MMC

MAXMIN COMPUTER

OPERATIONS MANUAL

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1. INTRODUCTION:

The Apex MMC (for MaxMin Computer) is a portable field computer designed to interface with MaxMin EM Systems, produced by Apex Parametrics Limited.

The purpose of the MMC is to enhance the MaxMin EM System capabilities and accuracy and to speed up the surveys by recording the data and assisting the operators during the survey with rough-terrain calculations when needed. Apparent conductivity values for individual frequencies are displayed and stored, as are the measured in-phase (real) and out-of-phase (imaginary) values and tolerances or standard deviations for same (in per cent of primary field). The combination of MaxMin and MMC results in a direct reading apparent conductivity meter, with a conductivity readout range from 0.1 to 3276.6 milliSiemens (millimhos) per metre, achieved by utilizing the entire horizontal coplanar or vertical coplanar loop induction curves rather than the "early" or linear part of the quadrature curves only. This also suggests the use of higher survey frequencies for improved response and conductivity accuracy. Parametric and geometric multilayer soundings can be interpreted and plotted using separately available optional programs for personal computers.

A dumping program is supplied for transferring stored data from the MMC to a personal computer as are formatting programs for further file formatting and for producing computed best fit multi-frequency apparent conductivity values and standard deviations (= fitting error for half-space model, in per cent of primary field) for the computed best-fit conductivities.

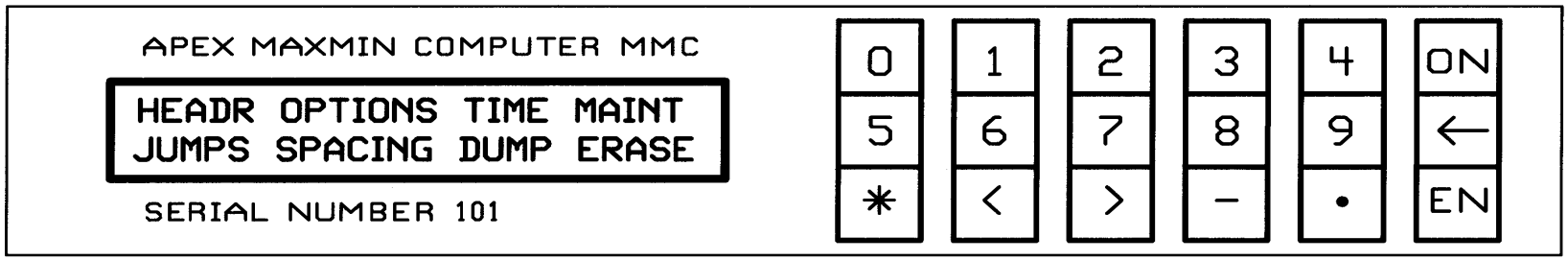
2. CHARACTERISTICS:

DISPLAY	- LCD, 2 lines of 24 alphanumeric characters each
KEYBOARD	- 18 pushbutton keys, snap action
AUDIBLE CUES	- Beeper, at bottom of case
MEMORY	- ROM: 16 Kb, expandable to 64 Kb
	- RAM: 256 Kb static CMOS
CLOCK	- Date, Time (year, month, day, hours and minutes)
TILTMETER	- Tilt display, with sensor and circuitry built in
ANALOG INPUT	- Four channels, ±1.000 VDC F.S. with 100% overrange programmable gain system
SIZE	- 24.2 x 17.3 x 4.3 cm (9.5 x 6.8 x 1.7 inches)
WEIGHT	- 1.0 Kg (2.2 Lbs)
BATTERIES	- Two 9 Volt-0.6 Ah alkaline batteries
	- One internal 3 volt lithium back-up battery, CR2032
CONNECTOR	- 19-pin bayonet type connector receptacle
TEMP. RANGE	- Minus 30 to Plus 60 deg. C (operating and storage).

3. INSTALLATION AND CARRYING:

The MMC is installed and carried in the MaxMin receiver leather case notebook pocket and connected to the MaxMin receiver with a short cord. The applicable cord connector receptacles are found on the underside of the MMC and of the MaxMin receiver leather case. Two spare cords are normally provided with each MMC.

MMC FRONT PANEL LAYOUT:



4. OPERATION

The "ON" key, the rightmost key on the upper row, can be used to power up the MMC. The computer also powers itself up automatically whenever the MaxMin receiver "READ" or "STORE" switch is activated, with the MMC connected to the receiver.

The MMC is menu-driven, with a hierarchical menu structure, thus keeping operator-entered keystrokes to a minimum.

Whenever the MMC is activated by pressing the "ON" key, the Main Menu will appear on the display. Each menu consists of a list of words or abbreviations. One and only one of these words will be highlighted with a cursor (the first letter in the word will be underlined). With the "<" and ">" keys, the cursor can be moved, left or right respectively, to any menu item. That menu choice may then be selected by pressing the "ENter" key. To get out of a menu, the left arrow or backspace "BS" key leads to the next higher menu level. If "BS" is pressed while in the Main (highest) Menu, MMC powers itself down.

Menu options and most MMC questions can be responded to simply by positioning the cursor and then pressing the ENter key. Where numeric data must be entered, there are two kinds: integer and real. The basic difference is that real numbers may contain decimal points, whereas integers never have them. In every case where there is a need to enter a number, MMC will suggest a "default" value. This is usually the current value of the particular parameter. If the default value shown on the display is correct, the operator simply presses "ENter", and the value is accepted. If the operator wishes to change the value shown, he has two ways to do so: he can use the "<" or ">", and other keys to "edit" the value, or he can key in a totally new value. In either case, ENter terminates the operation, and the value that appears on the display at that time is accepted. If a mistake is made while entering a number (e.g. a wrong digit is typed) then the backspace "BS" key can be used to erase the last digit entered. Note: Pressing "BS" when the cursor is already at the extreme left of a numeric field (i.e. when there is nothing to be erased) is a signal for the MMC to power itself down.

5. MAIN MENU

This (the highest) Menu serves both to select other (lower) Menus, and also to provide rapid access to commonly used functions.

HEADR	- Enter a new survey HEADER
OPTIONS	- Options selection
TIME	- Current Date and Time
MAINT	- Maintenance menu
JUMPS	- Jump to another station and/or another line
SPACING	- Change station spacing, i.e. measurement interval
DUMP	- Transfer data from Bulk RAM to personal computer
ERASE	- Erase all data stored in Bulk RAM

6. HEADER (HEADR) MENU

This menu leads the operator through a series of questions to be answered before a field survey can begin.

PROJECT NO.	- integer
OPERATOR NO.	- integer
UNITS	- choose either METRES or FEET
CO-ORDINATES	- N,S,E,W, or XY system selection
SLOPE RECORDING	- OFF, KEYIN or AUTO selection
MAXMIN MODEL	- choose one of four (4) models
MAXMIN SERIAL NO.	- integer
COIL SEPARATION	- real (assumed units as above)
STATION SPACING	- real (assumed units as above)
LINE NUMBER	- real, asked with NSEW co-ordinates only
LINE LOCATION	- N,S,E,W, asked for NSEW co-ords only,
FIRST PLOTTING PT	- unsigned real, with NSEW co-ords only, signed real X and Y values, with XY.
POINT LOCATION	- N,S,E,W, with NSEW co-ordinates only
SURVEY DIRECTION	- N,S,E,W, with NSEW co-ordinates, +X, -X, +Y, -Y with XY co-ordinates.
READY FOR READINGS	- header completed, ready for surveying

After the header information has been entered, the MMC powers down, ready for the first MaxMin readings. The current value of DATE - TIME is also part of the Header, but is recorded automatically from the internal real-time clock. A new Header may be created at any time, but usually only one is needed for a survey. Entering a new header does not erase any field data already stored, but might increase file editing requirements later on.

