameter), the LED is no longer under program control and will not give any status indication.

Appendix D: MTU Box Specifications

Phoenix Geophysics Limited
V5-2000 System
MTU-2E, MTU-3H, MTU-5, MTU-CL Specification
September 8, 1998

1. GENERAL

- Acquires and stores two electric field signals and/or three magnetic field signals for up to 30 hours (depending on data acquisition parameters) with external battery.
- The MTU-CL outputs UTC synchronized timing signals only. (Does not acquire data.)
- Light weight (4 kg) and compact.
- Surge protection, sealed case, and high quality connectors for reliable operation.
- Shuts down automatically when the battery voltage is low.
- Time series are stored at three different sample rates.
- In S2000 mode the sample rates are: 15 Hz, 300 Hz, 2,400 Hz precisely.
- In V5-50 Hz compatible mode sample rates are: 24 Hz, 320 Hz, 2,560 Hz.
- In V5-60 Hz compatible mode sample rates are: 24 Hz, 384 Hz, 3,072 Hz.
- Acquires low- and high-frequency data simultaneously as follows:
- The 15 Hz (“low range”) time series is acquired and stored continuously.
- Low range acquisition starts and stops at preprogrammed date/times.
- The 300/320/384 and 2,400/2,560/3,072 Hz (“high range”) time series acquisition can be limited to a preprogrammed date/time interval within the low range acquisition interval.
- Within its acquisition interval, high range time serie are acquired and stored according to a preprogrammed pattern.
- The 300/320/384 Hz time series is acquired for 1 - 16 s starting on specified minutes.
- The 2,400/2,560/3,072 Hz time series is acquired for 1 - 2 s starting on specified minutes.
- The “specified minutes” are multiples of 1, 2, 3, 4, 5, 6, 10, or 15 minutes past the hour, even multiples for the 300/320/384 Hz rate, odd multiples for the 2,400/2,560/3,072 rate.
- Sample times are synchronized with UTC using a combined GPS/stable oscillator clock.
- Long term absolute accuracy locked to GPS is 1 us regardless of duration of acquisition.
- Typical short term OCXO stability (applies during GPS dropouts) is 5×10^{-9}.

- Unnecessary to bring an MTU to another station to synchronize clocks.
- Samples are 24 bits resolution (MT) and 18-20 bits (AMT,CSAMT [*]).
- Connects via cable to an external PC parallel port for parameter setup and data output.
- Parameter setup program on the external PC allows parameters to be loaded into the MTU from a disk file, and optionally to be modified by filling in parameters in a table on the external PC screen.
- Data dumping to the external PC can be performed at 10 - 30 kbyte/s (higher speed data dumping under development).
- Data record format conforms to V5-2000 standard, defined here.
- Low power consumption: 9 W in the MTU-2E configuration.

2. EXTERNAL CONNECTIONS

- Case ground: External binding post, should be grounded via a porous pot.

- Telluric inputs (binding posts).

- Parallel port

  Circular, 26 pin, shell size 16.
  Electrically compatible with standard PC bidirectional parallel port
  All pins have 1 kV ESD protection.

- Auxiliary connector

  Multipurpose:
    Connects to magnetic sensors in MTU-3H and MTU-5 configurations
    Outputs timing signals in MTU-CL configuration.
  Circular, 18 pin, shell size 14.

- Battery connector

  Circular, 4 pin, shell size 8.
  Surge protection and overload protection, on all pins.
  A - Battery 1 +12 V
  B - Battery 2 +12 V
  C - Battery common
  D - Battery common

3. FILE TYPES AND LOGICAL RECORD FORMATS

Results are stored in the following types of files.

- .CLB - MTU box self calibration results file.

- .CLC - Coil calibration results file.

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- .TSL - Low frequency (“low range”) time series data. The data is typically contiguous, consisting of records of one sample rate only, all of the same size.
- .TSH - High frequency (“high range”) time series data. The data is not contiguous, but consists of continuous segments of time series. Each continuous segment begins on a GPS minute. The “level 4” (300, 320, or 384 scan/s) data segments begin on even numbered minutes, while “level 3” (2,400, 2,560, or 3,072 scan/s) segments begin on odd numbered minutes. Typically all level 3 records are of the same sample rate and size, and all level 4 records are of the same sample rate and size.

The calibration files provide a complete calibration of the instrument or sensor over its useful frequency range, independent of the mode of operation (e.g. line frequency, AC/DC coupling).

The time series file format is as follows.

- The file consists of records containing time series data, written in order of the time of the first sample in the record.
- The record lengths in one file may vary.
- Each record consists of a tag followed by time series data. The time series data in a record always starts exactly on a UTC second, and always has a sample rate which is an exact integer multiple of 1 Hz.
- The time series data is stored in 24 bit 2’s complement format, 3 bytes per sample, least significant byte first. A complete “scan” of samples from one channel is stored together, in order of channel number. (Channels are numbered starting at 1, not 0.) Consecutive scans are stored in order of sample time.
- Tag formats may vary, but the same tag format is used throughout a file.
- The tag format now implemented is 16 bytes long and the records using these tags contain exactly one second of time series data. The 16 byte tag format is a follows:

    Byte 0-7: UTC time of first scan in record, in the format second, minute, hour, day, month, year (last two digits), day of week, century, one byte per field.

    Byte 8-9: Serial number of the MTU (16 bit integer).

    Byte 10-11: Scans of data in the record, 16 bit integer. (Since the record contains 1 s of data, this is also the sample rate in Hz.)

    Byte 12: Number of channels of data per scan.

    Byte 13: Contains 0.

Byte 14: Status code.
0: Normal completion.
3: Saturation of Front End Board analog circuits.
4: Internal error in Front End board DSP.
6: Processor timed out waiting for data from Front End Board DSP.
1, 5, 7, 8: Internal errors.

Byte 15: Saturation flags.
Bit n is 1 if there is a saturation in channel n+1.

The UTC date and time, the serial number, and the sample rate uniquely identify the data record. No other data record can exist which duplicates all these fields (unless some are in error!).

The tag defines the record length, which is the tag length + 3 x Channels per scan x Scans in the record.

The “0” in byte 13 identifies this as a 16 byte tag, which can only have the format defined here. No other tag format is permitted to have “0” in byte 13.

- A 32 byte tag format which provides more data, allows records which are not exactly 1 second long, and allows sample rates < 1Hz, is under development and will be upward compatible with the 16 byte tag format.

4. MECHANICAL AND ENVIRONMENTAL

Operating temperature: -20° C to +50° C.
Case: Diecast aluminum, environmentally sealed.
Size: 230 mm x 225 mm x 110 mm.
Weight: 4 kg.