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Instruction Manual

Model GK-603

Inclinometer Readout

Version 3.1

Including MEMS type probes

(Doc. Rev. N 12/09)

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1. THEORY OF OPERATION

1.1. Inclinometer Theory

In the geotechnical field inclinometers are used primarily to measure ground movements such as might occur in unstable slopes (landslides) or in the lateral movement of ground around on-going excavations. They are also used to monitor the stability of embankments, slurry walls, the disposition and deviation of driven piles or drilled boreholes and the settlement of ground in fills, embankments, and beneath storage tanks.

In all these situations it is normal to either install a casing in a borehole drilled in the ground, to cast it inside a concrete structure, to bury it beneath an embankment, or the like. The inclinometer casing has four orthogonal grooves (Figure 1.1-1) designed to fit the wheels of a portable inclinometer probe (Figure 1.1-2). This probe, suspended on the end of a cable connected to a readout device, is used to survey the inclination of the casing with respect to vertical (or horizontal) and in this way to detect any changes in inclination caused by ground movements.

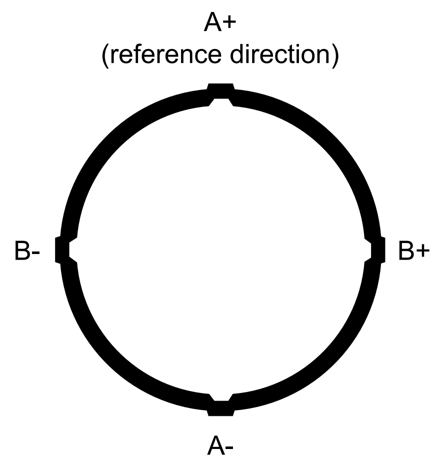


Figure 1.1-1 Inclinometer Casing

The probe itself contains a pendulous mass which is acted on by the force of gravity. Most inclinometers use a force balance accelerometer in which a position sensor detects the position of the mass and provides a restoring force sufficient to return the mass to its vertical null position. The greater the inclination from the vertical null, the greater the restoring force so that, in effect, the mass is prevented from moving. The magnitude of the restoring force, transduced into an electrical output and displayed on the readout, becomes a measure of inclination. Since the restoring force is proportional to the sine of the angle of inclination the output is also proportional in the same respect.

In order to obtain a complete survey of the ground around the installed inclinometer casing it is necessary to take a series of tilt measurements along the casing. Typically an inclinometer probe has 2 sets of wheels separated by a distance of 2 feet (English system) or .5 meter (Metric system). A casing survey would begin by lowering the probe to the bottom of the casing and taking a reading. The probe would then be raised at 2 foot (English system) or .5 meter (Metric system) intervals and a reading taken at each interval until the top of the casing is reached. The set of readings thus generated is called the A+ readings. Marks on the cable at 2 foot (English) or .5 meter (Metric) spacing facilitate the process. The probe is then removed from the casing, rotated through 180°, replaced in the casing, lowered to the bottom of the borehole and a second set of readings (the A– set) obtained as the probe is raised at the reading interval.

Inclinometer probes usually contain two accelerometers with their axes oriented at 90° to each other. The A axis is in line with the wheels (Figure 1.1-2 illustrates) with the B axis orthogonal to it. Thus, during the survey, as the A+, A− readings are obtained, the B+, B − readings are also recorded.

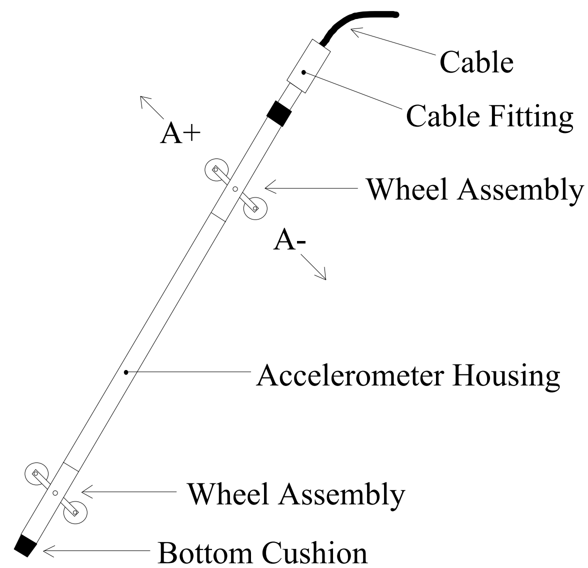


Figure 1.1-2 Inclinometer Probe

During the data reduction these two sets or readings (A+, A− and B+, B−) are combined (by subtracting one set of readings from the other) in such a way that the effect of any zero offset of the force balance accelerometer is eliminated. [This zero offset is the reading obtained from the inclinometer probe when it hangs vertical. Ideally the offset (or bias) would be zero, but usually there is a zero offset which can change during the life of the probe due to drift of the transducer, wear and damage of the wheels or most likely due to a sudden shock to the transducer caused by dropping or allowing it to hit too hard against the bottom of an installed inclinometer casing.]

Subsequent surveys of the inclinometer casing, when compared with the original survey, will reveal any changes of inclination of the casing and locations at which these changes are taking place. Analysis of the change of inclination is best performed by computing the horizontal offset of the upper wheels relative to the lower wheels which has produced the tilting (θ) over the reading interval (L) of the survey (usually the wheel base of the probe, 2 feet for English systems, .5 meter for Metric). At each position of the inclinometer the two readings taken on each axis (A+, A− and B+, B −) are subtracted from each other leaving a measure of sineθ. This value is then multiplied by the reading interval (L) and the appropriate factor to output horizontal deflection in engineering units (inches for English, centimeters or millimeters for Metric). Appendix E lists the data reduction formulas. Figure 1.1-3 illustrates.

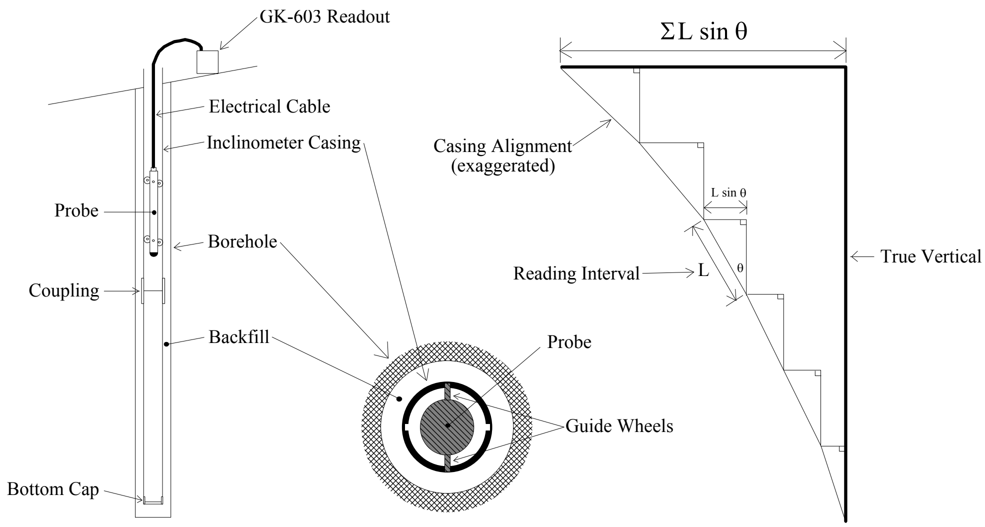


Figure 1.1-3 Inclinometer Survey Description

When all these incremental horizontal deflections are accumulated and plotted beginning at the bottom of the borehole the net result is to produce a plot of the change in horizontal deflection between the time of the initial survey and the time of any subsequent survey. See Figure 1.1-4. From such a deflection plot it is easy to see at which depth the movement is occurring and its magnitude.

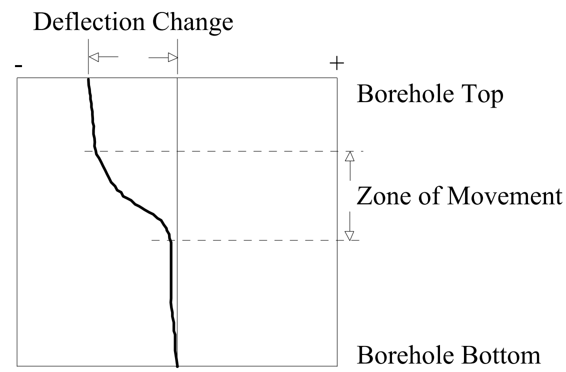


Figure 1.1-4 Plot of Borehole Deflection

Other methods of analysis can be used but generally add little to the overall understanding of the situation. For example, using a single set of data, a profile of the borehole can be created. Also, a plot can be made of the actual change in reading (inclination) at each measurement depth increment. A plot of this nature reveals the depths at which movement is occurring. But this information can be obtained from the change in deflection curve with little difficulty.

One other analysis is the Check Sum (or Instrument Check) which can be used to measure the quality of the survey data. The quality of the data can be impaired by any or all of the following;

- Skipping over or duplicating a reading.
- Not allowing the inclinometer sufficient time to come to rest before taking a reading.
- Not allowing sufficient time to allow the probe to reach temperature equilibrium before commencing the survey.
- Malfunction of the probe, cable or readout device. This may be the result of shock, moisture, low battery conditions, opens or shorts in the cable or probe, etc.
- Carelessness in positioning the wheels so that the probe wheels do not rest on the same part of the casing from one survey to the next.
- Positioning the wheels so that they fall right on top of a casing joint so that the reading is unstable or simply erroneous.

The Check Sum analysis is performed by adding the A+, A- readings and the B+, B- readings. When this is done the part of the reading due to the tilt is eliminated leaving only a value which is equivalent to twice the zero offset of the inclinometer transducer. See sections 3.2.2.1. and 3.2.2.2. for more information on the Check Sum analysis.

1.2. GK-603 Inclinometer Readout

The GK-603 Inclinometer Readout has been designed to facilitate the reading of inclinometer probes, (both force-balance and MEMS sensor types), and reduction of the data in field environments. Housed in a hardened aluminum case with sealed front panel and water resistant controls it is designed to withstand the rigors of operating in the out-of-doors. The internal rechargeable battery can operate the readout continuously for approximately 12 hours. An internal lithium battery retains configuration and measurement data while turned off, or if the rechargeable battery should go dead. See Appendix B for complete specifications.

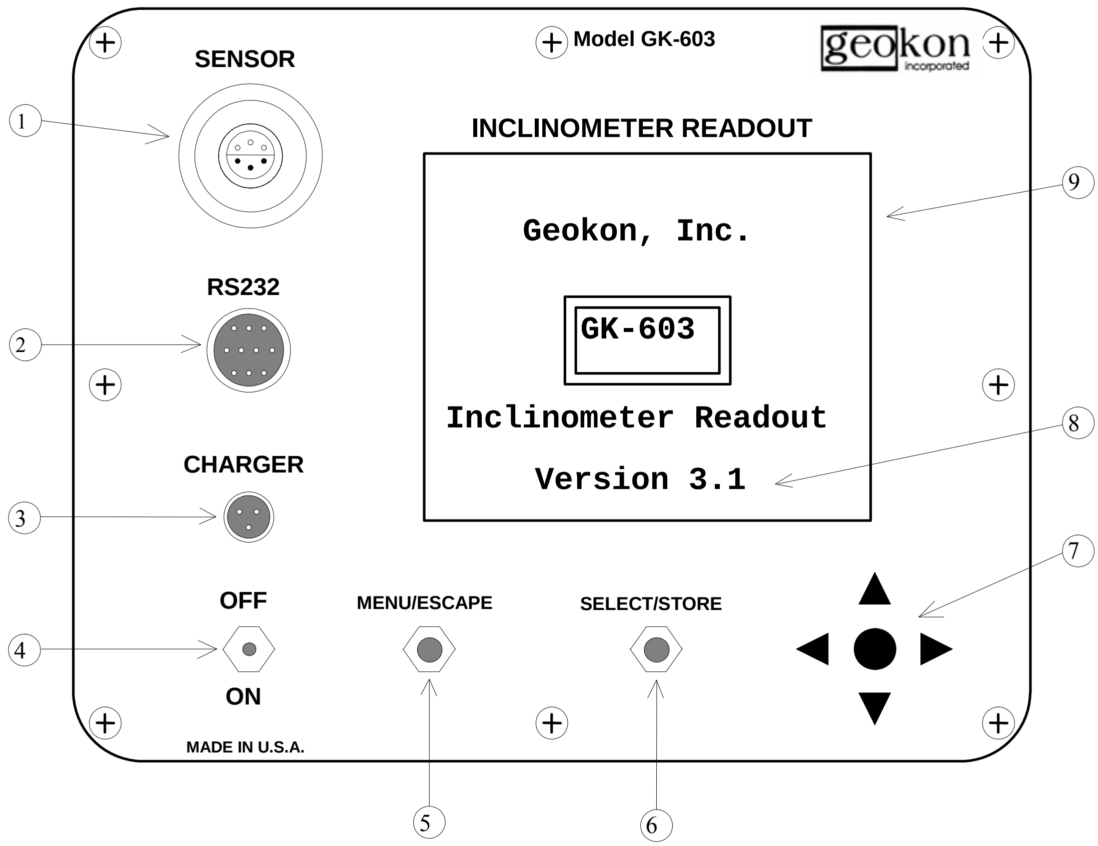


Figure 1.2-1 GK-603 Front Panel

<u>Note the following key for Figure 1.2-1;</u>
① 6 Pin Lemo connector for connecting the inclinometer probe.
② 10 pin Bendix connector for connecting computer, remote switch or digital probe.
③ 120/220 VAC charger or external battery connection.
④ Power On/Off switch. Unit automatically powers off after 5 minutes (user-configurable).
⑤ Pushbutton for returning to the previous menu or escaping from the current screen.
⑥ Pushbutton for selecting an option or advancing to the next screen.
⑦ Four way joystick for entering information or selecting options.
⑧ Software version of readout (displayed at power on).(Latest version, which accommodates MEMS type probes, is 3.1)
⑨ 15 × 20 character LCD viewing area.

1.2.1. GK-603 Software Features

The GK-603 has an extensive repertoire of software features that aid in storing data obtained during surveys and analyzing the resultant data.

Conducting Surveys
- Storage of survey information such as the Project Name, Hole Number, File Name, Date and Time, and Probe Number aid in identifying data sets.
- Large, easy to read display of readings while in the Readings Screen.
- Display of current readings and Check Sums while taking readings.
- Support for either fixed or variable reading intervals.
- Ability to position to any level or data set.
- Ability to load configuration or data information from previous surveys.
- Ability to be used with force balance or MEMS type accelerometers..
- Up to 255 levels can be stored in each configuration or data file.
- Reading intervals can be configured between 0 and ±9999.9 feet or meters.
- Dynamic memory allocation allows up to 16 configuration and 96 data files of varying sizes to be stored.

Data Reduction
- Easily compare two data files for deflection analysis.
- Easily generate hole profile from a single set of data.
- Directly prints to a compatible printer a variety of reports and plots.
- With an optional battery powered printer, reports and plots can be generated in the field.
- Report types include instrument check, change in digits, deflection and profile.
- Plot types include change in digits, deflection and profile.
- All plots can be viewed on screen before printing.
- Plot scales are automatically set with an auto-scaling feature but are user configurable.
- While viewing on plots on the display, plot scales can be adjusted to suit.
- Elevation can be entered as a reference for the survey casing.
- Calculations can be made from the bottom up or the top down of a borehole.
- Deflection or profile calculations can be made using fixed or variable intervals.
- Plot scales, elevation and corrective angles can be saved with data files.
- Deflection or profile calculations can be corrected for casing misalignment.
- Metric calculation units can be configured as centimeters or millimeters.

File Transfer
- Configuration and data files are easily transferred to/from a host computer for archival or data reduction.
- Files are easily transferred via modem to remote computers.
- Serial communication rate is user configurable at 1200 or 9600 baud.
- File format directly compatible with the analysis software, GTILT.

File Management
- Configuration and data files are easily deleted, copied or renamed.
- A full complement of file management commands are available via RS-232.

System Utilities
- The system voltages and memory usage are easily checked.
- The units of the readout are user configurable as either English or Metric.
- The display and storage units are configurable as either 2.0 or 2.5sinθ.
- Zero shifts for the A and B axis of the inclinometer probe can be entered.
- Gage factors for the A and B axis of the inclinometer probe can be entered.
- The date and time are easily changed.
- The contrast setting of the LCD is user configurable for difficult lighting conditions.
- The power off time is user configurable.
- The system continuously monitors its battery voltage and warns the user when it gets low.
- The memory system can be tested and is automatically repaired if problems are found.

2. GETTING STARTED

This section is designed for the user who would like basic instructions to obtain a complete survey of an inclinometer casing. These instructions also appear in briefer form on the inside of the GK-603 lid. The following table refers to manual sections containing additional information on each of these steps.

Step	Manual Section	Page	Title
1	3.	10	Readout Options
2	3.1.	11	Take Readings
3	3.1.1.	11	Readings Screen
4	3.1.1.1.	11	Project Name
5	3.1.1.2.	12	Hole Number
6	3.1.1.3.	12	Probe Number
7	3.1.1.4.	12	Starting Level
8	3.1.1.5.	13	Interval Type
9	3.1.1.6.	13	Reading Interval
10	3.1.1.7. 3.1.2.	13	Save Config Load Config
11	3.1.1.8.	14	Readings Screen
12	3.1.5.	17	Save Data File
13	3.1.5.	17	Save Data File
14	3.1.5.	17	Save Data File
15	3.2.	17	Data Reduction

Table 2-1 Getting Started Manual References

1. Turn the readout on. Initial screen will display followed by the GK-603 MAIN MENU.

2. Press <SELECT> with option 1 selected (Take Readings).

3. The Take Readings menu will appear. Press <SELECT> with option 1 selected (Readings Screen). Various questions regarding the survey about to be conducted will be asked.

4. First, the Project Name entry screen will display. Select characters with ▲ ▼. Move the cursor with ◄ ►. Press <STORE> when finished.

5. The Hole Number screen will display. Using ▲ ▼ and ◄ ►, enter the appropriate hole number. Press <STORE> when finished.