6.1. CO-ORDINATE SYSTEM SELECTION:

The user may choose one of two commonly used station co-ordinate systems: NSEW or XY by responding to the displayed CO-ORDINATES prompt.

6.11. NSEW (North, South, East, West) Co-ordinate System...
A reference point is assumed for the grid. All station co-ordinates consist of an absolute value displacement without sign (i.e. so many Metres or Feet away from the reference point) plus a location letter (which can be any one of N,S,E,W). For example, 200.00N would designate a point 200 units of distance North of the reference point. If the operator enters a negative displacement, a warning beep will be sounded and a proper re-entry will be requested. With this NSEW co-ordinate system a separate line number will be also asked for.

6.12 XY Station Co-ordinate System...
X and Y station co-ordinates are entered and displayed as signed reals. Negative values are prefixed with a minus ("-") sign; unsigned values are taken as being positive. With this system, no separate line numbers are asked for or used.

6.2 SURVEY DIRECTION - is the initial travel direction of the survey. This can be N or S or E or W under the NSEW Co-ordinate system or then +X or +Y (indicating successive station values on the increase) or -X or -Y (indicating successive station values on the decrease) with the XY Co-ordinate system.

6.3 STATION SPACING must be an exact submultiple of the COIL SEPARATION. For example, if COIL SEPARATION is 100 units, STATION SPACING of 20 or 25 units would be acceptable, whereas 37 units would be inappropriate.

6.4 FIRST PLOTTING POINT is the immediate starting point on the survey line at the mid-point of the reference cable. This is the station co-ordinate (NSEW System) on a given line, or the station co-ordinates (XY System), at which the initial readings will be plotted.

6.5 Real numbers may be keyed in with or without a decimal point (if omitted, the decimal point is assumed immediately to the right of the last digit entered) - however ral numbers are always displayed afterwards in a standard format for each parameter, including the imbedded decimal point.

7 OPTIONS MENU

SLOPES	- Select Slope Method to be used
BEEPS	- Activate/Deactivate Audible Cue System
TIMEOUTS	- Change Watchdog Timer Period

7.1 SLOPES

There are three slope options:

OFF	- No Slopes recorded,
KEYIN	- Operator keys in each slope manually,
AUTO	- MMC's internal tilt sensor is used to measure and to record slopes.

When using a hand-held inclinometer, such as the Suunto PM-5/SPC, to measure station to station slopes, the KEYIN option should be chosen, wherein the MaxMin receiver STORE switch, the MMC keyboard keys and the ENter key are used to enter the station to station slope values. A faster method would be to attach a small plastic (non-conductive) sighting scope (with cross-hairs) to one of the MAXMIN receiver antenna tubes at eye level. By looking through this scope along the survey line to the distant station, and tilting the MAXMIN receiver until the cross-hairs are on the next stake, the MMC-sensed slope could be entered rapidly by pressing the STORE switch on the MAXMIN.

The KEYIN and AUTO choices will bring out a sub-menu for the CHAINING used:

SLOPE	- Station distances measured along terrain slopes.
SECANT	- Station distances measured in the horizontal plane.

Paragraph 13 contains more information on the rough terrain operation.

7.2 BEEPS

The MMC issues "audible cues" to assist the operator with positive audio feedback. Once familiar with these cues, he needs not even look at the display most of the time.

1 SHORT BEEP:	- ACKNOWLEDGMENT. The requested action has been taken.
2 SHORT BEEPS:	- REQUEST to Enter a value or response to MMC request.
3 BEEPS WITH LONGER SPACES:	- Warning signal, indicates some unusual condition, with an accompanying message on the LCD.
4 SHORT BEEPS:	- a REMINDER that all readings at this station have been taken, and it is time to press the STORE switch.
1 LONG BEEP:	- the ERROR signal. Requested action was not completed satisfactorily. Please check display and correct the situation.

The OPTION-BEEPS Menu lets the operator enable or disable these audio cues selectively, according to personal preference.

7.3. TIMEOUTS

The MMC is either powered up (with something on the display) - or powered down (display blank). During powerup, current drain will be approximately 40 milliamperes, shared between two parallel batteries. Good quality fresh alkaline batteries have a capacity of some 600 mAh each. The resultant 1.2 Ah battery pack lasts for approximately two weeks of surveying under warm temperatures and much less than that in cold weather. When powered down, there is essentially no drain on the batteries. It may happen that the MMC is powered up manually and then left on - if left unattended, the batteries would be drained. To prevent this, the MMC has an internal watchdog timer. If there has been no keyboard activity for a preprogrammed period of time, the computer will automatically shut itself off. The default timeout period is presently set at 60 seconds. OPTION-TIMEOUT allows the operator to set this within the minimum value of 20 seconds and the maximum value of 3600 seconds (one hour).

8. TIME

The internal Real-Time Clock is displayed as follows: Year.Month.Day Hours:Minutes

A 24-hour clock is used. The time shown can be edited (change the time, then press ENter) - or simply escape by pressing "BS".

9. MAINTENANCE (MAINT) MENU

MAXMIN	- Displays MAXMIN shift register interface
TILT	- Reads out current TILT of the MMC
VOLTAGES	- Monitoring of battery voltages & temperature
MEM	- Bytes used and available in Bulk RAM
TLTCAL	- Tilt Sensor Recalibration
EDC	- Reserved for downloading applications progs.
INIT	- Initializes working memory
LCD	- Adjusts LCD viewing contrast

9.1 MAXMIN function may be used to verify that the serial interface between the MAXMIN and the MMC is functioning correctly and that the connecting cable interface connections are intact. A displayed value of all binary zeros indicates that a MAXMIN is not connected. The digits correspond to bit positions in the shift register.

9.2 VOLTAGES may be used to monitor the condition of the two 9-volt batteries. When this voltage drops below approximately 6 Volts, the batteries should be replaced. A "low-battery" warning is given on each powerup to alert the operator to low battery condition when the battery voltage drops to below 6.5 Volts. The voltages menu also displays the approximate ambient temperature and the back-up lithium battery voltage. The internal lithium battery is normally at over 3 volt level and it needs replacement once it has worn down to about 2.7 volt level, and even earlier if measured at room temperature but is used in very cold temperatures.

9.3 TLTCAL - the tiltmeter of the MMC may be recalibrated with this procedure if need be, for example in a case of a substantial discrepancy between the TILT meter or the bubble level in the MAXMIN and the tiltmeter of the MMC. Caution should be exercised.

9.4 EDC - Reserved for future custom application-program downloading.

9.5 INIT - All parameters in the working memory will be re-initialized. The Bulk RAM will be erased, and the Real Time clock will be reset. This procedure is protected by requiring a passcode entry to prevent accidents, and it is normally never required by users.

9.6 LCD - Used to adjust the LCD contrast by pressing and holding either the "<" or ">" key. While the selected key is held down, the contrast will either continue to decrease or to increase. A long beep signals adjustment range limit. Backspace key is used to exit from the menu.

If somehow the display contrast adjustement would be off so much that the MMC display can not be read in order to go into the contrast adjustment menu, a shortcut can be used. This is done by keeping any key depressed while powering the MMC up with the "ON" key. The MMC will power up into the LCD contrast adjustment menu and the arrow keys can be directly used to adjust the display contrast even if the display would not be readable.

10. JUMPS

This menu is used for changing line or station values abruptly, such as is the case when going from one line to the next, or when by-passing an open lake, for example..

11. SPACING

This is used for changing the station spacing without having to make a new header. Very useful item when detailing is required over anomalous zones.

12. TAKING READINGS

After the header has been entered, the MMC is ready for MaxMin readings. This is indicated by a "READY FOR READINGS" message flashed on the display. A reading is taken by pressing (and holding, if necessary, for further averaging) the MaxMin receiver READ switch to the right after the MaxMin receiver meter needles have more or less reached their apparent final positions. During the measurement, the LCD displays the current In-Phase and Out-of-Phase values as well as their relevant standard deviations in parentheses after each parameter. These measurement values are averaged for the length of the time the operator keeps pressing the READ switch. "Standard deviation" is the square root of the average squared deviation from the mean value. It provides an indication of the amount of fluctuations and noise present during the measurement, and as such is a measure of the tolerance or confidence level of the readings.

The apparent conductivity value is also displayed in milliSiemens (millimhos) per metre, as computed from the measured data. The smoothed TILT value is displayed in per cent grade at the top right corner of the display.

When the operator releases the READ switch, the readings are stored in a buffer, according to the frequency and mode used. As many readings may be taken as is required at a given station in any order or combination of frequencies and modes. If a reading is repeated for a previously measured frequency and mode, then the new values will overwrite the previous ones. When the operator is finished taking readings, he presses the MaxMin receiver STORE switch, at which time all readings in the temporary buffer are transferred to Bulk RAM, and the temporary buffer area is cleared.

After the readings have been stored at the first station, the MMC has a record of what frequencies and modes to expect at the next station. This information is used thereafter to provide the four beep reminder to press STORE before moving on to the next station. If the operator presses STORE before having taken all the expected readings, MMC will WARN him that some readings may have been inadvertently omitted. The warning signal is three beeps. At the same time, the LCD will list all the readings (by mode and frequency) that seem to be missing. If the operator so chooses, he may override this warning and store the taken readings anyway, by pressing ENter WHILE THE WARNING MESSAGE IS STILL ON THE DISPLAY. The warning message will remain on the display for as long as the operator continues to hold the STORE switch. If the STORE switch has already been released, it may be pressed again to get the computer powered up and the same warning message back.

13. ROUGH TERRAIN OPERATION, for slope chaining menu option:

During the survey, once the MaxMin readings have been stored and the rough-terrain slope method is being used, then MMC will ask the operator to enter the slope (from where he is standing to the next station along the line in the survey direction). When this slope has been completely entered, a message will be displayed showing the next (updated) plotting point, along with the computed Tilt and Distance Correction values for that point. The tilt is the slope, in percent grade, with respect to horizontal at which both the transmit and receive coil turns should be held for correct coplanar coupling when using the MAX1 horizontal-loop mode. The Distance Correction (when positive) is the amount by which the receiver should outdistance himself from the transmitter over and above the nominal cable length or the picket positions in order to have accurate readings that require no additional corrections. In flat terrain (or in cases where the slope is constant between the transmitter and receiver) - the distance correction will be zero. This correction is necessitated by the fact that the cable or the measuring tape, following the terrain, has further to go over undulating terrain, thus shortening the actual straight line distance between transmitter and receiver. The distance correction is always positive on lines chained along the terrain slopes. It can be accounted for by paying out additional cable amounting to the displayed correction value to be that much further along the survey line for the readings. After a few seconds the MMC will power down while the operator walks to the next station. The NextStn/Tilt/Correction message may be reviewed at any time (before starting to take new readings) by simply pressing and holding the STORE key.

NOTE: Should it be decided that the displayed separation correction be ignored during the survey, the resulting inaccuracies in the readings may easily be corrected later on with the supplied MMCFIX1.COM computer data editing program. This program also allows, among other things, correcting for survey data obtained keeping the coils horizontal, with zero tilt, at all times, even in rough terrains.

13.1. INCLINOMETER BROKEN SHOTS

Sometimes it is not possible to see the slope to the next station directly all in one go. For example, there may be a big boulder in the way, blocking the operator's view of the next picket along the line, or the next picket may have fallen down or been covered by new growth. In such cases it is possible to enter a succession of (broken) slopes to intermediate points, and to have the MMC compute the resulting station to station slope. The procedure is as follows:

A) Choose a point you can see along the line (called a Tiepoint). Estimate the distance to the tiepoint.

B) When the MMC asks for the slope, enter it as usual (either of the two methods, KEYIN or AUTO) - but instead of terminating the entry with the ENter key (or the STORE switch, if AUTO method is on) - use the "*" key to complete the entry. This signals the computer that a Broken Shot is in progress. After the MMC accepts the slope, it will immediately ask you to enter the distance to the Tiepoint. As a reminder, it will display the distance still-to-be-covered (which decreases at each successive Tiepoint), and this will be the default value. After distance-to-tiepoint has been entered, and if the station-to-station distance has not yet been covered, the MMC will ask for another slope. Move to the Tiepoint and repeat the above procedure as many times as necessary until you can see the stake at the next measurement station. Enter the last slope (from final Tiepoint to the stake) normally, using the ENter key (or the STORE switch if AUTO is enabled). This completes the procedure. The MMC then computes the true resulting slope from the previous station to the new station as follows:

C) Each slope and (slant) distance is converted to RISE and RUN.

D) The total RISE and total RUN are calculated. True slope is then (Total RISE divided by Total RUN) x 100 %.

N.B. This same algorithm is used to compute the coil TILT and separation CORRection factors as required.

Normally, during the Broken Shot Procedure, the MMC will remain powered up until all Tiepoints have been covered. If it is going to take a long time to move to the next tiepoint, the MMC may be manually powered down (use the "BS" key when slope is requested). If you forget, the MMC will automatically turn off when the watchdog timer expires (60 second default). When powered up (with the STORE switch), the MMC will remember it was in the middle of a Broken Shot Procedure, and carry on to finish it.

13.2 INCLINOMETER BACKSHOTS

The MMC expects you to enter the slope from the current station to the next (subsequent) station along the survey line. In some rare instances, it may be desirable to proceed to the next station and then turn around and look back along the line to the previous station. If the slopes are being KEYED IN manually, then you must enter the complement of the slope, i.e. reverse the sign of the slope measured (back to the previous station) with the hand-held inclinometer. For example, if the BACKslope is 10 percent, you would enter -10 (as it would appear looking in the direction of travel). In cases where the AUTO slope measuring feature is used (MMC's internal tilt sensor used to measure the slope) - this is not possible without the aid of mirrors. To permit backshots using the MMC internal tilt sensor, a special feature has been incorporated: pressing the minus ("-") key WHILE A TILT READING IS ON THE DISPLAY will reverse the polarity of the tilt sensor reading. A positive tilt will be recorded as negative and vice versa. This permits the correct (forward) slope to be entered into the MMC (by pressing the STORE key) even though it is measured as a backshot. The "-" key toggles the polarity of the tilt. It is effective ONLY during the current powerup session. When the MMC powers down and then reactivates at the next station, everything is back to normal.

If a slope method is enabled, and the operator refuses to enter a slope when requested, the MMC will not accept readings at the new station. Instead, it will continue to warn him that a slope is needed. He must either enter the requested slope (probably using the backshot procedure) - or disable the slope method (with the OPTION Menu).

When a new LINE is selected (or at the first measurement point on the first line) - the MMC needs a number of slopes covering the coil separation. For example, if the coil separation is 100 metres, and the station spacing is 25 metres, four slopes will be required to start off the line. The MMC will remind the operator to enter the required number of slopes (if using the KEYIN choice, press the MaxMin receiver STORE switch, then enter the slope via the MMC keyboard and then press the ENter key to store the slope, and so on again).