6. The Probe Number screen will display. Using ▲ ▼ and ◄ ►, enter the probe serial number. Press <STORE> when finished.

7. The Starting Level screen will display. Enter the hole depth. This is the starting level for the survey to be conducted. Select numeric values with ▲ ▼. Move the cursor with ◄ ►. Press <STORE> when finished.

8. The Interval Type? screen will display. Select "`Fixed`" using ▲ ▼. Press <STORE> when finished.

9. The Reading Interval screen will display. Select the default interval. If the readout is configured for metric units use –0.5 meter as the interval. If the readout is configured for English units use –2.0 feet. Use ▲ ▼ to change. Press <STORE> when finished.

10. User has the option of saving the configuration information just entered (in a config file) for use with later surveys of the same hole. Use ▲ ▼ to toggle between "`Yes`" and "`No`". Press <SELECT> with the appropriate option to continue. If "`No`" was selected user is advanced directly to the Readings Screen (step 11). If "`Yes`", user will be displayed the current config files stored in memory (total of 16). Use the joystick to move the file selection box. If this is a new file choose <new> and press <SELECT>. The filename entry screen will display. Using ▲ ▼ and ◄ ►, enter the file name. Press <STORE> when finished. To overwrite an existing config file (from the file list screen) select it then press <SELECT>.

11. The Readings Screen will display. Position the probe at the bottom of the borehole. When the readings have stabilized (±2 digits) press <STORE> (or depress the remote switch) to record them. Level indicator will advance to the next position. Audible will indicate when the readout is ready for the next reading. Pull the probe up (.5 meter or 2 feet), wait for readings to stabilize, then press <STORE>. Continue until the top of the hole is reached. The level indicator should display 0 at the top of the hole. Remove the probe from the borehole, rotate it 180° and lower back down to the bottom. Push ► to advance to data set 2. The level indicator should update to display the starting level. Repeat intervals for data set 2. When the second survey is complete remove the probe from the hole and press <ESCAPE>.

12. The Take Readings menu will re-display. Press <SELECT> to Save Data.

13. The data files list will display. Press <SELECT> to select <new>.

14. The File Name entry screen will display. Data are stored in the readout under this name. Select characters with ▲ ▼. Move the cursor with ◄ ►. Press <STORE> when finished.

15. Reading procedure is complete. Turn the readout off or continue on to the data reduction portion of the readout to analyze the recorded values.

3. READOUT OPTIONS

This section provides detailed information on all menus and options of the GK-603 Inclinometer Readout. The organization of this information is based on the MAIN MENU of the GK-603 as shown in Figure 3-1.

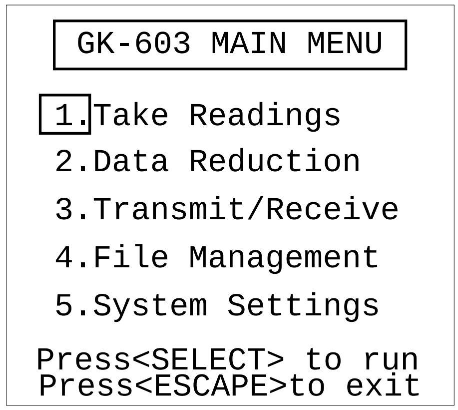


Figure 3-1 GK-603 MAIN MENU

Figure 3-2 illustrates the menu structure of the GK-603.

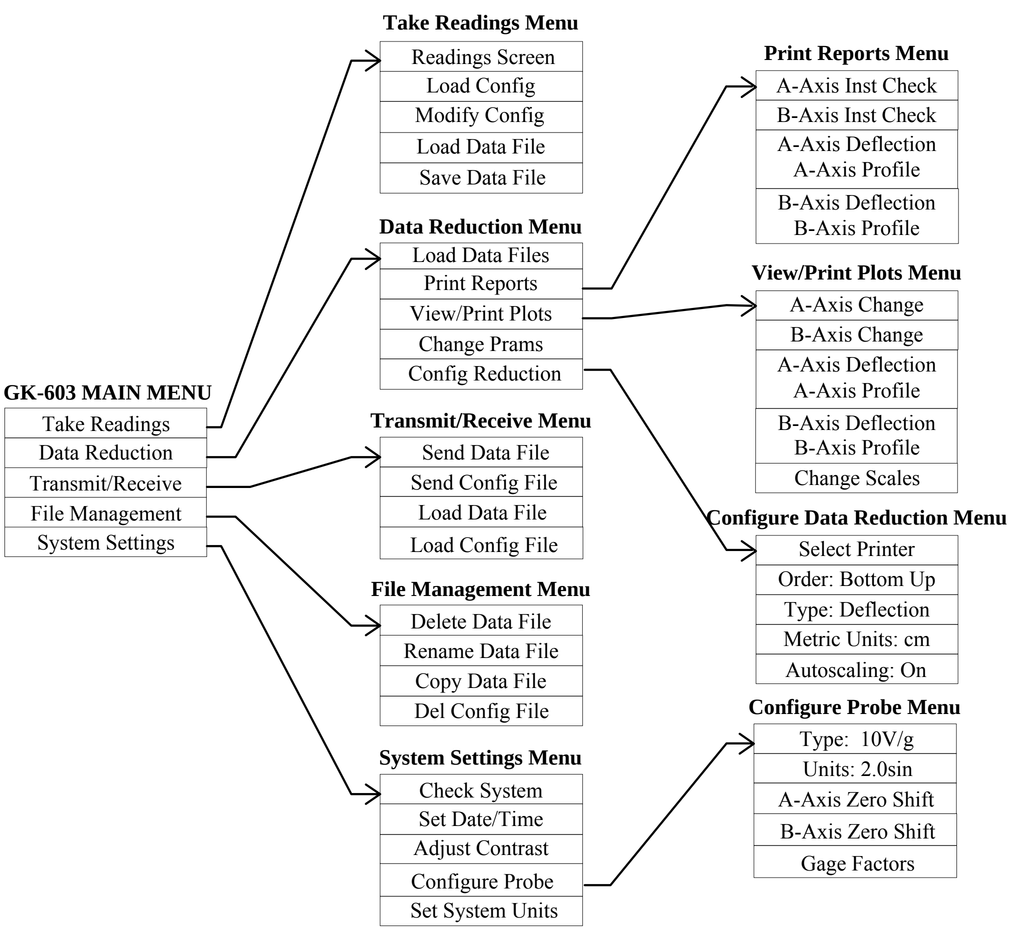


Figure 3-2 GK-603 Menu Structure

3.1. Take Readings

Selecting this option displays the Take Readings menu as shown in Figure 3.1-1. All the options displayed relate to functions carried out in the course of conducting inclinometer or tiltmeter surveys.

```
   Take Readings

1.Readings Screen
2.Load Config
3.Modify Config
4.Load Data File
5.Save Data File

Press<SELECT> to run
Press<ESCAPE>to exit
```

Figure 3.1-1 Take Readings Menu

3.1.1. Readings Screen

Select this option to advance directly to the Readings Screen of the GK-603 Readout. The Readings Screen displays current probe readings and other information related to the survey being conducted. See Figure 3.1-11 for an explanation of the various features of the Readings Screen.

Before advancing to the Readings Screen however, a series of questions related to the survey about to be conducted will be asked. These questions are explained in the following sections in the order they appear. *Note: These questions can be bypassed by the using the Load Config (section 3.1.2.) or the Load Data File (section 3.1.4.) options.*

3.1.1.1. Project Name

Enter up to 40 characters to be stored as part of the data file header which will help identify the project. This entry can be bypassed by pressing <STORE>. User will be advanced to the next question, entry of the Hole Number. Use ▲ ▼ to select characters. Permissible characters are 0-9, A-Z, and space. Use ◀ ▶ to move the cursor. Current position is indicated by the blinking underline. Press <ESCAPE> to return to the Take Readings menu. The cursor will wrap to the left of the screen (and down 1 line) when the cursor is moved past the right side of the screen (20 characters). Figure 3.1-2 illustrates the Project Name entry screen.

```
   Project Name

 Max 40 characters!

_

<LEFT/RIGHT> to move
Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.1-2 Project Name Entry Screen

3.1.1.2. Hole Number

Enter up to 10 characters to be stored as part of the data file header which will help identify the hole being surveyed. This entry can be bypassed by pressing <STORE>. User will be advanced to the next question, entry of the Probe Number. Use ▲ ▼ to select characters. Permissible characters are 0-9, A-Z, and space. Use ◀ ▶ to move the cursor. Current position is indicated by the blinking underline. Press <ESCAPE> to return to the Take Readings menu. Figure 3.1-3 illustrates the Hole Number entry screen.

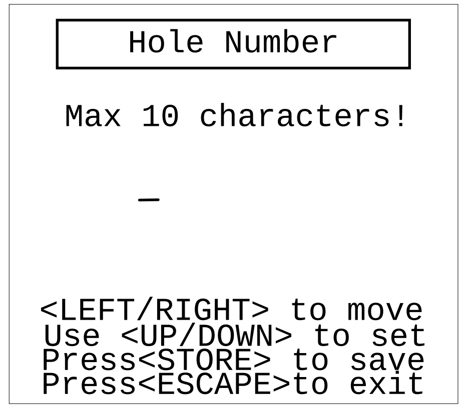


Figure 3.1-3 Hole Number Entry Screen

3.1.1.3. Probe Number

Enter up to 10 characters to be stored as part of the data file header to identify the probe used for this survey. This entry should be completed where a project uses more than 1 probe for the surveys. This entry can be bypassed by pressing <STORE>. User will be advanced to the next question, entry of the Starting Depth. Use ▲ ▼ to select characters. Permissible characters are 0-9, A-Z, and space. Use ◀ ▶ to move the cursor. Current position is indicated by the blinking underline. Press <ESCAPE> to return to the Take Readings menu. Figure 3.1-4 illustrates the Probe Number entry screen.

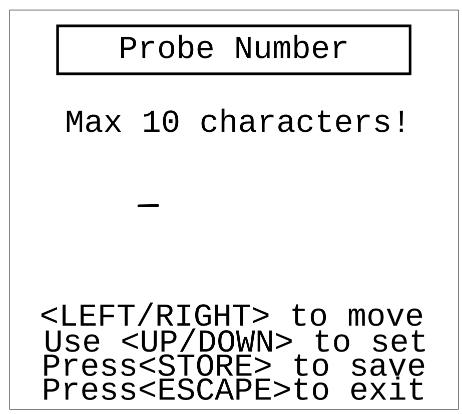


Figure 3.1-4 Probe Number Entry Screen

3.1.1.4. Starting Level

Enter the depth of the hole or starting point of the survey. In the case of borehole surveys, if this value has been entered correctly, the Readings Screen will display a value of 0 at the top of the hole. Use ▲ ▼ to increment/decrement the number at the cursor position. Use ◀ ▶ to move the cursor. Press <STORE> when finished to advance to the Interval Type selection screen. Press <ESCAPE> to return to the Take Readings menu. Figure 3.1-5 shows the Starting Level screen.

Numerical range for the entered value is -9999.9 to +9999.9, feet if English units, meters for Metric.

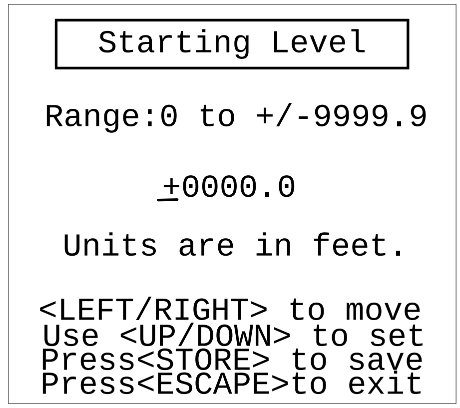


Figure 3.1-5 Starting Level Entry Screen

3.1.1.5. Interval Type

Next, the user has the option of selecting fixed or variable reading intervals. For a standard inclinometer borehole survey generally the fixed intervals are used. The variable intervals are typically used for horizontal deflection and profiling using a portable tiltmeter. Use ▲ ▼ to select either `Fixed` or `Variable`. Press <STORE> when finished to advance to the Reading Interval screen or press <ESCAPE> to return to the Take Readings menu. Figure 3.1-6 illustrates the Reading Interval entry screen.

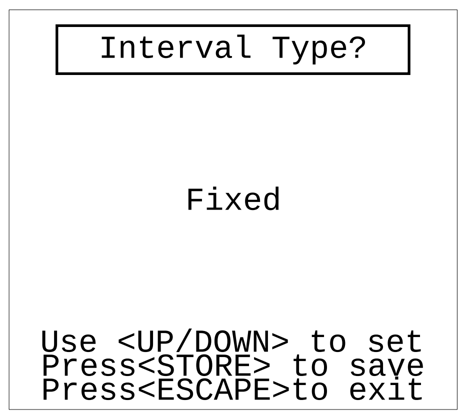


Figure 3.1-6 Interval Type Selection Screen

3.1.1.6. Reading Interval

Select the interval by which the Level indicator decrements (or increments) during the survey. Press <STORE> to accept the fixed interval defaults of -2.0 feet for English units and -0.5 meter for Metric. If variable intervals were selected, the default is -0.1 for English and Metric units. Use ▲ ▼ to increment/decrement the number at the cursor position. Use ◄ ► to move the cursor. After selecting user has the option of saving the configuration just entered for use at a later date. Press <ESCAPE> to return to the Take Readings menu. Figure 3.1-7 illustrates the Reading Interval entry screen.

```
Reading Interval

Range:0 to +/-9999.9

-0002.0

Units are in feet.

Use <UP> to increase
Use <DN> to decrease
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.1-7 Reading Interval Entry Screen