13.3 ROUGH TERRAIN SECANT METHOD

Although not described here in detail at this time, the MMC operating system now also has a menu selection for stations chained with the so-called SECANT method, using constant horizontal distances between stations. This method is generally the most accurate method in very rough terrain. It also provides for distortion free plane maps, i.e. X-Y projections. It should be noted that with this method the separation corrections are always negative, as the actual straight line distance between the coils is always equal (over flat terrain) or greater than (over sloping terrain) the nominal coil separation. This separation correction may be applied in the field by shortening the distance by the correction amount shown, or the corrections may be made later to the data files with the supplied MMCFIX1.COM or MAXMIN UTILITIES programs, described in paragraph 15, pages 11 and 12. For more information, see the MaxMin I or I+ operations manual Appendix II.

14. DATA DUMP PROGRAM MMC.COM for DOS

This program is run to dump field data stored in the Bulk RAM to another computer, through a serial port (MMC default is COM1). Although any serial communications program may be used to receive the data, the "MMC.COM" data transfer program, supplied with the MMC, is recommended when DOS operating system is used in the PC. XON/XOFF protocol is supported.

The default serial baudrate is 2400. Other higher baudrates up to 19200 are selectable. Higher baudrates reduce the time taken for the dump. The rate of 19200 is suitable for cases where the MMC and the host computer are linked together with only a short cable. Whenever the MMC.COM program is being used to receive the data, the MMC default dump choice of .DAT is used. (The .REF menu choice of the MMC may only be used when other communications programs or custom software is used to dump the data, in an ASCII format, identical to that produced by the MMC.REF formatting program, described later). The MMC prompts the operator to press ENter to begin dumping. The operator should ensure that the connecting cord is in place between the computers. Then ENter starts the data transfer. If need be, the dump can be aborted by pressing the MMC "BS"-key, then a "DUMP ABORTED" message will be shown and the MMC will be powered down.

The .DAT dump format is hexadecimal, with two ASCII-coded hex digits sent for each byte stored in the bulk RAM. At the end of the dump, an asterisk (*) is sent. When the dump is complete, the MMC will issue a Beep and flash the acknowledgement message "DUMP FINISHED", then power itself down.

NOTE: There have been reported cases of problems dumping the data when using the supplied MMC.COM program. The following possible causes should be checked: Broken data transfer cord (rare). Another cord can be tried as two cords have been provided. Host PC configuration problems have also been found: The MMC.COM program requires control of the serial port interrupts and IRQ used. It is not expected to work through the DOS icon or prompt when the PC is operating under a version of the Windows operating system. If problems are encountered under normal DOS operation, please ensure that there are no configuration conflicts for the serial port in use, such as a mouse driver which is loaded (even if the mouse may be disconnected) to use the same serial port or even the same IRQ (COM1 and COM3 usually share the same IRQ, as do COM2 and COM4). Other culprits may include resident TSR or background programs such as a fax receiving program, or PC power saving and power management (sleep) settings. If nothing else seems to solve a dumping problem, then a clean DOS system bootup diskette should be created and the MMC.COM copied to it. Then after booting the PC from this diskette, the MMC.COM should run from it.

Although the MMC.COM default port is COM1, other serial ports may also be used by launching the MMC.COM with a command such as MMC COM2, where COM2 is the serial port to be used, and it is entered with a space separating it from the MMC command.

15. FORMATTING PROGRAMS (DOS versions)

After the data from MMC has been written into a .DAT files with the MMC.COM program, these hex files may be converted to more user-friendly ASCII files with the supplied MMCPRO87.COM program (or with the slower MMCPRO.COM if the PC has no math co-processor) and/or the MMCREF.COM program.

The MMCPRO/MMCPRO87 programs format a file into a XYZ format compatible with the so-called Geosoft XYZ format (of Geosoft Inc. of Toronto), or into an easily readable notebook format. The MMCPRO also computes on demand best fit apparent conductivity values in milliSiemens (millimhos) per metre for each station using the specified multi-frequency data, and the standard deviations or fit errors (in per cent of the primary field).

There is also a MMCREF program on the diskette. This program recovers all of the information stored in the MMC file as entered, and is mostly used for reference or diagnostic purposes. It also contains rough terrain inclinometer broken shots, which are not available with the MMCPRO programs.

There are two other useful editing programs on the diskette, the MMCFIX1 and the MMCFIX2. The MMCFIX1 program allows for correction of systematic reading inaccuracies due to systematic deviations in rough terrain survey routines. This includes routines using horizontal coils at all times, procedures not utilizing the coil separation corrections as displayed by the MMC, and so on. The MMCFIX2 editing program is intended to be used for flat terrain surveys or as a secondary program for rough terrain surveys, and should always be applied after MMCFIX1 (if the rough terrain survey methods are such that MMCFIX1 corrections are needed). The MMCFIX2 program provides for the correction of instrumental amplitude (gain) and phase (mixing) errors when known or checked, for systematic zero level shifting of all in-phase and out-of-phase readings, or a systematic multiplication or scaling of all of the in-phase and out-of-phase values with scaling factors. It also allows separate level shifting of in-phase and/or out-of-phase readings on the individual frequencies. These corrections are useful when needed; for example, if the entire length of a reference cable was stretched out (with the extra length it normally contains) during the survey, producing a constant somewhat negative in-phase zero or background level error due to excessive coil separation (usually most noticeable and correctable based on the lowest frequency in-phase readings), or to correct for other frequency independent zero level or scale errors, which, if present, might significantly distort the apparent conductivity or other results when derived from the original .DAT hex file.

Both the MMCFIX1 and MMCFIX2 programs use the .REF as their source file, produced from the .DAT data file with the MMCREF program. This .REF file may have also been user edited first, with other editing or wordprocessing programs, for any individual readings or otherwise (always save in an unformatted form and be careful to keep column locations and formats unchanged when editing). A revised and renamed .DAT file is then generated from the edited .REF source file. The revised .DAT file is then reformatted as required using the MMCREF, MMCPRO87 or MMCPRO programs. This also allows conductivity values and best-fits to get corrected as they are computed from the .DAT files.

The use of the various programs listed herein is more or less self-explanatory and will not be described here. Inside the back cover of this manual there is a DOS-diskette containing all of the listed programs, together with a couple of sample .DAT survey data files.

It should be noted that with the use of a large number of frequencies, and with the wealth of information available from the MaxMin and MMC combination, the listing of all of the available parameters results in long line lengths, even exceeding 255 characters which is a limit for many subsequent interpretation, plotting or mapping programs. Also, the viewing of the files on the computer screen becomes inconvenient when the line length exceeds the number of characters for which the computer video mode has been set. Therefore, it is left to the user to exercise judgement as to what his data output requirements are. It may be decided, for example, to write one file for the in-phase and out-of-phase data and another file for the conductivity data, to keep the line lengths shorter. The formatted files can be printed after they have been written, by using separate printer commands, with DOS commands, or using wordprocessing or editing programs.
Filename extensions will be issued by these DOS utility programs as follow:

MMC:	.DAT
MMCREF:	.REF
MMCPRO87 -xyz format:	.XYZ;
and MMCPRO:-notebook format:	.PRN,
-condensed format:	.PRC,
MMCFIX1 and MMCFIX2:	.DAT.

The previously decribed data transfer and formatting DOS-program functions are now also provided as a single Windows* based program named MAXMIN UTILITIES, which is supplied on a set-up diskette for installation under Windows 3.xx, Windows 95 /98/ NT/2000. This program also allows viewing of the data profiles on the monitor screen and printing of same under the existing Windows* printer set-ups.

16. ERASE (MMC memory)

This procedure erases all the data stored in the MMC Bulk RAM. It should only be used after a successful dump. It is protected against inadvertent use by requiring a double entry: the operator must confirm that he really intends to erase the Bulk RAM.

17. OTHER NOTES

There have been some reported cases of corruption of the MMC operating system, possibly resulting from the use of depleted 3 Volt lithium memory back-up and/or 9 Volt main batteries, or from moisture condensation inside the MMC. This corruption typically shows as erratic MMC functioning and/or erratic display patterns. If a corrupt operating system is suspected, the operating system should be reinstalled after the dumping of any remaining survey data still in the MMC memory, by first turning the MMC power off, and removing the 9 Volt MMC batteries, then removing the 3 Volt lithium back-up battery from the spring loaded holder inside the MMC after gaining access to it by removing the large MMC side panel with its mounting screws. After removing the batteries one should wait for 10 to 20 seconds to allow all capacitors to discharge before the batteries are reinstalled . Then upon powering the MMC up with the ON key, the MMC reboots and reinstalls a noncorrupt operating system. If moisture condensation or water is observed inside the MMC, then the interior should be dried up with warm circulating air such as produced by a hair-dryer, and this should be done before reinstalling the batteries. Similarly, if worn-out batteries are suspected, they should be checked and new batteries should be installed if in doubt.

18. SAMPLE HEX FILE DUMPED FROM THE MMC WITH MMC.COM PROGRAM.

(Not for programming purposes, please dump a current sample file from MMC)

```
     1250 BYTES IN MEMORY
76886A000003768A2F000003778A3680000178FFF382188A4008EDE3005D001A
0B7A75FFF175FFEC75FFEC75001E75FFDA778A3180000178FFF382188A4004ED
05002400337FFF06ECD2FFEB00312DEA08EE15005D00240B7A75FFC475FFC476
8776000003768A2F00000375FFEC75FFEC75001E75FFDA75FFC9778A31800001
78FFEC82629E4004EB8E004C00317FFF06EBA8002D006B2DEA08EE6D002C0019
0B7A75FFBF778A2C80000178FFE48315B69004EBCD0065002F7FFF06EBD10041
00222DEA08EC790170002A0B7A75FFB5778A2780000178FFDA8331F48004FFFA
FFF70005000106ECD900AD00312DEA08EDFE020D001D0B7A75FFBF778A228000
0178FFC57F690D0004E7DF010200327FFF06E8A301F000282DEA08EB50030400
1D0B7A750055778A1D80000178FFDB8443BB6004EF2600AD002B7FFF06EFA901
91001A2DEA08F23E0386002700167500055778A1880000178FFF6851CC34004F0
91001E002F000306F031000700262DEA08F09A01B800250005750041778A1380
000178001185164658O4EF3FFFAC00357FFF06EE35FE9200227FFF08EC97FFBA
00297FFF75002C778A0E800001780029842F268004ED3FFF2B00277FFF06EBA7
FD11001F52DA08E7D8FD9D00211A0675002D778A0980000178003F8051008004
E77BFEF0001E7FFF06E575FC3F00323F3D08E0C5FD0F001414A0750019778A04
800001780033811BAC8004EA72FEF3002B7FFF06E822FC3C00233EFD08E37CFB
DF00710E2075000F77897F000001780026810E27C004EB44FFC400287FFF06EA
8BFE3C00207FFF08E8D5FC4500430FEA75000F77897500000178001C803D1300
04EB75FFEB002A7FFF06EB9BFEFC00C67FFF08E94CFC890022114D7500197789
6B0000017800197F7FCC0004EBA2002A00227FFF06EBBEFF93001F7FFF08EB96
FF59002576BD75001477896100000178001470 3C1C0004EDA9006200487FFF06
ED6600DA00142DEA08EEEB033F00230B7A75000577895700000178001O7E5574
0004ECA2006900237FFF06ECA700AF00272DEA08EE0E02D700540B7A75000577
894D00000178000E7F1BC90004F4A0003A002E000706EC6F005600232DEA08ED
E6023100470B7A75FFFB77894300000178000A8013BB0004EC92004100227FFF
06EC8C000A00232DEA08EDA900D700AB0B7A75FFFB778939000001780004 7F51
270004ECBF002400227FFF06ED43FFF400C02DEA08ED34001B003E0B7A75FFEC
77892F00000178FFFC7F51260004ECFE001600517FFF06ECE4FFCF00467FFF08
ECE8001700170B7A75FFEF77892500000178FFF87F4CCD0004ECA2002700297F
FF06EC79FFB5001A7FFF08ED52001700330B7A75000077891B00000178FFF77F
134E0004ED00002900267FFF06EDFCFF9D00507FFF08ED17FFD2001B7FFF75FF
F677891100000178FFF67F07750004ECDC002700327FFF06ECBFFFD400327FFF
08ED9C00A300730B7A75FFFB77890700000178FFF67F07730004ED8E006100AA
7FFF06EDE3002B00D22DEA08EE10016B006E0B7A75000077887A00000178FFFA
7E51620004ECE3002A002C7FFF06ED33FFEC00A02DEA08EDDE006D00470B7A75
FFF477886600000178FFFB7D771C0004ECB0001600257FFF06ECD0FFF000AA2D
EA08ECE90045004D0B7A75FFF4768A16000003768A1600000373852O000070B3
7B11120064000174002018AC7187480000738520000O768A16000003768A1600
0003
*
```

19. SAMPLE NOTEBOOK FORMAT FILE 1, PRODUCED WITH MMCPRO, NOTEBOOK OPTION. (Not for programming purposes, please dump a current sample file from MMC)

```
MAXMIN ELECTROMAGNETIC SURVEY
FILENAME:  SAMPLE1.prn
PROJECT NUMBER:       1286
OPERATOR NUMBER:       123
MAXMIN EQUIPMENT: MMI-10 S/N 10354
SLOPE METHOD: NO SLOPES
COIL SEPARATION:      50.0 METRES
STATION SPACING:      12.5 METRES
DATE-TIME-STAMP: 90.06.10  09:43
MODE: MAX1 (Horizontal Coplanar)
FREQUENCIES ON SAMPLE1.dat FILE: 440, 3520, 14080, 56320 Hz
```