3.1.1.7. Save Config

The configuration information just entered may be saved for later recall. This is recommended where many surveys of the same borehole will be conducted. Use ▲ ▼ to select either `Yes` or `No` at the Save Config? prompt. See Figure 3.1-8. If `No` is selected (default) the user will be advanced to the Readings Screen (section 3.1.1.8.). If `Yes` is selected a list of configuration files will display. See Figure 3.1-9.

```
Save Config?

Save Config? No

Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.1-8 Save Config? Screen

The box indicates the current selection. Use the joystick to move. Press <SELECT> with the appropriate selection. Select <new> if a new file is be created. User will be asked for an 8 character file name to save the configuration under. File locations that are <empty> are saved to by using <new>. To overwrite configuration in an existing file (its name should appear in the list) select that file and press <SELECT>.

Use ▲ ▼ to select characters for the Filename. Valid characters are 0-9, A-Z, and space. Move the cursor with ◄ ►. Press <STORE> when the Filename entry is complete. User will be advanced to the Readings Screen (finally!).

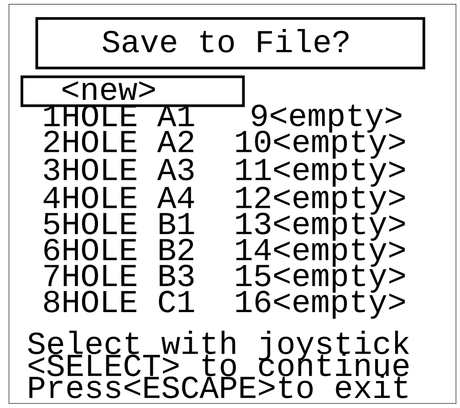


Figure 3.1-9 Save Configuration File Screen

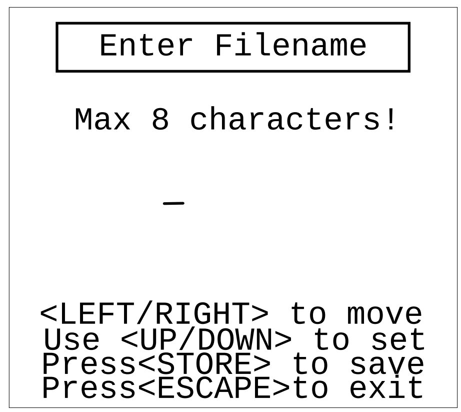


Figure 3.1-10 File Name Entry Screen

3.1.1.8. Readings Screen

Figure 3.1-11 depicts a typical Readings Screen with accompanying explanations.

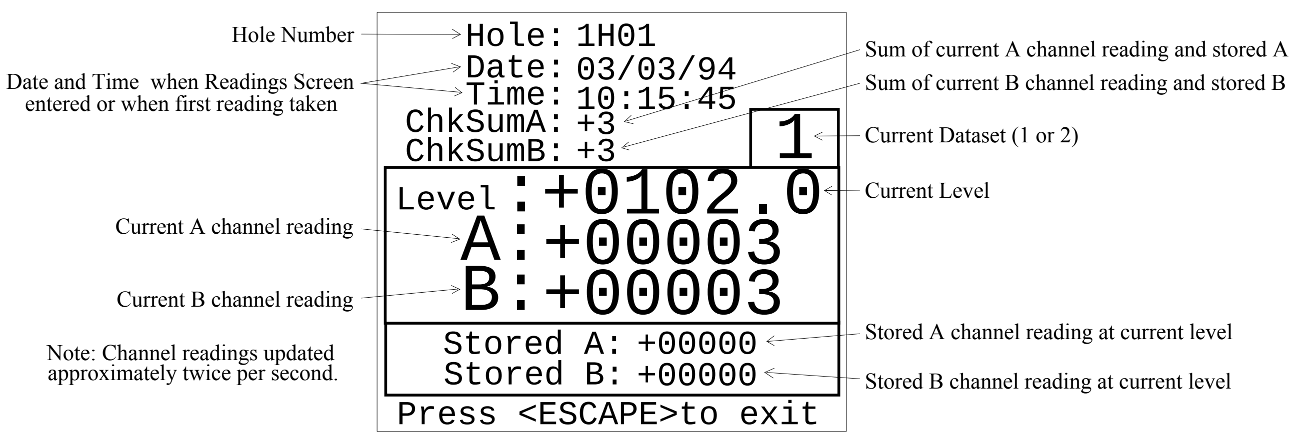


Figure 3.1-11 Readings Screen

To store the current readings (A and B in Figure 3.1-11) press <STORE>. Audible will sound to indicate completion of the reading sequence. Then the Level indicator advances (based on the reading interval, section 3.1.1.6.) to the next position. User can switch data sets at any time with ◄ ►. When switching data sets Level indicator will default to the Starting Level value (usually the bottom of the hole). To position to another level use ▲ ▼ to move up or down the hole respectively.

Press <ESCAPE> to return to the Take Readings menu. The Save Data option will be automatically selected when <ESCAPE> is pressed.

Visible in the Readings Screen are ChkSumA and ChkSumB. These values are derived from the addition of the current A–, B– readings to previous A+, B+ taken at the same depth. During the first part of the survey when the A+, B+ readings are being taken and stored the ChkSum readings will have no meaning, but during the second part of the survey when A–, B– readings are being taken and stored, the ChkSum values are a useful measure of data quality.

The effect of adding the A+, B+ readings to the A–, B– readings is to cancel out the part of the reading caused by inclination of the sensor, leaving only a residual which is a measure of the zero offset (or zero bias) of the inclinometer probe, i.e. the reading of the probe when it hangs perfectly vertical. This reading is a constant and should be the same at every level. Therefore it is good practice to always look at the ChkSum values during the A–, B– part of the survey to confirm the data quality before storing the A–, B– readings in memory.

Under normal circumstances the checksum values will vary during the course of the survey by about ± 20 digits around the average value. If, for some reason, the checksum is seen to fall outside these limits by a large margin then it is evidence of a bad reading at that level. If the discrepancy is observed during the survey it may be possible to repeat the reading at that level. Set the level indication using ▲ ▼, position the probe at the correct level, then press <STORE>. If the discrepancy is caught only after the survey has concluded, i.e. when the checksum report is printed, it can be corrected for artificially by editing the data. Usually it is possible to see which reading is incorrect and to estimate fairly accurately what the correct reading should be. This is done by examining previous checksum reports. Once the faulty reading has been corrected, the rest of the data is then usable.

In this regard it is possible to see the stored A+, B+ readings at any level by using ◀ ▶ to switch the data set and ▲ ▼ to find the correct level.

Note that there is a delay built into the reading process to allow the inclinometer probe to come to rest before a reading is taken. If reading proceeds at the correct pace there will always be an audible beep when <STORE> is pressed. If the button is pressed prematurely then there will be no sound and the button must be depressed again.

The correct sequence is to press <STORE>, hear the beep, pull the probe up to the next level, wait 2 seconds, press <STORE>, hear the beep, etc. (An incorrect sequence would be to press <STORE>, hear the beep, wait 2 seconds, pull the probe up, press <STORE>, hear the beep, etc. This would lead to the probe being read before it has settled down and false readings could be stored.) Any reading instability will be revealed by fluctuations of the current A and B values displayed. After a little practice the correct rhythm and sequence of actions will become second nature.

The main problem will be to remember whether a reading has been taken or not. This can happen due to many distractions during the survey. A good technique is to note that at each 10 foot marker on the cable (which is usually a different color) or at each 10 meter mark, the last digit of the level reading on the display is always the same, before pressing <STORE>.

For instance, suppose at the 10 foot markers on the cable the level reading always ends in 4 (54, 44, 34, 24, etc.) before <STORE> is pressed. Now suppose it is noticed that at one particular marker the reading ends in 6, then presumably a reading has been omitted. Instead of going back to the bottom of the hole to repeat the entire survey lower the probe to the last 10 foot cable marker, reset the depth indicator to the correct value (using ▲ ▼ , and then proceed with the survey. The new readings will overwrite any false readings that have been stored.

<u>Special notes regarding the Level indicator when using the variable reading intervals!</u>

When the Interval Type has been set to Variable the Level indicator operates differently from the typical configuration. When using the Fixed intervals increasing or decreasing the Level indicator using the joystick increases or decreases the reading number or position in the borehole. However, when using the Variable intervals, increasing or decreasing the Level indicator adjusts what levels will be stored (i.e. the number of levels and value of each) in the configuration or data file.

3.1.2. Load Config

Configuration files that were previously saved (or downloaded via RS-232) may be loaded with this option. This greatly facilitates the reading procedure as the configuration information for a particular hole need only be entered once, then simply loaded each time a survey is to be conducted. Use the joystick to select the file, then press <SELECT>. File locations that are <empty> cannot be loaded. See Figure 3.1-9 for a typical configuration file list screen. Selecting <new> from the list will restore default settings to the various configuration items. After loading configuration the Readings Screen will display (section 3.1.1.8.).

3.1.3. Modify Config

This option permits modification of the header configuration. Header configuration consists of the Project Name (3.1.1.1.), Hole Number (3.1.1.2.), Probe Number (3.1.1.3.), Starting Level (3.1.1.4.), Interval Type (3.1.1.5.) and Reading Interval (3.1.1.6.). See the respective manual sections for each item. User will have the option of saving the configuration modified (section 3.1.1.7). *Note: If readings have been recorded in the Readings Screen the user will not be allowed to modify the Starting Level, Interval Type or Reading Interval!*

3.1.4. Load Data File

To correct an erroneous reading (by taking another at the appropriate depth) or load the configuration from a previously saved data file. A list of saved data files will display. Selected file will be enclosed by a box. To select another file use the joystick. Press <ESCAPE> to return to the Take Readings menu or press <SELECT> to continue with the selected file. It is not possible to load a file from the <empty> locations!

The initial screen displays the first 16 data files stored in memory. To view the next series of files (17-32) select <more>. There are six screens of files to select from, for a total of 95 data files. Selecting <more> at the last list (files 81-96) will cycle the display back to files 1-16.

```
      File to Load?

                 <more>
 1<empty>      9<empty>
 2<empty>     10<empty>
 3<empty>     11<empty>
 4<empty>     12<empty>
 5<empty>     13<empty>
 6<empty>     14<empty>
 7<empty>     15<empty>
 8<empty>     16<empty>

Select with joystick
<SELECT> to continue
Press<ESCAPE>to exit
```

Figure 3.1-12 Load Data File Screen

3.1.5. Save Data File

This option is automatically selected when exiting the Readings Screen. The numbers to the left of <empty> refer to file locations. The text to right of the numbers indicates the status of the location. If the location is used the file name will display. See Figure 3.1-13.

Similar to the Load Data file list the next list of data file locations can be accessed by selecting <more>. It is not possible to save data directly to locations labeled <empty>. First, <new> must be selected and the appropriate file name entered to save the data under. See Figure 3.1-10 (and accompanying text) for a view of the file name entry screen. To over-write a file already stored select the location (as indicated by the name displayed) and press <STORE>. The file name displayed will be used for storing the new data.

```
      Save to File?

  <new>          <more>
 1INITA1       9<empty>
 2INITA2      10<empty>
 3INITA3      11<empty>
 4INITA4      12<empty>
 5<empty>     13<empty>
 6<empty>     14<empty>
 7<empty>     15<empty>
 8<empty>     16<empty>

Select with joystick
<SELECT> to continue
Press<ESCAPE>to exit
```

Figure 3.1-13 Save Data File Screen

3.2. Data Reduction

The GK-603 can generate a borehole profile from a single data file or make comparative analysis between two data surveys . Figure 3.2-1 depicts the Data Reduction menu. *Note: If readings have been taken in Take Readings and have not been saved a Warning! screen will display*. In this event press <SELECT> to ignore the error and continue (and lose the readings in memory) or <ESCAPE> to exit. After escaping, use the Save Data (section 3.1.5.) option in the Take Readings menu to save the current data set.

Initially, the only options that will execute from this menu are 1, Load Data Files, and 5, Config Reduction. The Data Reduction menu will re-display if an option other these is selected.

```
    Data Reduction

 1.Load Data Files
 2.Print Reports
 3.View/Print Plots
 4.Change Prams
 5.Config Reduction

Press<SELECT> to run
Press<ESCAPE>to exit
```

Figure 3.2-1 Data Reduction Menu

3.2.1. Load Data Files

This option prompts for the data file that will be used for profile calculations (Section 3.2.5.3) or for the Initial Data and then the Present Data if making deflection calculations (Section 3.2.5.3). The Initial Data is typically the file generated during the first survey of any particular borehole. The first series of data files (1-16) will display (Figure 3.2-2). Select <more> to advance to the next series of data files. Selection is similar to description found in section 3.1.4.

```
    Initial Data?

              <more>
 1<empty>   9<empty>
 2<empty>  10<empty>
 3<empty>  11<empty>
 4<empty>  12<empty>
 5<empty>  13<empty>
 6<empty>  14<empty>
 7<empty>  15<empty>
 8<empty>  16<empty>

Select with joystick
<SELECT> to continue
Press<ESCAPE>to exit
```

Figure 3.2-2 Load Initial Data Screen

In the case of the calculating deflection, after loading the files various checks are conducted between the files to ensure the validity of the subsequent data reduction. If there is a problem an Error! screen will display and the loading process will need to be repeated. See Table 3-1 for a list of error codes (with descriptions and examples) that could be displayed if discrepancies exist.

If the Error! screen displays note the error code, then press <ESCAPE> to return to the Data Reduction menu. Make corrections as needed to the data files or select new ones.

If the files (or file) were loaded successfully a "`Please Wait!`" and "`Calculating...`" message will display on the screen. Depending on the number of data points in the files calculation may take anywhere from 1 second to 15 seconds to complete. When finished, the Data Reduction menu will display. Options 2 through 4 can now be run.

Code	Description	Applicable To	Example
1	Different number of readings between files.	Data Reduction Deflection	50 in Initial, 51 in Present.
2	Different reading interval between files.	Data Reduction Deflection	2' in Initial, 4' in Present.
3	Different probe types between files.	Data Reduction Deflection	10 volt/g in Initial, 14 volt/g in Present.
4	Different units between files.	Data Reduction Deflection	English in Initial, Metric in Present. 2.0sin in Initial, 2.5sin in Present.
5	Incorrect file format.	RS-232 File Load	See Table 3-3
6	Timeout while loading the file.	RS-232 File Load	More than 10 seconds elapses between lines of data.
7	Not enough memory to save the current file.	File Saving	File requires 12 sectors, only 10 available.
8	Different interval types between files.	Data Reduction Deflection	Variable in Initial, Fixed in Present.

Table 3-1 Load Files Error Codes

3.2.2. Print Reports

Three types of reports may be printed using the GK-603; instrument check, deflection and profile. See Figures 3.2-3&4.

Figure 3.2-3 illustrates the menu that displays if `Deflction` is selected as the analysis type (section 3.2.5.3). Figure 3.2-4 illustrates the `Profile` menu (section 3.2.5.3).

```
   Print Reports

1.A-Axis Inst Chk
2.B-Axis Inst Chk
3.A-Axis Deflction
4.B-Axis Deflction


Select with joystick
Press<SELECT> to run
```

Figure 3.2-3 Print Reports Menu (Deflection)

```
   Print Reports

1.A-Axis Inst Chk
2.B-Axis Inst Chk
3.A-Axis Profile
4.B-Axis Profile


Select with joystick
Press<SELECT> to run
```

Figure 3.2-4 Print Reports Menu (Profile)

The printer should be connected, powered, and on-line before attempting to generate any reports. After selecting a report to print the screen will display "`Printing...`" while the report is sent to the printer. When the report is complete the Print Reports menu will re-display.

3.2.2.1. A-Axis Instrument Check

This report checks the integrity of the data by adding the A+ set of readings to the A– set of readings. The check- sum thus obtained is (theoretically) twice the zero offset of the inclinometer probe. **This check-sum may be anywhere between ±1000 digits**. Whatever the number, **it should be constant (+/- 25 digits), for each measurement at each level for a given survey** and over the life of the probe. (See Appendix I, page 62, for an explanation of why check-sums of less than 2000 are tolerable).

Inspection of the "`Sum`" column in the report (see examples, Appendices C.2.1. & C.3.1.) will reveal any discrepancies. These discrepancies (**from the typical or average check-sum**), if large (>±25 digits), might suggest that the data need to be either discarded or improved by adjusting any false reading. Alternately the survey may need to be repeated.

In order to correct and improve the data by adjustment of either the A+ or A– readings it will be necessary to transfer the data files to a computer (see section 3.3.) and edit them there. It is not possible to edit the data using only the GK-603. When editing the files either the A+ or A– reading will usually be found to be wrong. Just which one can be determined by inspection of reports of prior surveys.

When deflection is selected, the A-Axis Instrument Check Report also compares the inclinometer probe zero offset at different times (Initial and Present). The comparison is shown in the "`Shift`" column (see example, Appendix C.2.1.). The offset should remain the same. If it changes gradually with time then perhaps there is zero drift of the transducer or mechanical wear of the wheels. If the change is abrupt then this might be evidence of a sudden shock to the instrument, perhaps it was dropped, in which case the calibration may also have suffered, calling for the inclinometer probe to be re-calibrated.

As far as the computational process is concerned, zero shifts of the probe are not important so long as they do not occur during any particular survey. The effect of subtracting the A+ readings from the A– is to eliminate the zero offset whatever it may be. This is precisely why a survey involves the measurement of both the A+, B+ set of readings and the A–, B– set of readings.

The following examples show typical good data and bad data.

Elev.	----Initial Data----			----Present Data----				Corr.	Depth
Ft.	A+	A-	Sum	A+	A-	Sum	Shift	Shift	Ft.
+582.0	+142	-171	-29	+142	**-432**	-290	-261	-261	+2.0

Figure 3.2-5 Erroneous Data Resulting From Reading Error

Elev.	----Initial Data----			----Present Data----				Corr.	Depth
Ft.	A+	A-	Sum	A+	A-	Sum	Shift	Shift	Ft.
+582.0	+142	-171	-29	+235	-254	-19	+10	+10	+2.0

Figure 3.2-6 Acceptable Data Illustrating Large Shift in Inclination

These explanations and examples are by no means comprehensive in discussing problem areas inherent to inclinometer instrumentation and survey techniques. Additional information can be found in section 12.8. of the book *Geotechnical Instrumentation For Monitoring Field Performance* by John Dunnicliff (published by Wiley-Interscience, ISBN 0-471-09614-8).

3.2.2.2. B-Axis Instrument Check

Same type of report as the A-Axis Instrument Check (section 3.2.2.1.) except for the B-Axis!

3.2.2.3. A-Axis Deflection or Profile

When deflection is selected (section 3.2.5.3.), this report lists the calculated deflection change accumulated from the bottom of the casing upward or the top down (section 3.2.5.2.). This report is only of use if the user can be sure the bottom (or the top when calculating from the top down) of the casing has not moved, as the accumulation assumes this to be a fixed position. See Appendix C.2.2. for an example A-Axis Deflection report. See Appendix E.1. for an explanation of the deflection calculation. If the readout is configured for English units deflection will be in inches, Metric will calculate and output centimeters or millimeters (section 3.2.5.4.).

When profile is selected (section 3.2.5.3.), this report lists the profile of the casing as calculated from the bottom of the casing upward or the top down (section 3.2.5.2.). See Appendix C.3.2. for an example A-Axis Profile report. See Appendix E.2. for an explanation of the profile calculation. If the readout is configured for English units profile will be in inches, Metric will calculate and output centimeters or millimeters (section 3.2.5.4.).

> Note: When Variable is selected as the Interval Type the deflection or profile is calculated by subtracting the reading intervals. The first calculation, whether at the bottom (if bottom up is selected as the calculation order) or the top (if top down is selected), is always zero since there is no reference for the reading interval.

3.2.2.4. B-Axis Deflection or Profile

Same type of report as the A-Axis Deflection or Profile (section 3.2.2.3.) except for B-Axis!

3.2.3. View/Print Plots (Note the print option is no longer available)

Three types of plots may be viewed using the GK-603; change in digits, deflection and profile. See Figures 3.2-7&8.