LINE NUMBER	STATION NUMBER	440 Hz IP	440 Hz OP	3520 Hz IP	3520 Hz OP	14080 Hz IP	14080 Hz OP	56320 Hz IP	56320 Hz OP
12100.0	10212.5	0.96	-0.04	0.11	0.60	-0.16	1.55	0.59	3.43
12100.0	10200.0	0.91	0.18	0.22	0.77	0.10	2.02	0.83	7.24
12100.0	10187.5	1.50	0.33	0.74	0.82	0.68	2.00	1.02	7.30
12100.0	10175.0	2.02	0.28	1.29	1.00	1.32	2.05	1.58	7.65
12100.0	10162.5	1.33	0.20	1.00	1.12	1.56	2.09	1.34	7.75
12100.0	10150.0	1.61	0.48	1.53	1.54	2.22	2.33	2.56	7.51
12100.0	10137.5	1.67	0.61	1.97	2.07	4.04	2.11	5.59	3.01
12100.0	10125.0	2.30	0.76	3.11	2.76	5.82	3.31	7.55	9.21
12100.0	10112.5	1.65	0.09	0.71	-1.70	-5.42	-3.07	-14.23	2.36
12100.0	10100.0	0.98	-0.44	-0.82	-4.29	-11.55	-6.54	-24.61	-0.21
12100.0	10087.5	1.05	-1.43	-3.84	-6.53	-16.98	-6.18	-29.72	0.69
12100.0	10075.0	-0.12	-4.20	-13.12	-12.48	-33.55	-5.45	-44.72	3.48
12100.0	10062.5	-0.75	-4.57	-13.21	-10.22	-29.60	-4.09	-39.81	4.47
12100.0	10050.0	0.19	-3.49	-9.13	-8.42	-23.78	-5.05	-35.15	1.74
12100.0	10037.5	1.91	0.24	1.87	0.97	1.92	-0.40	0.72	-1.24
12100.0	10025.0	1.44	2.40	6.17	4.85	11.58	1.67	13.46	-1.01
12100.0	10012.5	2.45	1.82	5.35	3.19	8.18	0.99	8.48	2.85
12100.0	10000.0	2.61	0.79	3.90	1.80	4.50	0.77	4.46	4.13
12100.0	9987.5	2.11	0.50	2.35	0.92	2.13	0.17	0.49	2.99
12100.0	9975.0	1.40	0.35	1.10	0.65	0.47	0.60	-2.25	5.55
12100.0	9962.5	1.41	0.18	0.76	0.55	0.28	0.78	-1.07	4.59
12100.0	9950.0	2.13	0.29	1.37	0.71	0.93	1.21	-0.09	6.43
12100.0	9937.5	1.43	0.38	0.89	0.85	0.68	1.66	0.13	7.59
12100.0	9925.0	1.71	0.00	0.97	0.77	0.59	1.96	-0.71	9.51
12100.0	9912.5	1.78	0.05	0.45	0.82	0.28	2.07	-0.12	8.93
12100.0	9900.0	0.81	0.38	0.69	0.67	0.38	2.37	-0.54	11.10
12100.0	9887.5	0.62	0.29	-0.30	0.78	-1.35	2.68	1.01	6.45
12100.0	9875.0	0.68	0.36	0.53	0.28	-0.45	0.60	-2.71	4.15
12100.0	9862.5	0.83	-0.13	-0.02	-0.09	-0.83	-1.72	0.11	-0.18
12100.0	9850.0	0.39	0.16	0.01	-0.26	-1.00	-2.43	-6.43	-2.23
12100.0	9837.5	1.04	0.02	-0.12	0.14	-0.79	-0.54	0.60	1.56
12100.0	9825.0	-0.11	0.16	-0.83	0.35	-1.99	1.57	-2.55	9.24
12100.0	9812.5	0.61	0.04	-0.54	0.43	-1.35	1.59	3.17	2.48
12100.0	9812.0	0.91	0.07	-0.18	0.75	-0.66	2.51	-1.04	10.97
12100.0	9799.5	2.25	0.00	1.14	0.59	0.63	1.78	-0.76	9.22
12100.0	9787.0	1.24	0.14	0.07	0.71	-0.66	2.12	-0.71	9.27
12100.0	9774.5	1.48	-0.01	0.53	0.55	0.05	1.49	-0.43	6.54
12100.0	9762.0	1.00	-0.16	0.11	0.27	-1.09	0.70	-3.06	4.60
12100.0	9750.0	1.67	-0.16	0.44	0.08	-0.64	0.10	-3.94	2.75
12100.0	9737.5	1.26	-0.05	0.17	0.06	-1.36	-0.05	-4.65	2.20
12100.0	9725.0	1.32	-0.28	0.29	0.41	-0.40	0.80	-1.64	5.00
12100.0	9712.5	1.12	-0.01	0.16	0.66	-0.57	1.90	-1.77	8.59
12100.0	9700.0	0.84	0.29	-0.25	0.84	-0.54	2.23	-1.54	9.15
12100.0	9687.5	1.15	0.16	0.20	0.76	-0.28	2.11	-1.09	8.41
12100.0	9675.0	1.14	0.11	0.42	0.79	0.20	1.75	-0.28	8.19
12100.0	9662.5	1.68	0.21	1.07	0.82	0.89	1.56	0.08	7.28
12100.0	9650.0	1.15	0.15	0.07	0.64	-0.19	1.31	-0.86	5.97

```
TOTAL NUMBER OF RECORDS: 47
```

20. SAMPLE NOTEBOOK FORMAT FILE 2 PRINTOUT, PRODUCED WITH MMCPRO FROM .DAT HEX FILE, WITH IP AND OP, CONDUCTIVITY, BEST FIT AND FIT ERROR VALUES.

(Not for programming purposes, please dump a current sample file from MMC)

MAXMIN ELECTROMAGNETIC SURVEY

FILENAME: SAMPLE2.prn

PROJECT NUMBER: 9019

OPERATOR NUMBER: 1

MAXMIN EQUIPMENT: MMI-9 S/N 7339

SLOPE METHOD: KEYIN SLOPE

COIL SEPARATION: 100.0 METRES

STATION SPACING: 25.0 METRES

DATE-TIME-STAMP: 90.06.02 09:06

MODE: MAX1 (Horizontal Coplanar)