```
 View/Print Plots

1.A-Axis Change
2.B-Axis Change
3.A-Axis Deflection
4.B-Axis Deflection
5.Set Plot Scales

Select with joystick
Press<SELECT> to run
```

Figure 3.2-7 View/Print Plots Menu (Deflection)

```
 View/Print Plots

1.A-Axis Change
2.B-Axis Change
3.A-Axis Profile
4.B-Axis Profile
5.Set Plot Scales

Select with joystick
Press<SELECT> to run
```

Figure 3.2-8 View/Print Plots Menu (Profile)

Figure 3.2-7 illustrates the menu that displays if `Deflction` is selected as the analysis type (Section 3.2.5.3). Figure 3.2-8 illustrates the `Profile` menu (Section 3.2.5.3).

3.2.3.1. A-Axis Change

When calculating deflection this plot depicts the Change in Digits between the two loaded data files. It is useful in determining at what depth movement (if any) is occurring in the borehole. When calculating profile it depicts the profile (in digits) of the borehole.

The plot may be viewed on the display. Use ▲ ▼ to toggle between `View` and `Print`. Press <SELECT> to accept the selection or <ESCAPE> to return to the View/Print Plots menu. Viewing the plot is recommended as the scales may need to be adjusted. This can be done while in the plot view screen. See Figure 3.2-9 below for an example and explanation of the Change in Digits plot.

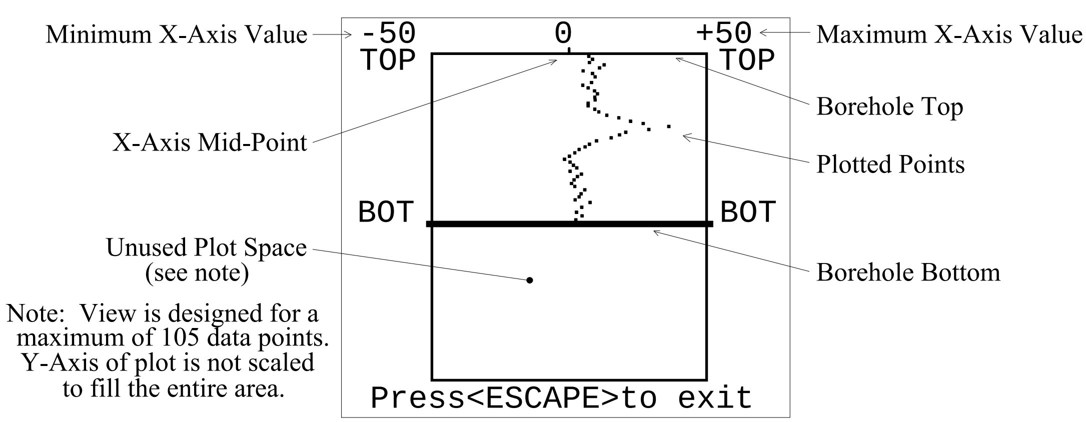


Figure 3.2-9 View Change in Digits Plot

Initially, the scales are calculated automatically, however, while in the Plot View screen use ◄ ► to decrease or increase the x-axis scale, respectively. The scale increment changes are scaled according to the present magnitude. For example, if the scale value is between 1 and 10 digits then the scale increment will be 1 digit. If the scale is between 10 and 100 the increment will be 10 digits. If between 100 and 1000 the increment is 100 digits.

Each time the scale is changed the plot is redraw. Each screen in the plot view mode displays up to 105 levels. If the survey consists of more than 105 points then the plot is viewed in sections with each section containing up to 105 levels. The maximum number of levels allowed per data file is 255 so there may be up to 3 plot sections. To select plot sections use ▲ ▼ Press <SELECT> to direct the plot to the printer or <ESCAPE> to return to the View/Print Plots menu.

Note: The x-axis scale can be manually set with the Set Plot Scales option in the View/Print Plots menu! See section 3.2.3.5. for more information.

Appendix C.2.3. illustrates a A-Axis Change in Digits plot output using the deflection analysis. Appendix C.3.3. illustrates the plot using the profile analysis.

3.2.3.2. B-Axis Change

Same plot as A-Axis Change in Digits (section 3.2.3.1.) except for the B-Axis!

3.2.3.3. A-Axis Deflection or Profile

When deflection is selected, this plot depicts the accumulated change in deflection between the two loaded data files. It is useful in determining the magnitude and direction of movement (if any) of the borehole.

When profile is selected, this plot depicts the profile of the casing as calculated from the magnitude of the readings at each level. It is useful in visualizing the actual installed characteristics (inclination, couplings, anomalies, etc.) of the casing.

The plot may be viewed on the display before printing or sent directly to the printer. Use ▲ ▼ to toggle between `View` and `Print`. Press <SELECT> to accept the selection or <ESCAPE> to return to the View/Print Plots menu. Viewing the plot before printing is recommended as the scales may need to be adjusted. This can be done while in the plot view screen. See Figure 3.2-10 for an example and explanation of the Deflection plot.

Initially, the scales are calculated automatically, however, while in the Plot View screen use ◄ ► to decrease or increase the x-axis scale, respectively. The scale increment changes are scaled according to the present magnitude. For example if the scale value is between 1 and 10 inches (or cm, mm) then the scale increment will be 1 inch. If the scale is between 10 and 100 the increment will be 10 inches. If between 100 and 1000 the increment is 100 inches.

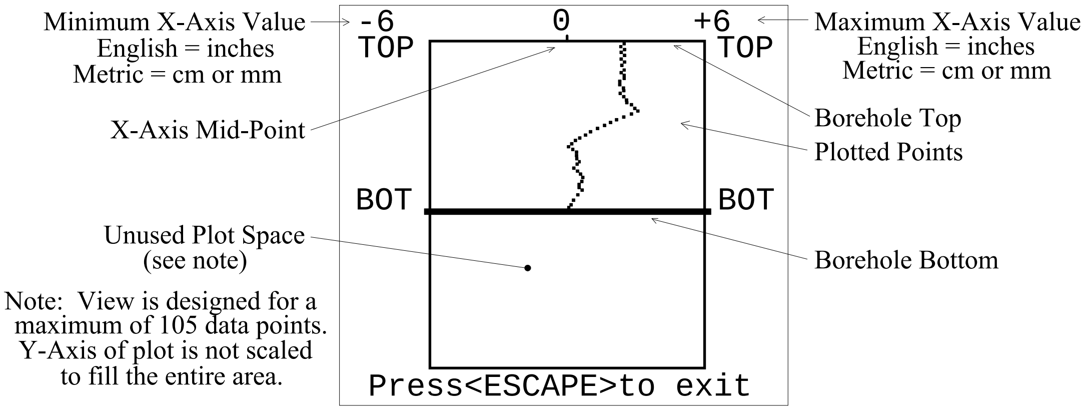


Figure 3.2-10 View Deflection/Profile Plot

Each time the scale is changed the plot is redraw. Each screen in the plot view mode displays up to 105 levels. If the survey consists of more than 105 points then the plot is viewed in sections with each section containing up to 105 levels. The maximum number of levels allowed per data file is 255 so there may be up to 3 plot sections. To select plot sections use ▲ ▼ Press <SELECT> to direct the plot to the printer or <ESCAPE> to return to the View/Print Plots menu.

Note: The x-axis scale can be manually set with the Set Plot Scales option in the View/Print Plots menu! See section 3.2.3.5. for more information.

Appendix C.2.4. illustrates a A-Axis Deflection in Inches plot output using the deflection analysis. Appendix C.3.4. illustrates the plot using the profile analysis.

3.2.3.4. B-Axis Deflection or Profile

Same plot as A-Axis Deflection or Profile (section 3.2.3.3.) except for the B-axis!

3.2.3.5. Set Plot Scales

The Change in Digits or Deflection plot scales can be set manually with this option. Numerical entry screens are similar to Starting Level entry screen described in section 3.1.1.4.

3.2.3.5.1. Change in Digits Scale

Sets the scale value for A and B-Axis plots. The value displayed or entered is the positive scale value. Only positive numbers are excepted. A scale value of less than 10 is not allowed. Press <STORE> to accept the value displayed and continue on to the deflection scale entry. Press <ESCAPE> to return to the View/Print Plots menu.

3.2.3.5.2. Deflection Scale

Sets the scale value for A and B-Axis plots. The value displayed or entered is the positive scale value. Only positive numbers are accepted. A scale value of less than 0.1 (zero) is not allowed. Press <STORE> to accept the value displayed and return to the View/Print Plots menu. Press <ESCAPE> to abort and also return to the View/Print Plots menu.

3.2.4. Change Prams

Various calculation parameters are entered with this option. The user will be asked a series of questions concerning the installation. The operation of the numerical entry screens are all similar to the Starting Level entry screen described in section 3.1.1.4. Pressing <ESCAPE> at any of the following screens returns the user to the Data Reduction menu. The calculation procedure will be re-run to incorporate any changes made.

3.2.4.1. Elevation

All reports and plots have provision for referencing the level to elevation. Typically, the casing top is entered as feet (English units) or meters (Metric units) above sea level (or some other reference). See the sample reports and plots in Appendix C to illustrate.

3.2.4.2. Actual Angle of Azimuth

If the casing was installed in a direction other than true north (orientation of A+), correction may be made by entering the angle of error (either positive or negative). The value entered here will be used in calculating deflection or profile (see Appendix E) for both axes and will appear on all reports and plots. The default is 0.

3.2.4.3. Computational Angle of Azimuth

Movement in a direction other than A+ or B+ may be calculated with this option. Enter the angle to calculate movement. The value entered here will be used in calculating deflection or profile (see Appendix E) for both axes and will appear on all reports and plots. The default is 0.

3.2.5. Config Reduction

Various data reduction configuration options are configurable with this option. See Figure 3.2-11.

Move the cursor with ▲ ▼ To change the selected option press <STORE>. When pressing <STORE> at Select Printer the screen is cleared and the Select Printer screen will display. See Figure 3.2-12. When pressing <STORE> at items 2 through 4 the displayed options are toggled. See the following sections for more information. Press <ESCAPE> when done to return to the Data Reduction menu.

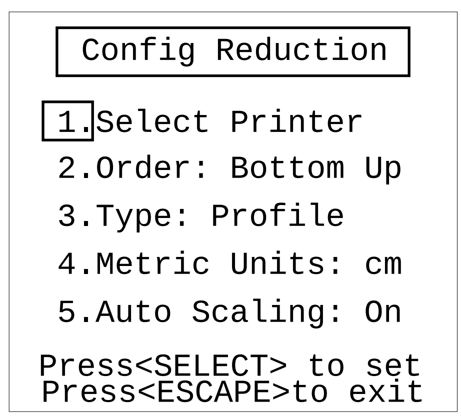


Figure 3.2-11 Config Reduction Menu

3.2.5.1. Select Printer (Note. This option is no longer available).

Numerous printer types are supported by the GK-603 (Table 3-2). Use ▲ ▼ to change. Press <STORE> when done to save the printer type selected. Press <ESCAPE> to abort. Control is returned to the Config Reduction menu.

Diconix 180si (old)
Diconix 180si (new)
IBM Proprinter
Canon BJ300 (IBM)
Epson FX-850
Tandy DMP130-134
Canon BJ-30 (BJ)

Table 3-2 Available Printer Types

```
Select Printer

Canon BJ-30 (BJ)

Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.2-12 Select Printer Screen

The factory default is `Canon BJ-30 (BJ)`.

3.2.5.2. Order

Deflection or profile calculations may be made from the bottom up or the top down of the borehole. Both settings should result in identical calculation results; the difference is the point of reference. Press <SELECT> to toggle between `Bottom Up` and `Top Down`. The factory default is `Bottom Up`.

3.2.5.3. Type

Use this option to select the type of analysis. Deflection analysis compares two sets of data for change, profile generates a profile of the borehole from a single set of data. Appendix E describes the data reduction techniques employed for each option. Press <SELECT> to toggle between `Deflction` and `Profile`. The factory default is `Deflction`.

3.2.5.4. Metric Units

For a Metric system configuration, the data reduction units are configurable between centimeters and millimeters. Press <SELECT> to toggle between `cm` and `mm`. The factory default is `mm`.

3.2.5.5. Auto Scaling

The auto scaling feature can be disabled if the uniformity of plot scales is desired. Press <SELECT> to toggle between `On` and `Off`. The factory default is `On`.

3.3. Transmit/Receive

Options accessed through this menu facilitate transfer of files (via RS-232) either to or from the host computer. It is recommended that all configuration and data files (especially initial) be stored in a secondary location, such as a computer, to ensure a backup is maintained. If further data reduction tasks will be carried out on the host computer this menu facilitates transfer of the files. See Appendix B.7. for the RS-232 specifications. Figure 3.3-1 depicts the menu. *Note: All of the transmit/receive menu options are accessible directly through the RS-232 interface.* See Appendix F for more information.

```
Transmit/Receive

1.Send Data File
2.Send Config File
3.Load Data File
4.Load Config File


Select with joystick
Press<SELECT> to run
```

Figure 3.3-1 Transmit/Receive Menu

3.3.1. Send Data File

Selecting this option initially displays a list of data files 1-16. See Figure 3.1-12. Use ▲ ▼ and ◀ ▶ to select the file to send. Select <more> to display the next screen of files. Select <all> to transmit all of the data files in memory. The files can be sent to the PC using Hyperterminal. The instructions are outlined in Appendix K. Alternatively, if GTILT Plus is being used to reduce the data, use the TiltComm utility of GTILT Plus to download the data files.

3.3.2. Send Config File

Configuration files can be saved on the host computer for backup or modification and later transfer back to the GK-603. See Appendix A.1. for a sample configuration file and guidelines for creating and/or modifying. Selecting this option displays a list of the 16 configuration files. Use ▲ ▼ and ◀ ▶ to select the file to send. Select <all> to send of the configuration files in memory. See the previous section (3.3.1.) for the file upload instructions.

3.3.3. Load Data File

This option initially displays the first group of data files, 1-16. Select a file location that is <empty> or over-write an existing one with ▲ ▼ and ◀ ▶. Select <more> to advance to other screens. If <empty> is selected, the filename within the received data file will be used by the GK-603.

Hyperterminal can be used to upload data files to the readout.

If there is a problem with the format of the file sent, the Error! screen will display on the GK-603 and the file will not be stored in memory. See Table 3-1 for complete list of error codes (only codes 5 & 6 apply). Table 3-3 details the reasons for code 5. See Appendix A.2. for a sample data file and additional format information.

- Missing 3 asterisks at the beginning of the file.
- Missing System Units indicator in the header.
- Date is in the wrong format, i.e. `03//94` or `///`
- Time is in the wrong format, i.e. `25:10:00` or `::30`
- Probe Output Type indicator (`10G`, `14G` or `D`) is missing or invalid.
- Number of readings is greater than 255.
- Missing any of the header lines.
- Some or all of the data incorrectly formatted.
- Some of the data is missing.

Table 3-3 File Format Problems

Code 6 is returned if there is a time-out on the loading process (greater than 10 seconds). This could be the result of waiting too long to send the file on the host computer, or there is an unacceptable time lag between lines of the file being sent, or not enough lines are sent. Press <ESCAPE> at the Error! screen to return to the Transmit/Receive menu. Repeat the steps for uploading the file if necessary.

3.3.4. Load Config File

Configuration files can be loaded into the GK-603 from the host computer. See Appendix A.1. for a sample configuration file and guidelines for creating and/or modifying. Selecting this option displays a list of the 16 configuration files. Use ▲▼ and ◄ ► to select the file location to receive. Select <empty> to create a new file or overwrite an existing file by selecting its location. The filename contained in the received configuration will be used by the GK-603. See the previous section (3.3.3.) for instructions related to the download of files.

Possible error codes resulting from the configuration file reception are the same as for data files. See section 3.3.3. for additional information.

3.3.5. Transferring Data from the GK-603 to a PC via Hyperterminal

Please refer to Appendix K for step-by-step instructions for downloading data files from the GK-603 using Hyperterminal.

3.4. File Management

Numerous options are available for dealing with stored configuration and data files in the GK-603. See Figure 3.4-1. *Note: The Delete Data File and Del Config File options are accesible directly through the RS-232 interface.* See Appendix F for more information.

```
File Management
1.Delete Data File
2.Rename Data File
3.Copy Data File
4.Del Config File

Select with joystick
Press<SELECT> to run
```

Figure 3.4-1 File Management Menu

3.4.1. Delete Data File

This option permanently removes a data file from memory. The file location and memory used is then free to be used for other files. Initially, the first series of data files (1-16) stored in memory are displayed. Select the file to delete and press <SELECT>. Select <more> to advance to other screens. Select <all> to delete all data files. *Note: Confirmation is required if <all> is selected!* Press <SELECT> to continue with the deletion or <ESCAPE> to abort. After deletion the File Management menu will re-display. Abort from the file list screen by pressing <ESCAPE>.

3.4.2. Rename Data File

Changes the name of a currently stored data file. The file location remains the same after renaming. Initially, the first series of data files (1-16) stored in memory are displayed. Select the file to rename and press <SELECT>. Select <more> to advance to other screens. Prompting for the new file name will occur when a file is selected. Press <STORE> when through to save or <ESCAPE> to abort the renaming.

3.4.3. Copy Data File

Copies the contents of one data file to another. Initially, the first series of data files (1-16) stored in memory are displayed. Select <more> for additional data files. Select the file to copy and press <SELECT>. The destination of the file must then be selected. Select <new> to enter a new name and store to a new file location. Select <empty> to store directly to a new file location or select a currently stored file to overwrite.

3.4.4. Del Config File

This option permanently removes a configuration file from memory. The file location and memory used by that file is then free to be used for other files. Initially, the configuration files stored in memory are displayed. Select the file to delete and press <SELECT>. Select <all> to delete all of the stored configuration files. *Note: Confirmation is required if <all> is selected!* Press <SELECT> to continue with the deletion or <ESCAPE> to abort. After deletion or pressing <ESCAPE> the File Management menu re-displays.

3.5. System Settings

The System Settings menu is used for setting/checking various operating parameters of the GK-603 Readout. See Figure 3.5-1.

```
System Settings

1.Check System
2.Set Date/Time
3.Adjust Contrast
4.Configure Probe
5.Set System Units

Select with joystick
Press<SELECT> to run
```

Figure 3.5-1 System Settings Menu

3.5.1. Check System

Various system voltages are read and displayed with this option. These can be used to check the level of the main power battery, the internal lithium backup battery and/or verify the proper (or improper) functioning of the readout. See Figure 3.5-2 for a typical display.

Press <SELECT> to initiate another measurement sequence while remaining in the Check System screen. A few comments on each of the measurements follows;

```
Check System

Battery:+12.35 VDC
Backup:+3.40 VDC
Probe+:+11.98 VDC
Probe-:-11.83 VDC
Memory:17.0% used

Press<ESCAPE>to exit
```

Figure 3.5-2 Check System Screen

`Battery:` This is the voltage level of the main battery. Nominally it is 12 volts, fully charged it should be around 13.0 volts. When the voltage drops below 11.5 the backlight will begin flashing on and off to indicate a low battery. In that event, the readout should be plugged into the charger as soon as possible. When the level reaches 10.5 volts the readout will shut off. If a survey was being conducted at the time the current set of readings will be lost! There will be approximately 60 minutes between the time the backlight begins flashing and the readout turns off.

`Backup:` This is the voltage level of the battery used for non-volatile memory storage. System settings such as the Date/Time (section 3.5.2.), Contrast (section 3.5.3.), Probe Output (section 3.5.4.), System Units (section 3.5.5.), as well as configuration and data files are stored in non-volatile memory. If this battery is depleted all of these settings are reset. Nominally the voltage will read 3.5 volts. If it drops below 2.5 volts it should be replaced. Return the unit to the factory for battery replacement.

`Probe+:` This is the positive supply voltage to the probe (and other electronics internal to the GK-603). Nominally it is 12 volts. It should never go below 11.5 volts or above 12.5. Consult the factory if otherwise.

`Probe-:` This is the negative supply voltage to the probe (and other electronics internal to the GK-603). Nominally it is -12 volts. It should never go above -11.5 volts or below -12.5. Consult the factory if otherwise.

`Memory:` This is the percent of file storage memory that has been used. The readout has 892 sectors (128 bytes per sector) of available memory. See Appendix G for additional information regarding the file storage scheme used by the GK-603.

3.5.2. Set Date/Time

Use this option to set/check the real time clock settings of the GK-603. When the option is selected the current date and time are displayed. See Figure 3.5-3. To increment/decrement the value at the cursor position use ▲ ▼ Use ◄ ► to move the cursor (indicated by the blinking underline). The Date format is `MM/DD/YY`. Time is `HH:MM:SS`.

Press <STORE> to save the settings displayed or <ESCAPE> to leave the date/time unchanged. Both <STORE> and <ESCAPE> return control to the System Settings menu.

```
 Set Date/Time

  Date: 03/08/94

  Time: 14:07:34


<LEFT/RIGHT> to move
Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.5-3 Set Date/Time Screen

3.5.3. Adjust Contrast

Allows adjustment of the contrast of the LCD.

Use ▲ ▼ to increase or decrease the value. Increasing the contrast value lessens the contrast while decreasing increases contrast (confused?). Use ◄ ► to toggle the backlight on/off. Turning the backlight off reduces the load on the internal battery hence results in a longer operating time (from full charge to minimum charge approximately a 45 minute gain). Press <STORE> to save the setting (stored in non-volatile memory) or <ESCAPE> to restore the original value. Both <STORE> and <ESCAPE> return control to the System Settings menu.

```
Adjust Contrast

Current Value: 128

Use <UP> to increase
Use <DN> to decrease
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.5-4 Adjust Contrast Screen

3.5.4. Configure Probe

Numerous configuration options are available for the particular inclinometer probe being used by the GK-603 such as the type, units, zero shifts and gage factors. These settings define the default configuration of the readout. In other words, when the readout is turned on or a new file is created in the course of taking readings, these settings will be used to configure the readout and subsequently stored with the configuration or data file. When the configuration or data file is loaded for the purpose of conducting another survey the settings stored in the file will be used to configure the readout.

```
Configure Probe
1.Type: 10V/g
2.Units: 2.0sin
3.A-Axis Zero Shft
4.B-Axis Zero Shft
5.Gage Factors
Press<SELECT> to run
Press<ESCAPE>to exit
```

FFigure 3.5-5 Set Probe Output Screen

3.5.4.1. Type

Select **10V/g** for all Geokon probes, Models 6000, 6015; spiral sensor Model 6005, and IPI Model 6050 and for all Geokon MEMS probes, tiltmeters and In Place Inclinometers. Select **14V/g** for Slope Indicator probes

The current setting can be checked by inclining the probe 30° while in the Readings Screen (section 3.1.1.8.). The reading on the inclined axis should be close to ±10000 if "**2.0sin**" is selected as the Units (Section 3.5.4.2.), ±12500 if the units are "**2.5sin**".

Use ▲ ▼ to toggle the setting. Press <STORE> to save or <ESCAPE> to abort. This setting is stored in non-volatile memory of the readout. On exit the System Settings menu displays.

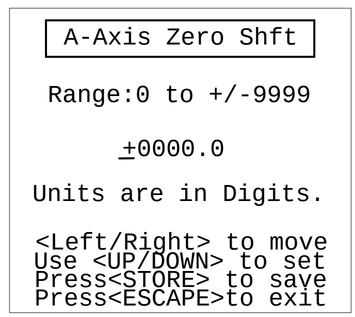
3.5.4.2. Units

The default display and storage units of the probe readings are configurable with this option. Pressing <SELECT> will toggle the setting between "**2.0sin**" and "2.5sin". The display and storage of Geokon inclinometer probe readings are based on the following equation: **2.0 sinθ × 10000**. The default units are "2.0sin". This results in a display of 10000 digits while in the Readings Screen with the probe inclined at approximately 30° (assuming the probe type setting is correct, see section 3.5.4.1.). For Slope Indicator probes the Units are set to "2.5sin" then the display at 30° is 12500.

Note: This setting should only be changed by direction of Geokon!

3.5.4.3. A-Axis Zero Shift

Correction may be applied to the A-axis probe readings for zero shift. Zero shifts can occur, i.e. the zero shift can change because of wear and tear on the probe caused by rough handling. **The zero offset does not affect the accuracy of the readings because it is automatically eliminated by the way the probe survey is conducted (2 sets of readings at 180 degrees).**



F

Figure 3.5-6 Zero Shift Entry Screen

Pressing <SELECT> at this option displays the entry screen as depicted in Figure 3.5-6. The appropriate value of the zero shift can be obtained from the calibration sheet or at any time by conducting a baseline survey and then printing the A-Axis Instrument Check Report using the Profile option (Appendix C.3.1.). Calculate the average value for the "Shift" column in the report and then divide by 2. Be sure to preserve the sign. A repeat survey should show zero's or near zero in the Sum column if the sign and magnitude has been chosen correctly.

Again, it is emphasized that the zero shift, provided it is within ±1000 digits, plays no part in the deflection or profile calculation and has no effect on the accuracy of the probe. So adjustment of the Zero shift is not recommended.

The entry screen indicates a number range of 0 to ±9999 digits but actually only a range of 0 to ±1000 digits is accepted.

This value is stored in the non-volatile memory.

3.5.4.4. B-Axis Zero Shift

See description in section 3.5.4.3. For the B-axis.

3.5.4.5. Gage Factors

For the greatest accuracy it is necessary to enter the Gage Factors of the probe. Pressing <SELECT> at this option will display the entry screen as depicted in Figure 3.5-7. If <SELECT> is pressed at the "A-Axis Factor" entry screen the "B-Axis Factor" screen will display and the factor the B-axis can then be entered. **The appropriate values for both the A and B-axis are taken from the calibration sheet supplied with the instrument.** The default value for both the A and B-axis Gage Factor is 1.0000. Valid input range is 0.1 to 2.0, positive or negative. Force balance types have gage factors close to 1.000. MEMS units have gage factors of about 0.6. See the calibration sheet for the exact values.

```
A-Axis Factor

Range:0.1 to 2.0

+1.0000

Enter as multiplier.

<Left/Right> to move
Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.5-7 Gage Factor Entry Screen

Note: This setting should only be changed by direction of Geokon! Also, be aware that changing the sign to negative will reverse all deflection calculations made for that axis! When using the Digital Probe set the B-axis sign to negative (select -1.0000).

This value is stored in the non-volatile memory.

3.5.5. Set System Units

The GK-603 can be configured for use as an English units readout or Metric. This setting primarily configures the units of the data reduction portion of the readout. With English selected all calculations are based on units of inches and feet, while Metric uses millimeters, centimeters and meters. See section 3.2 for additional information concerning the Data Reduction capabilities of the GK-603. Figure 3.5-8 illustrates the Set System Units screen.

```
Set System Units

English

Use <UP/DOWN> to set
Press<STORE> to save
Press<ESCAPE>to exit
```

Figure 3.5-8 Set System Units Screen

Toggle between English and Metric units with ▲ ▼. To save the setting press <STORE>. To abort press <ESCAPE>. <STORE> and <ESCAPE> return control to the System Settings menu. If this is configured improperly the units on all reports and plots will be in error! (not to mention the calculations!)

This setting is stored in non-volatile memory.

4. MAINTENANCE

The GK-603 Inclinometer Readout is designed to operate in harsh field environments, nevertheless there are some basic maintenance procedures that should be followed to insure maximum reliability and functionality. They are as follows:

4.1. Charging

When the unit is not in use, especially for extended periods of time, it should be left connected to the charger. This will ensure a proper charge maintained on the batteries, hence a reduction of the risk of battery failure. There is no problem with leaving the unit plugged into the charger. Use the Check System feature accessible through the System Settings menu to check the levels of the internal batteries (section 3.5.1.).

4.2. Cleaning

The exterior of the readout can be cleaned with a soft cloth dampened with soap and water. Do not use harsh cleaning solutions on the front panel as the LCD viewing window could be damaged! The connector sockets can be cleaned using a small stiff brush (i.e. small painters brush) dipped in soap and water. The sockets are waterproof so the internal electronics will not be adversely affected by them filling with water or other liquids. Be aware, however, that readings could be affected by shorting or other effects of an improper connection so be sure to thoroughly dry all connectors/plugs before attempting to use the readout!

4.3. Calibration

The readout and probe should be sent periodically (once a year) back to the manufacturer for inspection, cleaning and calibration. A nominal fee will be charged for the service, but it is highly recommended. Contact the factory to schedule the return.

5. TROUBLESHOOTING

The section lists the more common problems encountered when using the GK-603 and possible remedial action. Consult the factory for help with problems not described herein or after exhausting possibilities listed.

Unit does not power on when ON is pressed.

- ✓ Leave the battery on charge overnight.
- ✓ Check if the internal fuses are blown. Replace if necessary.
- ✓ Check the output of the charger with a voltmeter (see Appendix D.2.5. for the pinout).

In the Readings Screen values larger than ±00010 are displayed with no probe attached.

- ✓ Thoroughly clean Sensor connector on front panel.
- ✓ Check that battery is fully charged (Check System, section 3.5.1.).

In the Readings Screen A or B (or both) channels read -99999.

- ✓ Thoroughly clean the Sensor connector on front panel.
- ✓ If the probe is lying down it may be over-ranging the input.
- ✓ Check that battery is fully charged (Check System, section 3.5.1.).

When attempting to send files via RS-232 from GK-603 reception is garbled.

- ✓ Check that the communication parameters for the host computer are correct.

Date/Time or other system information (files, configuration, etc.) is being lost.

- ✓ Check the internal lithium battery (Check System, section 3.5.1.).

Cannot turn the readout off.

- ✓ Wait until the power off time-out occurs. Alternately, connect the GK-603 to a host computer and issue the "E" command (see Appendix F). Turn readout back on. Try turning off again. If it does not turn off contact the factory to schedule return of unit.

The backlight is flashing.

- ✓ Indicates a low battery condition. Finish the survey or process as quickly as possible. Plug the charger in and leave overnight. The readout will turn itself off when the voltage reaches 10.5 volts! Use the Check System option to check the battery (section 3.5.1.).

The Error! screen displays with a code when attempting to load a file for the Data Reduction.

- ✓ There is a compatibility problem between the files. See section 3.2.1. for more information.

The Error! screen displays with a code when attempting to load a file from the RS-232 port.

- ✓ A time-out has occurred or the file is not in the correct format. See sections 3.3.3. and 3.3.4. for more information.

APPENDIX A - GEOKON FILE FORMATS

A.1. Config File Format

The following is a sample config file followed by explanatory notes.

```
***
GK 603E(v2.4,08/96);2.0;FORMAT II
PROJECT  :INCLINOMETER DATA
HOLE NO. :IH01
DATE     :03/02/94
TIME     :16:46:12
PROBE NO.:14G01
FILE NAME:TEST3
#READINGS: 2
FLEVEL,  A+,  A-,  B+,  B-
+102 ,0 ,0 ,0 ,0
+100 ,0 ,0 ,0 ,0
```

Note the following concerning the config file format;

1. The letter after "GK 603" in the header indicates the readout units. "E" indicates English units. "M" indicates Metric.
2. The "v2.4" after "GK 603E" indicates the software version of the readout that saved the file. The software version is followed by the date (month/year) of its revision.
3. The "2.0" describes the units of the data in this file, in this case indicating the units are 2sinθ × 10,000 (or a reading of 10,000 when the probe is inclined 30°). If the header contains "2.5" instead of "2.0" then the units are 2.5sinθ × 10,000 (or a reading of 12,500 when the probe is inclined 30°C).
4. "PROJECT" is followed (after colon) by a maximum of 40 ASCII text characters.
5. "HOLE NO." is followed by a maximum of 10 ASCII text characters.
6. The "DATE" and "TIME" refers to when the config file was created. For data files this indicates when readings were first recorded.
7. The probe type is indicated by a prefix to the Probe Number entered by the user. "10G" refers to a 10 volts per g probe, "14G" indicates 14 volts per g and "D" indicates a digital probe (section 3.5.3). The Probe Number that follows the probe type is 10 character ASCII text.
8. "FILE NAME" refers to the name (maximum of 8 ASCII characters) used to store the config in the GK-603.
9. "#READINGS" is always "2" for a config file.
10. The letter in front of "LEVEL" indicates whether fixed or variable intervals were used to record the data. "F" preceding "LEVEL" indicates fixed intervals while "V" indicates variable.
11. There are no blank lines separating the data sets or the header information.
12. When using fixed intervals, two arrays of data are sent to determine the reading interval and starting level. The first "Level" value is used as the Starting Level. The difference between the first and second "Level" values is used as the Reading Interval. In the example above the Starting Level would be 102 feet, the Reading Interval –2 feet. When using variable intervals all the levels, as determined by the "#READINGS" entry are sent. The discrete reading levels are determined by the data sent. The default Reading Interval of 0.1 (meters or feet) is assumed.

A.2. Data File Format

The following is a sample data file followed by explanatory notes.

```
***
GK 603E(v2.4,08/96);2.0;FORMAT II
PROJECT  :INCLINOMETER DATA
HOLE NO. :IH01
DATE     :03/02/94
TIME     :16:46:12
PROBE NO.:14G01
FILE NAME:TEST3
#READINGS: 22
FLEVEL,  A+,  A-,  B+,  B-
44 ,-849 , 52 ,-281 , 127
42 ,-877 , 85 ,-238 , 84
40 ,-901 , 105 ,-188 , 35
38 ,-924 , 130 ,-144 ,-10
36 ,-928 , 134 ,-110 ,-43
34 ,-951 , 160 ,-115 ,-37
32 ,-943 , 151 ,-92 ,-61
30 ,-933 , 144 ,-71 ,-80
28 ,-923 , 131 ,-51 ,-101
26 ,-916 , 124 ,-5 ,-150
24 ,-907 , 115 , 41 ,-194
22 ,-886 , 93 , 62 ,-214
20 ,-850 , 59 , 78 ,-229
18 ,-812 , 23 , 84 ,-237
16 ,-710 ,-88 , 104 ,-250
14 ,-577 ,-216 , 149 ,-302
12 ,-599 ,-189 , 135 ,-285
10 ,-638 ,-152 , 114 ,-265
8 ,-680 ,-115 , 89 ,-243
6 ,-772 ,-19 , 39 ,-187
4 ,-883 , 88 ,-40 ,-114
2 ,-799 ,-8 , 21 ,-166
```

Note the following concerning the data file format;

1. See the data file section (A.1) for an explanation of the header information.
2. Commas separate the fields (in the data portion) in the file.
3. Leading zeroes are suppressed and there are no fixed fields.
4. Data points are not preceded by "+" if positive.
5. The data are stored in units of 100 microvolts (digits).
6. The first array of data refers to the Starting Level.

APPENDIX B - SPECIFICATIONS

B.1. Measurement Capability
Biaxial analog servo-accelerometer
Biaxial digital servo-accelerometer
Main battery voltage (lead acid battery)
Backup battery voltage (lithium battery)
Probe positive supply (+12 VDC)
Probe negative supply (-12 VDC)
A/D reference voltage (+1.0000 VDC)

B.2. Analog Measurement
Resolution: 1 part in 40000
Resolution = 0.0006 inches /foot or
Resolution = 0.05mm/meter
Input range: ±10 VDC
Input bias current: 10 µA
Input impedance: >1 MΩ
Input bandwidth: 20 Hz
A to B channel isolation: −92 db
Accuracy: 0.15% FSR(over temperature)
Probe supply: ±12VDC @ 50mA
Output: 20,000 sin θ [the tilt angle]{with Geokon type probes outputting 10V/G}

B.3. Digital Measurement
Resolution: 16 bit (1 part in 65536)
Interface: RS-232

B.4. Processor
Type: Hitachi 6303X
Oscillator frequency: 7.3728 MHz
System clock frequency: 1.8432 MHz

B.5. Memory
RAM: 128K Static
ROM: 64K EPROM
Config file storage: 16 files
Data file storage: 96 files
Max levels per data File: 255
Total data point storage: 28544

B.6. Clock
Features: Full calendar
Time format: 24 hour
Oscillator: 32.768kHz
Accuracy: ±1 minute per month

B.7. Serial Interface
Interface speed: 1200 or 9600 baud
Communication parameters: 8 databits,1 stop bit,no parity,full duplex
Software handshake: XON/XOFF
Data output format: ASCII text

B.8. Power
Quiescent current draw: <0.2 mA
Operating current:≈175 mA (no probe)
≈225 mA (with probe)
Battery: 12 Volt 7.0 Ahr
Battery type: Sealed lead-acid
Operating time: ≈12 hours
Backup battery: 3.6 volt 1.8 Ahr
Backup battery type: Lithium
Backup battery life: ≈4 years

B.9. Charger
120 VAC: 18 VDC @ 533mA
220 VAC: 15 VDC @ 800mA

B.10. Physical
Size: 8.25"×6.5"×8" (L×W×H)
210mm×165mm×203mm
Weight: 8 lbs., 3.6 kg.
Operating temperature: 32-120° F
0-50° C
Humidity: 95% (non-condensing)

APPENDIX C - SAMPLE FILES/REPORTS/PLOTS

C.1.1. Initial Data File

```
***
GK 603E(v2.4,08/96);2.0;FORMAT II
PROJECT  :Inclinometer Data
HOLE NO. :IH01
DATE     :01/05/94
TIME     :09:19:02
PROBE NO.:14G01
FILE NAME:TEST1
#READINGS: 51
LEVEL,  A+,  A-,  B+,  B-
 102 ,-265 , 245 , 277 ,-295
 100 ,-258 , 237 , 338 ,-358
 98 ,-302 , 282 , 410 ,-420
 96 ,-516 , 496 , 415 ,-417
 94 ,-473 , 452 , 430 ,-435
 92 ,-417 , 396 , 434 ,-440
 90 ,-381 , 359 , 433 ,-444
 88 ,-359 , 342 , 448 ,-450
 86 ,-329 , 309 , 569 ,-584
 84 ,-339 , 320 , 535 ,-549
 82 ,-335 , 316 , 501 ,-515
 80 ,-320 , 301 , 487 ,-505
 78 ,-313 , 292 , 495 ,-498
 76 ,-277 , 257 , 545 ,-562
 74 ,-263 , 242 , 533 ,-552
 72 ,-249 , 228 , 521 ,-538
 70 ,-230 , 207 , 509 ,-527
 68 ,-193 , 168 , 480 ,-483
 66 ,-47 , 28 , 372 ,-381
 64 ,-56 , 34 , 380 ,-385
 62 ,-69 , 48 , 376 ,-381
 60 ,-76 , 56 , 364 ,-369
 58 ,-114 , 94 , 388 ,-396
 56 ,-243 , 222 , 570 ,-584
 54 ,-213 , 193 , 553 ,-570
 52 ,-167 , 145 , 539 ,-558
 50 ,-122 , 101 , 529 ,-547
 48 ,-105 , 82 , 520 ,-529
 46 ,-263 , 242 , 405 ,-409
 44 ,-217 , 196 , 434 ,-438
 42 ,-155 , 136 , 465 ,-472
 40 ,-103 , 82 , 497 ,-502
 38 ,-55 , 37 , 519 ,-526
 36 ,-21 , 3 , 577 ,-592
 34 , 1 ,-19 , 576 ,-592
 32 , 16 ,-36 , 563 ,-578
 30 , 30 ,-51 , 548 ,-564
 28 , 55 ,-72 , 526 ,-536
 26 , 103 ,-125 , 517 ,-532
 24 , 120 ,-138 , 486 ,-502
 22 , 142 ,-159 , 455 ,-472
 20 , 157 ,-175 , 424 ,-439
 18 , 166 ,-188 , 392 ,-394
 16 , 235 ,-255 , 152 ,-169
 14 , 216 ,-237 , 181 ,-195
 12 , 190 ,-212 , 226 ,-238
 10 , 167 ,-186 , 266 ,-278
 8 , 135 ,-155 , 333 ,-337
 6 , 14 ,-31 , 508 ,-513
 4 , 64 ,-79 , 493 ,-513
 2 , 142 ,-171 , 382 ,-404
```

C.1.2. Present Data File