FREQUENCIES ON SAMPLE2.dat FILE: 440, 1760, 7040, 14080 Hz

LINE NUMBER	STATION NUMBER	440 Hz IP	440 Hz OP	440 Hz COND	1760 Hz IP	1760 Hz OP	1760 Hz COND	7040 Hz IP	7040 Hz OP	7040 Hz COND	14080 Hz IP	14080 Hz OP	14080 Hz COND	BEST FIT	FIT ERR
-1100.0	-1425.0	0.39	0.42	0.5	-0.27	1.16	0.4	0.40	2.58	0.3	0.67	4.42	0.3	0.3	0.2
-1100.0	-1400.0	0.58	0.54	0.7	0.17	0.93	0.3	0.83	2.42	0.2	0.74	4.58	0.3	0.3	0.2
-1100.0	-1375.0	0.65	0.35	0.4	0.87	0.80	0.3	1.31	2.96	0.3	2.54	5.14	0.3	0.3	0.1
-1100.0	-1350.0	0.92	0.51	0.7	0.77	1.31	0.5	1.38	3.13	0.3	3.17	5.43	0.4	0.4	0.2
-1100.0	-1325.0	0.57	0.28	0.4	0.52	1.20	0.4	1.26	3.01	0.3	2.22	5.34	0.3	0.3	0.1
-1100.0	-1300.0	0.41	0.24	0.3	0.26	0.98	0.3	0.87	2.51	0.2	1.82	4.40	0.3	0.3	0.1
-1100.0	-1275.0	0.36	0.36	0.5	0.00	0.76	0.3	0.47	2.53	0.3	0.45	4.55	0.3	0.3	0.1
-1100.0	-1250.0	0.85	0.36	0.5	0.60	1.00	0.3	1.33	2.20	0.2	2.24	3.93	0.2	0.2	0.2
-1100.0	-1225.0	0.23	0.18	0.2	0.52	0.53	0.2	1.50	1.75	0.2	3.28	2.64	0.1	0.1	0.2
-1100.0	-1200.0	0.54	0.26	0.3	0.37	0.77	0.3	0.64	2.77	0.3	-0.38	4.96	0.3	0.3	0.1
-1100.0	-1175.0	0.99	0.56	0.7	0.89	1.13	0.4	1.27	2.73	0.3	0.45	4.92	0.3	0.3	0.2
-1100.0	-1150.0	0.38	0.28	0.4	0.28	0.82	0.3	0.44	2.41	0.2	0.27	4.32	0.3	0.2	0.1
-1100.0	-1125.0	0.45	0.66	0.9	0.39	0.99	0.3	0.83	3.62	0.4	1.73	6.52	0.5	0.4	0.3
-1100.0	-1100.0	0.92	0.65	0.9	0.93	0.66	0.2	1.11	2.52	0.3	1.41	4.49	0.3	0.3	0.2
-1100.0	-1075.0	0.70	0.60	0.8	0.64	0.78	0.3	1.29	2.78	0.3	2.00	5.20	0.3	0.3	0.2
-1100.0	-1050.0	0.12	0.48	0.6	0.17	0.96	0.3	0.68	3.37	0.4	1.42	6.04	0.4	0.4	0.2
-1100.0	-1025.0	0.35	0.42	0.5	0.20	1.24	0.4	0.23	3.57	0.4	0.06	6.47	0.5	0.4	0.2
-1100.0	-1000.0	0.60	0.20	0.2	0.14	1.26	0.4	0.88	3.72	0.4	1.92	6.90	0.5	0.5	0.3
-1100.0	-975.0	0.46	0.42	0.5	0.12	1.41	0.5	1.35	3.52	0.4	1.48	6.97	0.6	0.5	0.4
-1100.0	-950.0	0.55	0.56	0.7	0.47	1.28	0.5	1.18	4.25	0.5	1.04	8.50	1.1	0.6	0.7
-1100.0	-925.0	1.26	0.61	0.8	1.46	1.55	0.6	1.59	4.10	0.5	1.74	7.77	0.7	0.6	0.5
-1100.0	-900.0	1.24	0.46	0.6	1.30	1.21	0.4	2.44	3.37	0.4	3.87	6.52	0.5	0.4	0.3
-1100.0	-875.0	1.36	0.48	0.6	0.91	0.83	0.3	2.41	2.42	0.2	4.76	4.19	0.2	0.2	0.2
-1100.0	-850.0	0.36	0.35	0.4	0.85	0.81	0.3	1.04	2.96	0.3	0.76	5.38	0.3	0.3	0.2
-1100.0	-825.0	0.36	0.49	0.6	-0.10	1.43	0.5	0.51	4.51	0.5	0.10	8.15	0.9	0.6	0.5
-1100.0	-800.0	0.39	0.41	0.5	0.36	1.52	0.6	2.32	4.31	0.5	4.92	8.57	1.1	0.6	0.7
-1200.0	-750.0	0.17	0.57	0.7	0.08	0.70	0.2	0.82	2.48	0.2	1.33	4.46	0.3	0.3	0.2
-1200.0	-775.0	1.03	0.39	0.5	0.84	0.80	0.3	1.33	3.24	0.3	2.99	5.57	0.4	0.4	0.1
-1200.0	-800.0	0.68	0.10	0.0	0.42	0.70	0.2	1.68	2.66	0.3	3.40	4.29	0.3	0.3	0.1
-1200.0	-825.0	0.32	0.31	0.4	0.57	0.98	0.3	1.25	2.41	0.2	2.43	4.01	0.2	0.2	0.2
-1200.0	-850.0	0.48	0.16	0.2	0.72	1.05	0.4	1.28	2.77	0.3	2.47	5.10	0.3	0.3	0.2
-1200.0	-875.0	-0.14	0.82	1.1	0.17	0.91	0.3	1.04	3.65	0.4	2.38	6.72	0.5	0.5	0.4
-1200.0	-900.0	0.66	0.43	0.6	0.73	1.19	0.4	1.03	4.57	0.5	2.08	8.71	1.1	0.7	0.7
-1200.0	-925.0	0.56	0.16	0.2	0.88	1.03	0.4	1.58	4.02	0.5	2.88	7.18	0.6	0.5	0.4
-1200.0	-950.0	1.22	0.40	0.5	0.87	1.06	0.4	1.86	2.80	0.3	3.03	4.33	0.3	0.3	0.2
-1200.0	-975.0	1.22	0.26	0.3	1.32	1.02	0.4	2.32	1.38	0.1	4.41	1.58	0.1	0.1	0.5
-1200.0	-1000.0	0.83	-0.02	0.0	0.58	0.53	0.2	1.65	0.64	0.1	5.53	0.47	0.0	0.1	0.6

TOTAL NUMBER OF RECORDS: 37

BEST FIT CONDUCTIVITY IS USING FREQUENCIES ON THIS FILE

21. SAMPLE XYZ FORMAT FILE PRODUCED WITH MMCPRO USING .XYZ OPTION.

(Not for programming purposes, please dump a current sample file from MMC)

```
/ MAXMIN ELECTROMAGNETIC SURVEY
/ FILENAME: SAMPLE1.xyz
/ PROJECT NUMBER:      1286
/ OPERATOR NUMBER:      123
/ MAXMIN EQUIPMENT: MMI-10 S/N 10354
/ SLOPE METHOD: NO SLOPES
/ COIL SEPARATION:     50.0 METRES
/ STATION SPACING:     12.5 METRES
/ DATE-TIME-STAMP: 90.06.10  09:43
/ MODE: MAX1 (Horizontal Coplanar)
/ FREQUENCIES ON SAMPLE1.dat FILE: 440, 3520, 14080, 56320 Hz
```

LINE 12100.0			ELEV	440		3520		14080		56320	
12100.0	10212.5	10212.5	0.0	0.96	-0.04	0.11	0.60	-0.16	1.55	0.59	3.43
12100.0	10200.0	10200.0	0.0	0.91	0.18	0.22	0.77	0.10	2.02	0.83	7.24
12100.0	10187.5	10187.5	0.0	1.50	0.33	0.74	0.82	0.68	2.00	1.02	7.30
12100.0	10175.0	10175.0	0.0	2.02	0.28	1.29	1.00	1.32	2.05	1.58	7.65
12100.0	10162.5	10162.5	0.0	1.33	0.20	1.00	1.12	1.56	2.09	1.34	7.75
12100.0	10150.0	10150.0	0.0	1.61	0.48	1.53	1.54	2.22	2.33	2.56	7.51
12100.0	10137.5	10137.5	0.0	1.67	0.61	1.97	2.07	4.04	2.11	5.59	3.01
12100.0	10125.0	10125.0	0.0	2.30	0.76	3.11	2.76	5.82	3.31	7.55	9.21
12100.0	10112.5	10112.5	0.0	1.65	0.09	0.71	-1.70	-5.42	-3.07	-14.23	2.36
12100.0	10100.0	10100.0	0.0	0.98	-0.44	-0.82	-4.29	-11.55	-6.54	-24.61	-0.21
12100.0	10087.5	10087.5	0.0	1.05	-1.43	-3.84	-6.53	-16.98	-6.18	-29.72	0.69
12100.0	10075.0	10075.0	0.0	-0.12	-4.20	-13.12	-12.48	-33.55	-5.45	-44.72	3.48
12100.0	10062.5	10062.5	0.0	-0.75	-4.57	-13.21	-10.22	-29.60	-4.09	-39.81	4.47
12100.0	10050.0	10050.0	0.0	0.19	-3.49	-9.13	-8.42	-23.78	-5.05	-35.15	1.74
12100.0	10037.5	10037.5	0.0	1.91	0.24	1.87	0.97	1.92	-0.40	0.72	-1.24
12100.0	10025.0	10025.0	0.0	1.44	2.40	6.17	4.85	11.58	1.67	13.46	-1.01
12100.0	10012.5	10012.5	0.0	2.45	1.82	5.35	3.19	8.18	0.99	8.48	2.85
12100.0	10000.0	10000.0	0.0	2.61	0.79	3.90	1.80	4.50	0.77	4.46	4.13
12100.0	9987.5	9987.5	0.0	2.11	0.50	2.35	0.92	2.13	0.17	0.49	2.99
12100.0	9975.0	9975.0	0.0	1.40	0.35	1.10	0.65	0.47	0.60	-2.25	5.55
12100.0	9962.5	9962.5	0.0	1.41	0.18	0.76	0.55	0.28	0.78	-1.07	4.59
12100.0	9950.0	9950.0	0.0	2.13	0.29	1.37	0.71	0.93	1.21	-0.09	6.43
12100.0	9937.5	9937.5	0.0	1.43	0.38	0.89	0.85	0.68	1.66	0.13	7.59
12100.0	9925.0	9925.0	0.0	1.71	0.00	0.97	0.77	0.59	1.96	-0.71	9.51
12100.0	9912.5	9912.5	0.0	1.78	0.05	0.45	0.82	0.28	2.07	-0.12	8.93
12100.0	9900.0	9900.0	0.0	0.81	0.38	0.69	0.67	0.38	2.37	-0.54	11.10
12100.0	9887.5	9887.5	0.0	0.62	0.29	-0.30	0.78	-1.35	2.68	1.01	6.45
12100.0	9875.0	9875.0	0.0	0.68	0.36	0.53	0.28	-0.45	0.60	-2.71	4.15
12100.0	9862.5	9862.5	0.0	0.83	-0.13	-0.02	-0.09	-0.83	-1.72	0.11	-0.18
12100.0	9850.0	9850.0	0.0	0.39	0.16	0.01	-0.26	-1.00	-2.43	-6.43	-2.23
12100.0	9837.5	9837.5	0.0	1.04	0.02	-0.12	0.14	-0.79	-0.54	0.60	1.56
12100.0	9825.0	9825.0	0.0	-0.11	0.16	-0.83	0.35	-1.99	1.57	-2.55	9.24
12100.0	9812.5	9812.5	0.0	0.61	0.04	-0.54	0.43	-1.35	1.59	3.17	2.48
12100.0	9812.0	9812.0	0.0	0.91	0.07	-0.18	0.75	-0.66	2.51	-1.04	10.97
12100.0	9799.5	9799.5	0.0	2.25	0.00	1.14	0.59	0.63	1.78	-0.76	9.22
12100.0	9787.0	9787.0	0.0	1.24	0.14	0.07	0.71	-0.66	2.12	-0.71	9.27
12100.0	9774.5	9774.5	0.0	1.48	-0.01	0.53	0.55	0.05	1.49	-0.43	6.54
12100.0	9762.0	9762.0	0.0	1.00	-0.16	0.11	0.27	-1.09	0.70	-3.06	4.60
12100.0	9750.0	9750.0	0.0	1.67	-0.16	0.44	0.08	-0.64	0.10	-3.94	2.75
12100.0	9737.5	9737.5	0.0	1.26	-0.05	0.17	0.06	-1.36	-0.05	-4.65	2.20
12100.0	9725.0	9725.0	0.0	1.32	-0.28	0.29	0.41	-0.40	0.80	-1.64	5.00
12100.0	9712.5	9712.5	0.0	1.12	-0.01	0.16	0.66	-0.57	1.90	-1.77	8.59
12100.0	9700.0	9700.0	0.0	0.84	0.29	-0.25	0.84	-0.54	2.23	-1.54	9.15
12100.0	9687.5	9687.5	0.0	1.15	0.16	0.20	0.76	-0.28	2.11	-1.09	8.41
12100.0	9675.0	9675.0	0.0	1.14	0.11	0.42	0.79	0.20	1.75	-0.28	8.19
12100.0	9662.5	9662.5	0.0	1.68	0.21	1.07	0.82	0.89	1.56	0.08	7.28
12100.0	9650.0	9650.0	0.0	1.15	0.15	0.07	0.64	-0.19	1.31	-0.86	5.97
12100.0	9637.5	9637.5	0.0	1.43	-0.04	0.03	0.25	-0.99	0.58	-2.72	4.21

```
/ TOTAL NUMBER OF RECORDS: 48
```