```
***
GK 603E(v2.4,08/96);2.0;FORMAT II
PROJECT  :Inclinometer Data
HOLE NO. :IH01
DATE     :01/06/94
TIME     :09:39:18
PROBE NO.:14G01
FILE NAME:TEST2
#READINGS: 51
LEVEL,  A+,  A-,  B+,  B-
 102 ,-264 , 246 , 277 ,-294
 100 ,-257 , 237 , 337 ,-358
 98 ,-302 , 283 , 405 ,-420
 96 ,-515 , 497 , 411 ,-418
 94 ,-473 , 453 , 429 ,-435
 92 ,-416 , 398 , 433 ,-440
 90 ,-380 , 361 , 433 ,-443
 88 ,-359 , 344 , 444 ,-446
 86 ,-329 , 309 , 567 ,-582
 84 ,-338 , 321 , 533 ,-548
 82 ,-334 , 318 , 499 ,-515
 80 ,-320 , 302 , 487 ,-504
 78 ,-311 , 294 , 493 ,-497
 76 ,-277 , 258 , 544 ,-562
 74 ,-262 , 242 , 532 ,-553
 72 ,-249 , 229 , 518 ,-539
 70 ,-229 , 208 , 507 ,-525
 68 ,-195 , 171 , 479 ,-485
 66 ,-47 , 29 , 370 ,-379
 64 ,-55 , 35 , 379 ,-385
 62 ,-68 , 49 , 373 ,-381
 60 ,-76 , 57 , 363 ,-370
 58 ,-113 , 95 , 384 ,-397
 56 ,-242 , 223 , 568 ,-584
 54 ,-212 , 194 , 552 ,-571
 52 ,-165 , 149 , 537 ,-558
 50 ,-121 , 103 , 528 ,-547
 48 ,-105 , 82 , 518 ,-529
 46 ,-262 , 243 , 404 ,-407
 44 ,-216 , 197 , 431 ,-439
 42 ,-155 , 138 , 464 ,-472
 40 ,-102 , 83 , 496 ,-501
 38 ,-54 , 37 , 518 ,-527
 36 ,-21 , 1 , 577 ,-594
 34 , 1 ,-18 , 575 ,-593
 32 , 14 ,-34 , 562 ,-578
 30 , 31 ,-50 , 545 ,-565
 28 , 56 ,-71 , 526 ,-536
 26 , 106 ,-126 , 513 ,-533
 24 , 120 ,-136 , 485 ,-503
 22 , 141 ,-157 , 453 ,-471
 20 , 157 ,-174 , 421 ,-439
 18 , 168 ,-187 , 390 ,-398
 16 , 235 ,-254 , 152 ,-169
 14 , 218 ,-235 , 182 ,-197
 12 , 190 ,-211 , 225 ,-239
 10 , 166 ,-184 , 264 ,-279
 8 , 137 ,-153 , 330 ,-338
 6 , 14 ,-31 , 508 ,-512
 4 , 64 ,-85 , 494 ,-512
 2 , 142 ,-169 , 382 ,-409
```

C.2.1. A-Axis Instrument Check-Sum Report (Deflection)

REPORT: A-Axis Instrument Check

PROJECT NAME: Inclinometer Data
HOLE NUMBER: IH01
TOP ELEVATION: +584.0

Actual Angle of Azimuth: +0.0 Computed Angle of Azimuth: +0.0

	--Initial Data--	--Present Data--
File Name:	TEST1	TEST2
Reading Date:	01/05/94	01/06/94
Reading Time:	09:19:02	09:39:18
Probe Number:	01	01

Elev.	----Initial Data----			----Present Data----				Corr.	Level
Ft.	A+	A-	Sum	A+	A-	Sum	Shift	Shift	Ft.
+582.0	+142	-171	-29	+142	-169	-27	+2	+2	+2.0
+580.0	+64	-79	-15	+64	-85	-21	-6	-6	+4.0
+578.0	+14	-31	-17	+14	-31	-17	+0	+0	+6.0
+576.0	+135	-155	-20	+137	-153	-16	+4	+4	+8.0
+574.0	+167	-186	-19	+166	-184	-18	+1	+1	+10.0
+572.0	+190	-212	-22	+190	-211	-21	+1	+1	+12.0
+570.0	+216	-237	-21	+218	-235	-17	+4	+4	+14.0
+568.0	+235	-255	-20	+235	-254	-19	+1	+1	+16.0
+566.0	+166	-188	-22	+168	-187	-19	+3	+3	+18.0
+564.0	+157	-175	-18	+157	-174	-17	+1	+1	+20.0
+562.0	+142	-159	-17	+141	-157	-16	+1	+1	+22.0
+560.0	+120	-138	-18	+120	-136	-16	+2	+2	+24.0
+558.0	+103	-125	-22	+106	-126	-20	+2	+2	+26.0
+556.0	+55	-72	-17	+56	-71	-15	+2	+2	+28.0
+554.0	+30	-51	-21	+31	-50	-19	+2	+2	+30.0
+552.0	+16	-36	-20	+14	-34	-20	+0	+0	+32.0
+550.0	+1	-19	-18	+1	-18	-17	+1	+1	+34.0
+548.0	-21	+3	-18	-21	+1	-20	-2	-2	+36.0
+546.0	-55	+37	-18	-54	+37	-17	+1	+1	+38.0
+544.0	-103	+82	-21	-102	+83	-19	+2	+2	+40.0
+542.0	-155	+136	-19	-155	+138	-17	+2	+2	+42.0
+540.0	-217	+196	-21	-216	+197	-19	+2	+2	+44.0
+538.0	-263	+242	-21	-262	+243	-19	+2	+2	+46.0
+536.0	-105	+82	-23	-105	+82	-23	+0	+0	+48.0
+534.0	-122	+101	-21	-121	+103	-18	+3	+3	+50.0
+532.0	-167	+145	-22	-165	+149	-16	+6	+6	+52.0
+530.0	-213	+193	-20	-212	+194	-18	+2	+2	+54.0
+528.0	-243	+222	-21	-242	+223	-19	+2	+2	+56.0
+526.0	-114	+94	-20	-113	+95	-18	+2	+2	+58.0
+524.0	-76	+56	-20	-76	+57	-19	+1	+1	+60.0
+522.0	-69	+48	-21	-68	+49	-19	+2	+2	+62.0
+520.0	-56	+34	-22	-55	+35	-20	+2	+2	+64.0
+518.0	-47	+28	-19	-47	+29	-18	+1	+1	+66.0
+516.0	-193	+168	-25	-195	+171	-24	+1	+1	+68.0
+514.0	-230	+207	-23	-229	+208	-21	+2	+2	+70.0
+512.0	-249	+228	-21	-249	+229	-20	+1	+1	+72.0
+510.0	-263	+242	-21	-262	+242	-20	+1	+1	+74.0
+508.0	-277	+257	-20	-277	+258	-19	+1	+1	+76.0
+506.0	-313	+292	-21	-311	+294	-17	+4	+4	+78.0
+504.0	-320	+301	-19	-320	+302	-18	+1	+1	+80.0
+502.0	-335	+316	-19	-334	+318	-16	+3	+3	+82.0
+500.0	-339	+320	-19	-338	+321	-17	+2	+2	+84.0
+498.0	-329	+309	-20	-329	+309	-20	+0	+0	+86.0
+496.0	-359	+342	-17	-359	+344	-15	+2	+2	+88.0
+494.0	-381	+359	-22	-380	+361	-19	+3	+3	+90.0
+492.0	-417	+396	-21	-416	+398	-18	+3	+3	+92.0
+490.0	-473	+452	-21	-473	+453	-20	+1	+1	+94.0
+488.0	-516	+496	-20	-515	+497	-18	+2	+2	+96.0
+486.0	-302	+282	-20	-302	+283	-19	+1	+1	+98.0
+484.0	-258	+237	-21	-257	+237	-20	+1	+1	+100.0
+482.0	-265	+245	-20	-264	+246	-18	+2	+2	+102.0

C.2.2. A-Axis Change in Digits and Deflection Report

REPORT: A-Axis Change in Digits and Deflection in Inches (Bottom Up,Fixed)

PROJECT NAME: Inclinometer Data
HOLE NUMBER: IH01
TOP ELEVATION: +584.0

Actual Angle of Azimuth: +0.0 Computed Angle of Azimuth: +0.0

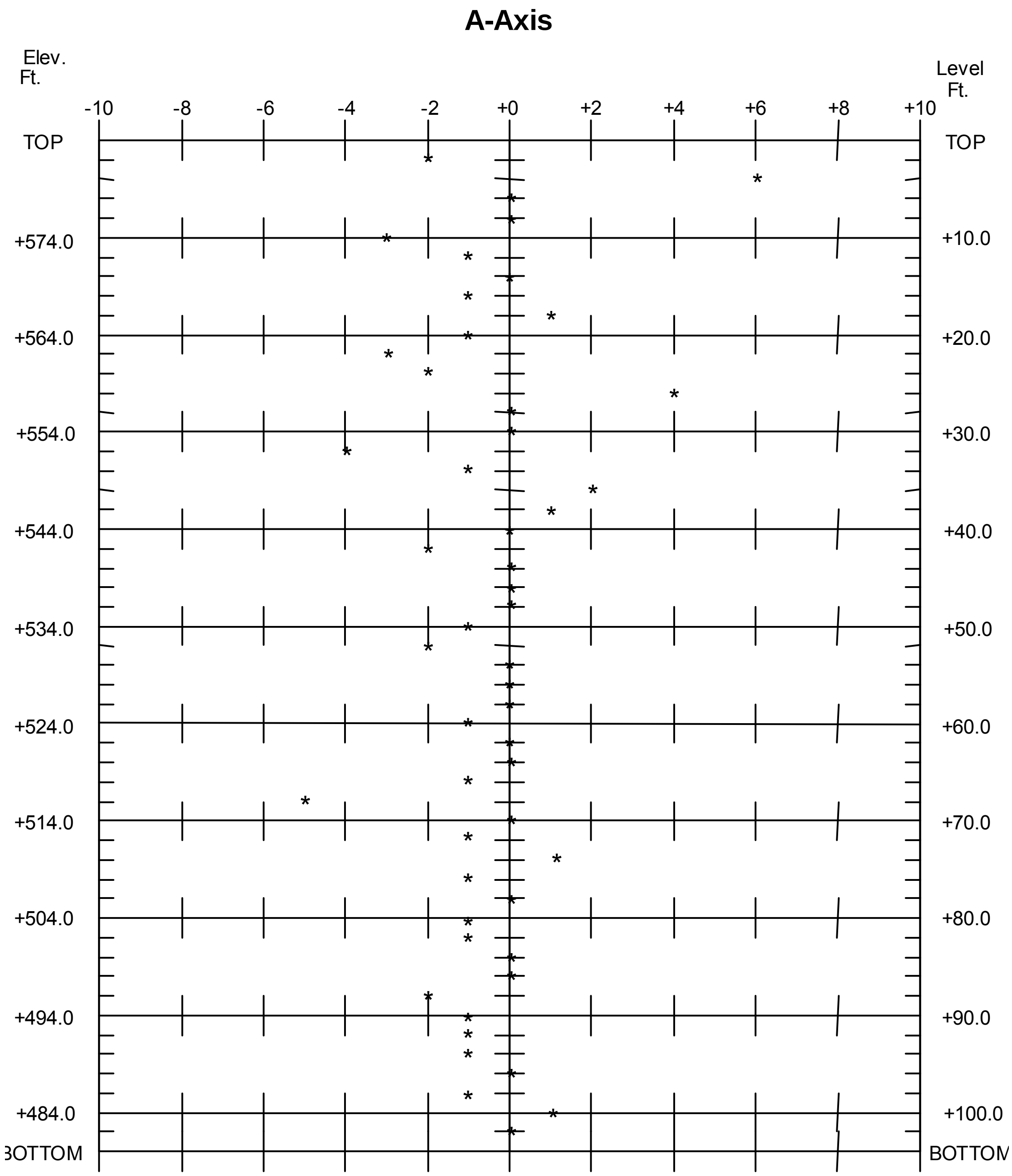
	--Initial Data--	--Present Data--
File Name:	TEST1	TEST2
Reading Date:	01/05/94	01/06/94
Reading Time:	09:19:02	09:39:18
Probe Number:	01	01

Elev.	----Initial Data----			----Present Data----			Corr.	Defl.	Level
Ft.	A+	A-	Diff	A+	A-	Diff	Change	Inches	Ft.
+582.0	+142	-171	+313	+142	-169	+311	-2	-0.0144	+2.0
+580.0	+64	-79	+143	+64	-85	+149	+6	-0.0132	+4.0
+578.0	+14	-31	+45	+14	-31	+45	+0	-0.0168	+6.0
+576.0	+135	-155	+290	+137	-153	+290	+0	-0.0168	+8.0
+574.0	+167	-186	+353	+166	-184	+350	-3	-0.0168	+10.0
+572.0	+190	-212	+402	+190	-211	+401	-1	-0.0150	+12.0
+570.0	+216	-237	+453	+218	-235	+453	+0	-0.0144	+14.0
+568.0	+235	-255	+490	+235	-254	+489	-1	-0.0144	+16.0
+566.0	+166	-188	+354	+168	-187	+355	+1	-0.0138	+18.0
+564.0	+157	-175	+332	+157	-174	+331	-1	-0.0144	+20.0
+562.0	+142	-159	+301	+141	-157	+298	-3	-0.0138	+22.0
+560.0	+120	-138	+258	+120	-136	+256	-2	-0.0120	+24.0
+558.0	+103	-125	+228	+106	-126	+232	+4	-0.0108	+26.0
+556.0	+55	-72	+127	+56	-71	+127	+0	-0.0132	+28.0
+554.0	+30	-51	+81	+31	-50	+81	+0	-0.0132	+30.0
+552.0	+16	-36	+52	+14	-34	+48	-4	-0.0132	+32.0
+550.0	+1	-19	+20	+1	-18	+19	-1	-0.0108	+34.0
+548.0	-21	+3	-24	-21	+1	-22	+2	-0.0102	+36.0
+546.0	-55	+37	-92	-54	+37	-91	+1	-0.0114	+38.0
+544.0	-103	+82	-185	-102	+83	-185	+0	-0.0120	+40.0
+542.0	-155	+136	-291	-155	+138	-293	-2	-0.0120	+42.0
+540.0	-217	+196	-413	-216	+197	-413	+0	-0.0108	+44.0
+538.0	-263	+242	-505	-262	+243	-505	+0	-0.0108	+46.0
+536.0	-105	+82	-187	-105	+82	-187	+0	-0.0108	+48.0
+534.0	-122	+101	-223	-121	+103	-224	-1	-0.0108	+50.0
+532.0	-167	+145	-312	-165	+149	-314	-2	-0.0102	+52.0
+530.0	-213	+193	-406	-212	+194	-406	+0	-0.0090	+54.0
+528.0	-243	+222	-465	-242	+223	-465	+0	-0.0090	+56.0
+526.0	-114	+94	-208	-113	+95	-208	+0	-0.0090	+58.0
+524.0	-76	+56	-132	-76	+57	-133	-1	-0.0090	+60.0
+522.0	-69	+48	-117	-68	+49	-117	+0	-0.0084	+62.0
+520.0	-56	+34	-90	-55	+35	-90	+0	-0.0084	+64.0
+518.0	-47	+28	-75	-47	+29	-76	-1	-0.0084	+66.0
+516.0	-193	+168	-361	-195	+171	-366	-5	-0.0078	+68.0
+514.0	-230	+207	-437	-229	+208	-437	+0	-0.0048	+70.0
+512.0	-249	+228	-477	-249	+229	-478	-1	-0.0048	+72.0
+510.0	-263	+242	-505	-262	+242	-504	+1	-0.0042	+74.0
+508.0	-277	+257	-534	-277	+258	-535	-1	-0.0048	+76.0
+506.0	-313	+292	-605	-311	+294	-605	+0	-0.0042	+78.0
+504.0	-320	+301	-621	-320	+302	-622	-1	-0.0042	+80.0
+502.0	-335	+316	-651	-334	+318	-652	-1	-0.0036	+82.0
+500.0	-339	+320	-659	-338	+321	-659	+0	-0.0030	+84.0
+498.0	-329	+309	-638	-329	+309	-638	+0	-0.0030	+86.0
+496.0	-359	+342	-701	-359	+344	-703	-2	-0.0030	+88.0
+494.0	-381	+359	-740	-380	+361	-741	-1	-0.0018	+90.0
+492.0	-417	+396	-813	-416	+398	-814	-1	-0.0012	+92.0
+490.0	-473	+452	-925	-473	+453	-926	-1	-0.0006	+94.0
+488.0	-516	+496	-1012	-515	+497	-1012	+0	+0.0000	+96.0
+486.0	-302	+282	-584	-302	+283	-585	-1	+0.0000	+98.0
+484.0	-258	+237	-495	-257	+237	-494	+1	+0.0006	+100.0
+482.0	-265	+245	-510	-264	+246	-510	+0	+0.0000	+102.0

C.2.3. A-Axis Change in Digits Plot (Deflection)

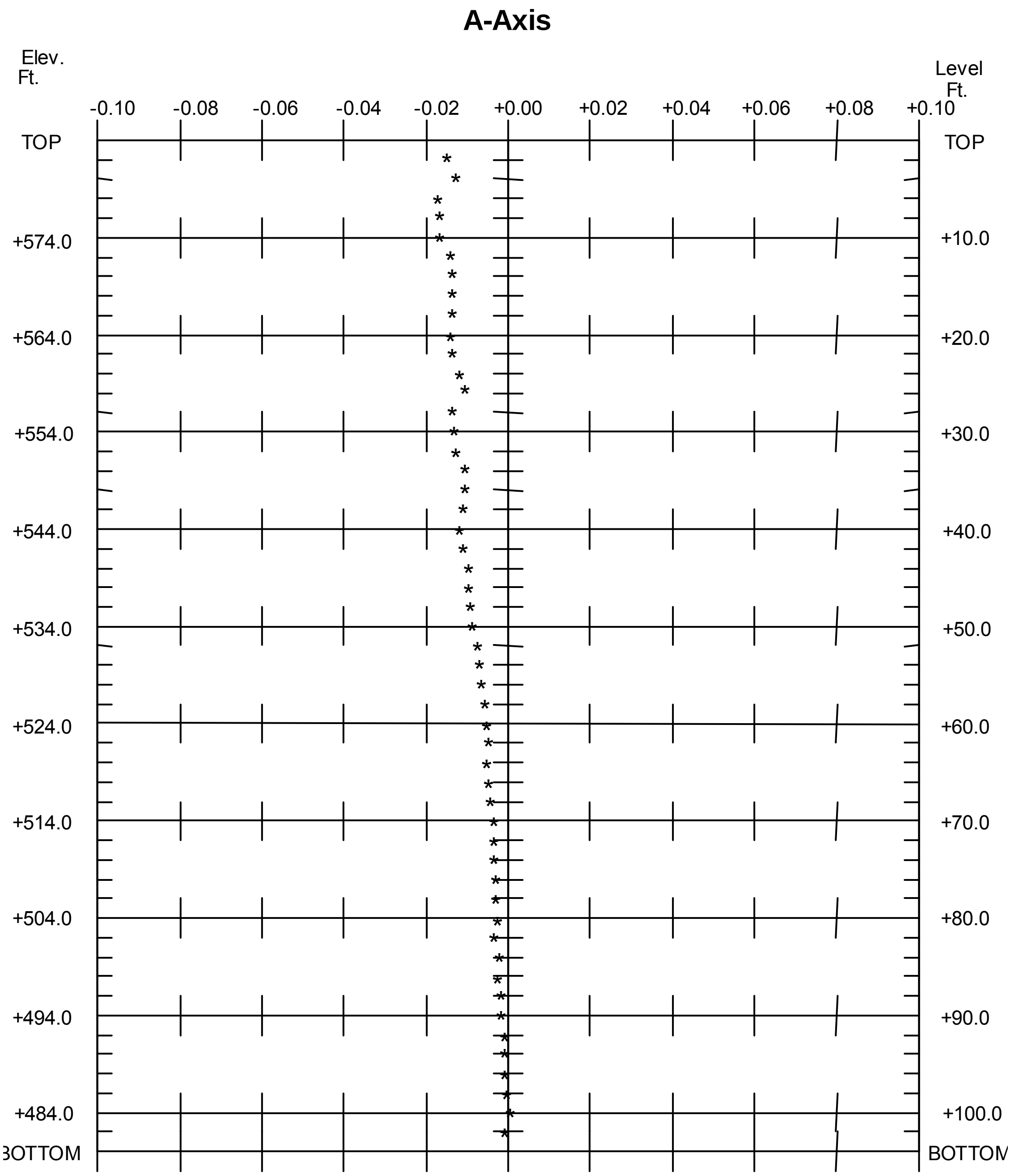
PLOT: A-Axis Change in Digits