22. SAMPLE .REF FILE PRINTOUT PRODUCED WITH MMCREF PROGRAM, LISTING ALL DATA CONTAINED IN THE MMC, INCLUDING THE ROUGH TERRAIN SLOPES.

(Note: RE = Real = In-Phase; IM = Imaginary =Quadrature=Out-of-Phase).

```
Date-Time: 90.06.02  09:06
Project Number:     9019   Operator Number:       1
FLAGS:   16  METRES KEYIN SLOPE, COORD SYSTEM: NSEW MM Model: I-9
MAXMIN SERIAL NUMBER:    7339
Coil Separation:     100.00
Station Spacing:        25.00
Slope:   -15 percent.
Slope:   -10 percent.
Slope:     5 percent.
Slope:    34 percent.
Slope:    55 percent.
Line:    1000.00 W,  Stn:     800.00  S
Tilt:    20 %,   CORR:        2.73
  MAX1   440  RE:    0.54 IM:    0.39 NOISE:    0.14 CONDUCT:     0.5
  MAX1  1760  RE:   -0.02 IM:    1.23 NOISE:    0.11 CONDUCT:     0.4
  MAX1  7040  RE:   -0.47 IM:    3.69 NOISE:    0.28 CONDUCT:     0.4
  MAX1 14080  RE:   -2.82 IM:    7.64 NOISE:    0.23 CONDUCT:     0.7
Broken Shot...
   48 % for     20.00 M
   -7 % for      5.00 M
Slope:    36 percent.
Line:    1000.00 W,  Stn:     825.00  S
Tilt:    32 %,   CORR:        1.32
  MAX1   440  RE:    0.15 IM:    0.45 NOISE:    0.08 CONDUCT:     0.6
  MAX1  1760  RE:   -0.12 IM:    1.55 NOISE:    0.03 CONDUCT:     0.6
  MAX1  7040  RE:    0.25 IM:    4.26 NOISE:    0.06 CONDUCT:     0.5
  MAX1 14080  RE:    0.22 IM:    7.38 NOISE:    0.15 CONDUCT:     0.6
Slope:    25 percent.
Line:    1000.00 W,  Stn:     850.00  S
Tilt:    37 %,   CORR:        0.43
  MAX1   440  RE:    0.48 IM:    0.31 NOISE:    0.10 CONDUCT:     0.4
  MAX1  1760  RE:    0.62 IM:    1.39 NOISE:    0.09 CONDUCT:     0.5
  MAX1  7040  RE:    0.70 IM:    3.91 NOISE:    0.21 CONDUCT:     0.4
  MAX1 14080  RE:    1.21 IM:    7.34 NOISE:    0.07 CONDUCT:     0.6
Slope:    17 percent.
Line:    1000.00 W,  Stn:     875.00  S
Tilt:    33 %,   CORR:        0.78
  MAX1   440  RE:    0.53 IM:    0.42 NOISE:    0.05 CONDUCT:     0.5
  MAX1  1760  RE:    0.29 IM:    1.10 NOISE:    0.06 CONDUCT:     0.4
  MAX1  7040  RE:    1.47 IM:    2.48 NOISE:    0.17 CONDUCT:     0.2
  MAX1 14080  RE:    4.79 IM:    4.06 NOISE:    0.08 CONDUCT:     0.2
Slope:    12 percent.
Line:    1000.00 W,  Stn:     900.00  S
Tilt:    22 %,   CORR:        0.36
  MAX1   440  RE:    0.77 IM:    0.18 NOISE:    0.03 CONDUCT:     0.2
  MAX1  1760  RE:    0.53 IM:    0.93 NOISE:    0.05 CONDUCT:     0.3
  MAX1  7040  RE:    1.11 IM:    2.51 NOISE:    0.22 CONDUCT:     0.2
  MAX1 14080  RE:    1.36 IM:    4.30 NOISE:    0.13 CONDUCT:     0.3
Slope:    20 percent.
Line:    1000.00 W,  Stn:     925.00  S
Tilt:    18 %,   CORR:        0.10
  MAX1   440  RE:    0.46 IM:    0.32 NOISE:    0.04 CONDUCT:     0.4
  MAX1  1760  RE:    0.20 IM:    0.92 NOISE:    0.02 CONDUCT:     0.3
  MAX1  7040  RE:    0.11 IM:    2.43 NOISE:    0.10 CONDUCT:     0.2
  MAX1 14080  RE:    0.66 IM:    3.97 NOISE:    0.13 CONDUCT:     0.2
```