```
--------------------------------------------------------------------------------------
           PROJECT NAME: Inclinometer Data
            HOLE NUMBER: IH01
          TOP ELEVATION: +584.0
--------------------------------------------------------------------------------------
 Actual Angle of Azimuth: +0.0          Computed Angle of Azimuth: +0.0
--------------------------------------------------------------------------------------
                          --Initial Data--    --Present Data--
              File Name:  TEST1               TEST2
           Reading Date:  01/05/94            01/06/94
           Reading Time:  09:19:02            09:39:18
           Probe Number:  01                  01
--------------------------------------------------------------------------------------
```



C.2.4. A-Axis Deflection in Inches Plot

```
PLOT:  A-Axis Deflection in Inches (Bottom Up,Fixed)

---------------------------------------------------------------------------------------
            PROJECT NAME: Inclinometer Data
             HOLE NUMBER: IH01
           TOP ELEVATION: +584.0
---------------------------------------------------------------------------------------
 Actual Angle of Azimuth: +0.0           Computed Angle of Azimuth: +0.0
---------------------------------------------------------------------------------------
                          --Initial Data--    --Present Data--
               File Name:  TEST1               TEST2
            Reading Date:  01/05/94            01/06/94
            Reading Time:  09:19:02            09:39:18
            Probe Number:  01                  01
---------------------------------------------------------------------------------------
```



C.3.1. A-Axis Instrument Check Report (Profile)

REPORT: A-Axis Instrument Check

```
--------------------------------------------------------------------------------------
            PROJECT NAME: Inclinometer Data
             HOLE NUMBER: IH01
           TOP ELEVATION: +584.0
--------------------------------------------------------------------------------------
 Actual Angle of Azimuth: +0.0          Computed Angle of Azimuth: +0.0
--------------------------------------------------------------------------------------
                           --Profile Data--
               File Name:  TEST1
            Reading Date:  01/05/94
            Reading Time:  09:19:02
            Probe Number:  01
--------------------------------------------------------------------------------------
```

Elev. Ft.	A+	A-	Sum	Shift	Corr. Shift	Level Ft.
+582.0	+142	-171	-29	-29	-29	+2.0
+580.0	+64	-79	-15	-15	-15	+4.0
+578.0	+14	-31	-17	-17	-17	+6.0
+576.0	+135	-155	-20	-20	-20	+8.0
+574.0	+167	-186	-19	-19	-19	+10.0
+572.0	+190	-212	-22	-22	-22	+12.0
+570.0	+216	-237	-21	-21	-21	+14.0
+568.0	+235	-255	-20	-20	-20	+16.0
+566.0	+166	-188	-22	-22	-22	+18.0
+564.0	+157	-175	-18	-18	-18	+20.0
+562.0	+142	-159	-17	-17	-17	+22.0
+560.0	+120	-138	-18	-18	-18	+24.0
+558.0	+103	-125	-22	-22	-22	+26.0
+556.0	+55	-72	-17	-17	-17	+28.0
+554.0	+30	-51	-21	-21	-21	+30.0
+552.0	+16	-36	-20	-20	-20	+32.0
+550.0	+1	-19	-18	-18	-18	+34.0
+548.0	-21	+3	-18	-18	-18	+36.0
+546.0	-55	+37	-18	-18	-18	+38.0
+544.0	-103	+82	-21	-21	-21	+40.0
+542.0	-155	+136	-19	-19	-19	+42.0
+540.0	-217	+196	-21	-21	-21	+44.0
+538.0	-263	+242	-21	-21	-21	+46.0
+536.0	-105	+82	-23	-23	-23	+48.0
+534.0	-122	+101	-21	-21	-21	+50.0
+532.0	-167	+145	-22	-22	-22	+52.0
+530.0	-213	+193	-20	-20	-20	+54.0
+528.0	-243	+222	-21	-21	-21	+56.0
+526.0	-114	+94	-20	-20	-20	+58.0
+524.0	-76	+56	-20	-20	-20	+60.0
+522.0	-69	+48	-21	-21	-21	+62.0
+520.0	-56	+34	-22	-22	-22	+64.0
+518.0	-47	+28	-19	-19	-19	+66.0
+516.0	-193	+168	-25	-25	-25	+68.0
+514.0	-230	+207	-23	-23	-23	+70.0
+512.0	-249	+228	-21	-21	-21	+72.0
+510.0	-263	+242	-21	-21	-21	+74.0
+508.0	-277	+257	-20	-20	-20	+76.0
+506.0	-313	+292	-21	-21	-21	+78.0
+504.0	-320	+301	-19	-19	-19	+80.0
+502.0	-335	+316	-19	-19	-19	+82.0
+500.0	-339	+320	-19	-19	-19	+84.0
+498.0	-329	+309	-20	-20	-20	+86.0
+496.0	-359	+342	-17	-17	-17	+88.0
+494.0	-381	+359	-22	-22	-22	+90.0
+492.0	-417	+396	-21	-21	-21	+92.0
+490.0	-473	+452	-21	-21	-21	+94.0
+488.0	-516	+496	-20	-20	-20	+96.0
+486.0	-302	+282	-20	-20	-20	+98.0
+484.0	-258	+237	-21	-21	-21	+100.0
+482.0	-265	+245	-20	-20	-20	+102.0

C.3.2. A-Axis Digits and Profile in Inches Report

REPORT: A-Axis Digits and Profile in Inches (Bottom Up,Fixed)

PROJECT NAME: Inclinometer Data
HOLE NUMBER: IH01
TOP ELEVATION: +584.0

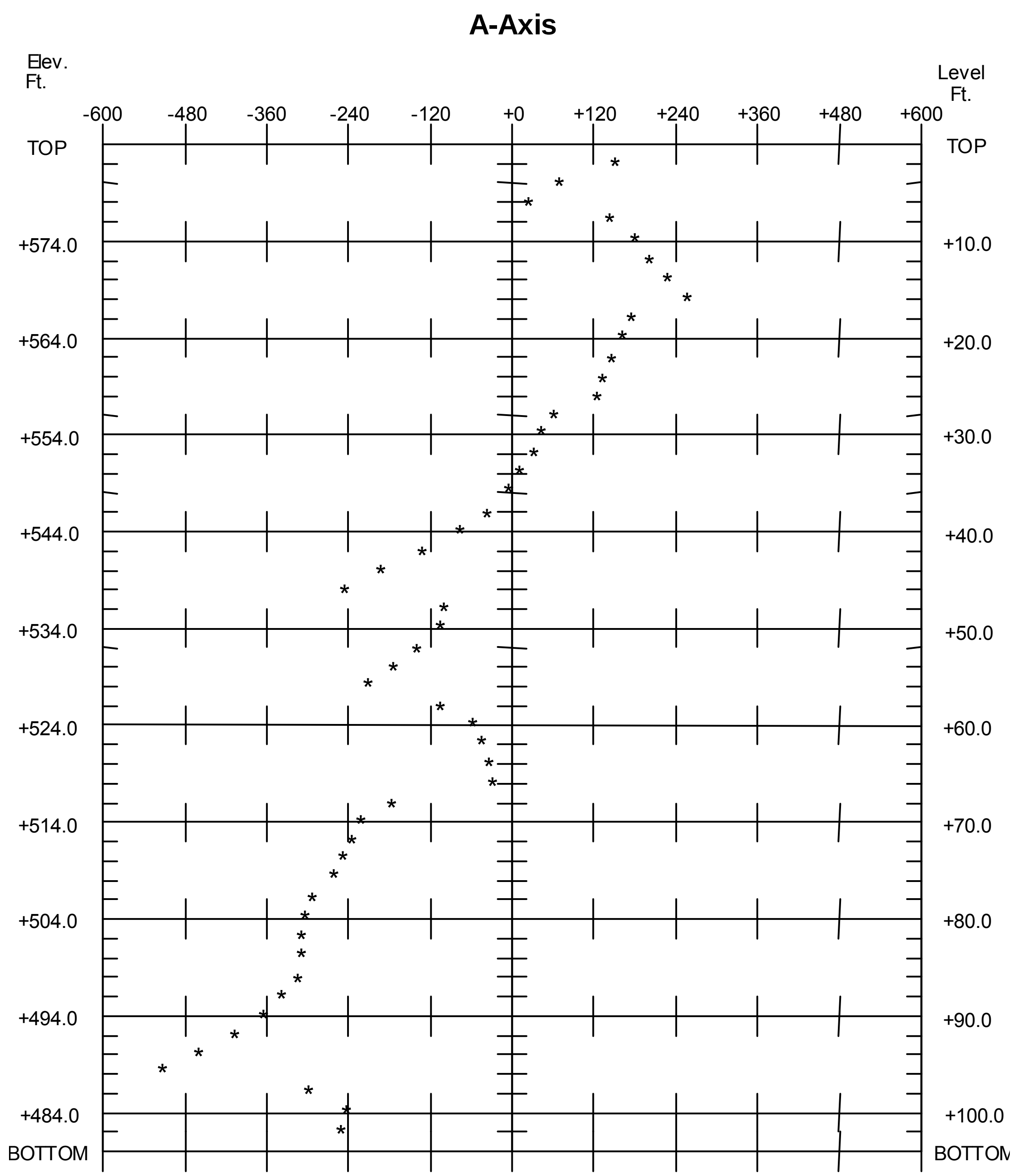
Actual Angle of Azimuth: +0.0 Computed Angle of Azimuth: +0.0

--Profile Data--
File Name: TEST1
Reading Date: 01/05/94
Reading Time: 09:19:02
Probe Number: 01

Elev. Ft.	----Profile Data---- A+	A-	Diff	Corr. Diff/2	Defl. Inches	Level Ft.
+582.0	+142	-171	+313	+157	-6.4506	+2.0
+580.0	+64	-79	+143	+72	-6.6384	+4.0
+578.0	+14	-31	+45	+23	-6.7242	+6.0
+576.0	+135	-155	+290	+145	-6.7512	+8.0
+574.0	+167	-186	+353	+177	-6.9252	+10.0
+572.0	+190	-212	+402	+201	-7.1370	+12.0
+570.0	+216	-237	+453	+227	-7.3782	+14.0
+568.0	+235	-255	+490	+245	-7.6500	+16.0
+566.0	+166	-188	+354	+177	-7.9440	+18.0
+564.0	+157	-175	+332	+166	-8.1564	+20.0
+562.0	+142	-159	+301	+151	-8.3556	+22.0
+560.0	+120	-138	+258	+129	-8.5362	+24.0
+558.0	+103	-125	+228	+114	-8.6910	+26.0
+556.0	+55	-72	+127	+64	-8.8278	+28.0
+554.0	+30	-51	+81	+41	-8.9040	+30.0
+552.0	+16	-36	+52	+26	-8.9526	+32.0
+550.0	+1	-19	+20	+10	-8.9838	+34.0
+548.0	-21	+3	-24	-12	-8.9958	+36.0
+546.0	-55	+37	-92	-46	-8.9814	+38.0
+544.0	-103	+82	-185	-93	-8.9262	+40.0
+542.0	-155	+136	-291	-146	-8.8152	+42.0
+540.0	-217	+196	-413	-207	-8.6406	+44.0
+538.0	-263	+242	-505	-253	-8.3928	+46.0
+536.0	-105	+82	-187	-94	-8.0898	+48.0
+534.0	-122	+101	-223	-112	-7.9776	+50.0
+532.0	-167	+145	-312	-156	-7.8438	+52.0
+530.0	-213	+193	-406	-203	-7.6566	+54.0
+528.0	-243	+222	-465	-233	-7.4130	+56.0
+526.0	-114	+94	-208	-104	-7.1340	+58.0
+524.0	-76	+56	-132	-66	-7.0092	+60.0
+522.0	-69	+48	-117	-59	-6.9300	+62.0
+520.0	-56	+34	-90	-45	-6.8598	+64.0
+518.0	-47	+28	-75	-38	-6.8058	+66.0
+516.0	-193	+168	-361	-181	-6.7608	+68.0
+514.0	-230	+207	-437	-219	-6.5442	+70.0
+512.0	-249	+228	-477	-239	-6.2820	+72.0
+510.0	-263	+242	-505	-253	-5.9958	+74.0
+508.0	-277	+257	-534	-267	-5.6928	+76.0
+506.0	-313	+292	-605	-303	-5.3724	+78.0
+504.0	-320	+301	-621	-311	-5.0094	+80.0
+502.0	-335	+316	-651	-326	-4.6368	+82.0
+500.0	-339	+320	-659	-330	-4.2462	+84.0
+498.0	-329	+309	-638	-319	-3.8508	+86.0
+496.0	-359	+342	-701	-351	-3.4680	+88.0
+494.0	-381	+359	-740	-370	-3.0474	+90.0
+492.0	-417	+396	-813	-407	-2.6034	+92.0
+490.0	-473	+452	-925	-463	-2.1156	+94.0
+488.0	-516	+496	-1012	-506	-1.5606	+96.0
+486.0	-302	+282	-584	-292	-0.9534	+98.0
+484.0	-258	+237	-495	-248	-0.6030	+100.0
+482.0	-265	+245	-510	-255	-0.3060	+102.0

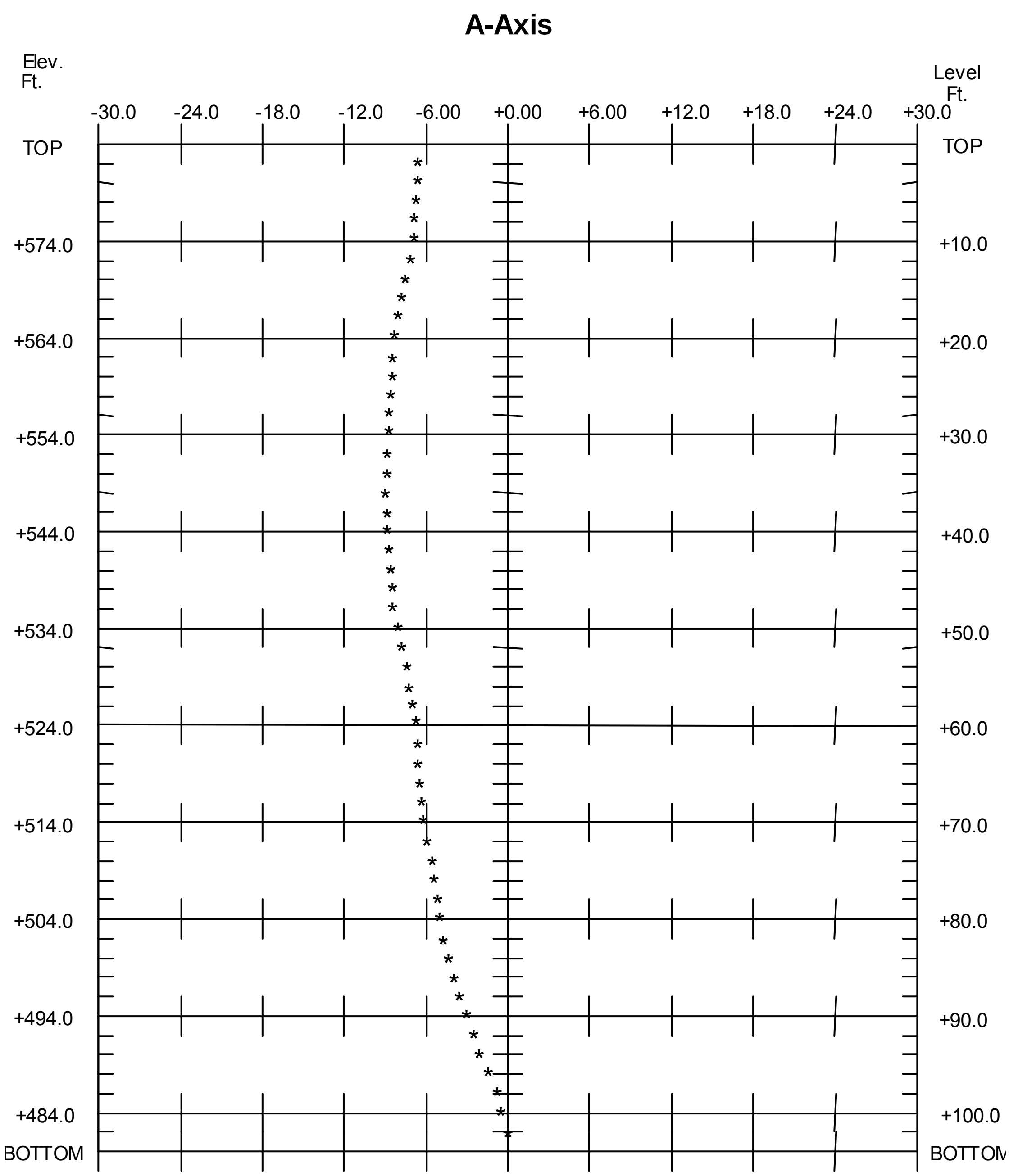
C.3.3. A-Axis Profile in Digits Plot

```
      PLOT:  A-Axis Profile in Digits

--------------------------------------------------------------------------------------
            PROJECT NAME: Inclinometer Data
             HOLE NUMBER: IH01
           TOP ELEVATION: +584.0
--------------------------------------------------------------------------------------
 Actual Angle of Azimuth: +0.0          Computed Angle of Azimuth: +0.0
--------------------------------------------------------------------------------------
                           --Profile Data--
               File Name:  TEST1
            Reading Date:  01/05/94
            Reading Time:  09:19:02
            Probe Number:  01
--------------------------------------------------------------------------------------
```



C.3.4. A-Axis Profile in Inches Plot

```
       PLOT:  A-Axis Profile in Inches (Bottom Up,Fixed)

--------------------------------------------------------------------------------
            PROJECT NAME: Inclinometer Data
             HOLE NUMBER: IH01
           TOP ELEVATION: +584.0
--------------------------------------------------------------------------------
 Actual Angle of Azimuth: +0.0           Computed Angle of Azimuth: +0.0
--------------------------------------------------------------------------------
                               --Profile Data--
               File Name:  TEST1
            Reading Date:  01/05/94
            Reading Time:  09:19:02
            Probe Number:  01
--------------------------------------------------------------------------------
```



APPENDIX D - CONNECTOR AND CABLE WIRING

D.1. Connectors (on GK-603 front panel)

D.1.1. 10 Pin Bendix RS232 Connector

Pin	Name	Description	Wire Color (from J4)
A	SGND	System Ground	Brown
B	TXD	Transmit Data	Red
C	RXD	Receive Data	Orange
D	RTS	Request to Send	Yellow
E	CTS	Clear to Send	Green
F	SGND	System Ground	Blue
G	DTR	Data Terminal Ready	Purple
H	V+	+5 VDC Supply	Grey
J	SW_SEL	Switch Select	White
K	REZZUB	Buzzer Enable	Black

D.1.2. 6 Pin Lemo Sensor Connector

Pin	Name	Description	Wire Color (from J3)
1	+12PROBE	+12 VDC Probe Supply	Brown
2	-12PROBE	-12 VDC Probe Supply	Red
3	PGND	Power Ground	Orange
4	VA	A Axis Input	Yellow
5	VB	B Axis Input	Green
6	AGND	Analog Ground	Blue

D.1.3. 3 pin Bendix Charger Connector

Pin	Name	Description	Wire Color
A	SGND	System Ground	Black
B	+12_IN	External Power Input (12-14 VDC)	Red
C	+CHG_IN	Charger Input (14-22 VDC)	White

D.2. Cables

D.2.1. RS-232 Cable

10 Pin Bendix (RS232)	Belden Wire Color	DB-25 (female)	DB-9 (female)
A	Brown	7	5
B	Red	2	3
C	Orange	3	2
D	Yellow	4	7
E	Green	5	8
G	Violet	20	4

D.2.2. Diconix 180si Printer Cable

10 Pin Bendix (RS232)	Belden Wire Color	DB-25 (male)
A	Brown	7
B	Red	2
C	Orange	3
D	Yellow	4
E	Green	5,6,8
G	Violet	20

D.2.3. Canon BJ-30 Printer Cable

10 Pin Bendix (RS232)	Belden Wire Color	DB-25 (male)
A	Brown	7
B	Red	3
C	Orange	2
E	Violet	20
H	Grey	20

D.2.4. Remote Switch Cable

10 Pin Bendix (RS232)	Wire Color	To
A	Black	Remote Switch
H	White	Remote Buzzer +
J	Red	Remote Switch
K	Green	Remote Buzzer -

D.2.5. Charger (110VAC/220VAC) Cable

Pin	Wire Color	Description
A	Black	Ground
C	Black with White Stripe	Positive

D.2.6. External Power Cable

Pin	Wire Color	Description	Clip
A	Black	Ground	Black
B	Black with White Stripe	Positive	Red

APPENDIX E - DATA REDUCTION FORMULAS

E.1. Deflection Calculation

<table>
<tr><th>Label</th><th>Description</th></tr>
<tr><td>Z</td><td>Actual Angle of Azimuth.</td></tr>
<tr><td>ZY</td><td>Computational Angle of Azimuth.</td></tr>
<tr><td>ZZ</td><td>Correction Angle (usually 0°).</td></tr>
<tr><td>RINT</td><td>Absolute Reading Interval in feet or meters.</td></tr>
<tr><td>IA+,IA–</td><td>Initial A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).</td></tr>
<tr><td>PA+,PA–</td><td>Present A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).</td></tr>
<tr><td>IB+,IB–</td><td>Initial B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).</td></tr>
<tr><td>PB+,PB–</td><td>Present B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).</td></tr>
<tr><td>SA</td><td>Calculated Digit Change for A Axis.</td></tr>
<tr><td>SB</td><td>Calculated Digit Change for B Axis.</td></tr>
<tr><td>M</td><td>Multiplier, where:<table>
<tr><td>Probe config.</td><td>2sin θ</td><td>2.5sin θ</td></tr>
<tr><td>metric (mm)</td><td>0.025</td><td>0.02</td></tr>
<tr><td>imperial (in)</td><td>0.0003</td><td>0.00024</td></tr>
</table></td></tr>
<tr><td>CA</td><td>Deflection A (in inches, English units, not corrected).
Deflection A (in centimeters or millimeters, Metric units, not corrected).</td></tr>
<tr><td>CB</td><td>Deflection B (in inches, English units, not corrected).
Deflection B (in centimeters or millimeters, Metric units, not corrected).</td></tr>
<tr><td>DA</td><td>Deflection A (in inches, English units, corrected for angle).
Deflection A (in centimeters or millimeters, Metric units, corrected for angle).</td></tr>
<tr><td>DB</td><td>Deflection B (in inches, English units, corrected for angle).
Deflection B (in centimeters or millimeters, Metric units, corrected for angle).</td></tr>
<tr><td>cos</td><td>Cosine function.</td></tr>
<tr><td>sin</td><td>Sine function .</td></tr>
</table>

Table E-1 Data Reduction Variables (Deflection)

$$SA = ((PA+)-(PA-))-((IA+)-(IA-))$$
$$SB = ((PB+)-(PB-))-((IB+)-(IB-))$$

Equation E-1 Change in Digits Calculation (Deflection)

$$CA = M \times RINT \times SA$$
$$CB = M \times RINT \times SB$$
$$DA = (CA \times \cos(ZZ))+(CB \times \sin(ZZ))$$
$$DB = (CA \times \sin(ZZ))+(CB \times \cos(ZZ))$$

Equation E-2 Deflection Calculation

Note: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the deflection change (Figure 1.1-3).

E.2. Profile Calculation

Label	Description
Z	Actual Angle of Azimuth.
ZY	Computational Angle of Azimuth.
ZZ	Correction Angle (usually 0°).
RINT	Absolute Reading Interval in feet or meters.
A+, A–	A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).
B+, B–	B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).
SA	Calculated Digit Change for A Axis.
SB	Calculated Digit Change for B Axis.
M	Multiplier, where: Geokon probe / Sinco Probe Probe configuration: 2sinθ, / 2.5sinθ. Metric units, millimeters: 0.05 / 0.04 Metric units, centimeters: 0.005 / 0.004. Imperial units, inches: 0.0006 / 0.00048
CA	Deflection A (in inches, English units, not corrected). Deflection A (in centimeters or millimeters, Metric units, not corrected).
CB	Deflection B (in inches, English units, not corrected). Deflection B (in centimeters or millimeters, Metric units, not corrected).
DA	Deflection A (in inches, English units, corrected for angle). Deflection A (in centimeters or millimeters, Metric units, corrected for angle).
DB	Deflection B (in inches, English units, corrected for angle). Deflection B (in centimeters or millimeters, Metric units, corrected for angle).
cos	Cosine function.
sin	Sine function .

Table E-2 Data Reduction Variables (Profile)

```
SA = ((A+)-(A-))/2
SB = ((B+)-(B-))/2
```

Equation E-3 Change in Digits Calculation (Profile)

```
CA = M × RINT × SA
CB = M × RINT × SB
DA = (CA × cos(ZZ))-(CB × sin(ZZ))
DB = (CA × sin(ZZ))+(CB × cos(ZZ))
```

Equation E-4 Profile Calculation

Note: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the profile.

E.3. GTILT Users

When using GTILT with the GK-603 use a Probe Constant of 10000 for both English and Metric probes when using 2.0sin Units! For 2.5sin Units use a Probe Constant of 12500.

APPENDIX F - RS-232 COMMUNICATION COMMANDS

The GK-603 supports a number of commands entered directly via the RS-232 interface from the host computer. Follow these steps to make the RS-232 connection:

1. Connect the GK-603 and host computer with the supplied RS-232 cable.
2. Run a telecommunications program on the host computer (such as Hyperterminal (see Appendix K Page 65)) to allow RS-232 communication.
3. Press <Enter> a few times on the host computer to verify proper connection. Asterisks will be returned by the GK-603 if the connection is made. Communication parameters are 1200 or 9600 baud, 8 data bits, 1 stop bit, no parity, XON/XOFF handshaking enabled. ***Note: Type all commands in capital letters followed by <Enter>.*** If a command has been entered incorrectly usually there will be no acknowledgment from the GK-603.

Table F-1 lists the available RS-232 commands.

Command	Description
`B`	Returns the current baud rate setting. Use `Bnnnn` to set the baud rate.
`Bnnnn`	Set the baud rate of the RS-232 communications where `nnnn`= 1200 or 9600 for 1200 or 9600 baud, respectively. Note: To change from 9600 baud to 1200 baud you must enter the command while communicating at 9600 baud! Thereafter, all communications must be at 1200 baud. This setting is retained at power off.
`C`	Return the current clock values of the GK-603. For example; **`*C`** **`Date: 02/21/96  Time: 09:28:52`** **`*`**
`CFDnn`	Deletes the configuration file specified by `nn`. Use `CFL` to list the stored configuration files.
`CFDALL`	Deletes all the configuration files in memory. Be sure you want to do this as there is no prompt to check your intentions!
`CFL`	List the stored configuration files.
`CFRnn`	Receive a configuration file from the host computer and store it in file location nn. The GK-603 will allocate a file location (if one is available) if no number is specified.
`CFSnn`	Send the configuration file nn to the host computer.
`CFSALL`	Send all the configuration files stored in the GK-603 to the host computer.
`CSmm/dd/yy/hh:mm:ss`	Set the clock of the GK-603, where; `mm` = month `dd` = day `yy` = year `hh` = hour `mm` = minutes `ss` = seconds For example; **`*C`** **`Date: 02/21/96  Time: 09:28:52`** **`*CS///10:30`** **`Date: 02/21/96  Time: 10:30:10`** **`*`**

Table F-1 RS-232 Commands

Command	Description
DFDnn	Deletes the data file specified by nn. Use DFL to list the stored data files.
DFDALL	Deletes all the data files in memory. Be sure you want to do this as there is no prompt to check your intentions! For example; ***DFDALL** **Data files deleted.** *****
DFL	List the stored data files.
DFRnn	Receive a data file from the host computer and store it in file location nn. The GK-603 will allocate a file location (if one is available) if no number is specified.
DFSnn	Send the data file nn to the host computer.
DFSALL	Send all the data files stored in the GK-603 to the host computer.
E	End communications and power the GK-603 off.
H or ?	Display help on RS-232 commands.
Kn	Simulate a frontpanel key being pressed, where; n=1, ▲ on joystick n=2, ▼ on joystick n=3, ◀ on joystick n=4, ▶ on joystick n=5, <SELECT/STORE> n=6, <MENU/ESCAPE>
M	Returns the current status of file storage memory. For example; ***M** **Sectors free: 747** **Sectors used: 153** **Memory used: 17.0%** ***** The maximum number of sectors is 892. See Appendix G for more information.
MT	Test the current use of memory by the GK-603. This command will sort through all the stored files, both configuration and data, and make sure that they are complete and using memory properly. If any discrepancies are found between the memory usage indicated by a particular file and the actual memory of the GK-603 the file is deleted and the sectors used and sectors free pointers are corrected.
PO	Returns the current power off setting in minutes. Use POnn to set. Default is 15.
Ponn	Sets the power off time in minutes. The range is between 0 and 38 minutes. Setting the power off time to 0 minutes disables auto power off. In that event the readout will only power off when the main battery goes below 10.5 volts.
R	Resets all internal settings and memory of the GK-603. Warning! All configuration and data files will be erased! User will be asked to confirm, press Y, N or <Escape>. Note: Clock information is not affected. For example; ***R** **Are you sure(Y/N)? Y** **Memory cleared.** *****
S	Returns the status of various system settings of the GK-603. See Table F-2.
SV	Returns the installed software version. This number is stored in all configuration and data files and can be found in the header section of configuration or data files.
Z	Returns the current contrast value (between 0 and 255) of the LCD contrast circuit.
Znnn	Set the contrast value for the LCD contrast circuit, where n = 0-255. In low light conditions a higher value may produce a more easily read screen. In bright light a lower value may be more suitable. The factory default is 128.

Table F-1 RS-232 Commands (continued)

Command Reply	Description

`*S`
`Signature of RAM1: 42811`
`Signature of RAM2: 45327`
`Signature of RAM3: 1423`
`Signature of RAM4: 14235`
`Signature of ROM1: 61069`
`Signature of ROM2: 39969`
`Trap count: 0`
`CY325 read errors: 0`
`CY325 write errors: 0`
`Battery check counter: 190`
`Power off time: 0 minute(s)`
`Sectors free: 747`
`Sectors used: 153`
`Memory used: 17.0%`
`*`
	The signatures are a test of the contents of memory and the sequence of the contents. Each memory bank consists of 32K bytes of storage. This command is useful particularly for the ROM1 and ROM2 portions of memory. Checking the values reported against the factory default for that version of software is a good check of whether the operating system software of the GK-603 has been corrupted (not very likely).
	
	The trap count is a record of the number of times the system has "bombed". Occasionally this may occur because of static electricity, electrical interference, or power outages. This counter is reset by the "R" command.
	
	The CY325 read and write errors are counters for any errors encountered between the processor of the GK-603 and the LCD controller. These errors occur periodically and are not necessarily indicative of any problem with the unit. These counters are reset by the "R" command.
	
	The battery check counter indicates when the next check of the battery voltage is to be made. When the counter reaches 1687 (exactly) the battery voltage is checked. If the voltage is below 11.5 volts the backlight begins flashing on and off. If the voltage is below 10.5 volts the unit will power off. In that event the current dataset will be lost.
	
	The power off time is the same value as that returned by the "PO" command.
	
	The sectors free, sectors used pointers and the memory used percentage is the same as returned by the "M" command.

Table F-2 "S" Command

APPENDIX G - GK-603 MEMORY USAGE

The GK-603 dynamically allocates memory, in the form of 128 byte sectors, to store configuration and data files. How many sectors are required for a particular file depends on a number of factors such as the type of file, whether configuration or data, whether fixed or variable intervals are used, and how many levels of data there are.

There are a total of 892 sectors available for file storage. All data points, whether intervals or readings, require 4 bytes of memory.

To calculate how many sectors are required for a particular file note the following guidelines:

- The header information of a file, whether configuration or data, requires 1 sector.
- If variable intervals are used, sectors must be allocated to store the intervals. Each interval is a 4 byte floating point value hence, 32 intervals can be stored in each sector. If the sector is only partially used the remaining bytes are wasted. No additional sectors are needed if fixed intervals are used.
- Each array of level data consists of 4 floating point values, A+, A-, B+ and B-. Hence, 16 bytes are required for each level, 8 levels can be stored per sector ($16 \times 8 = 128$).

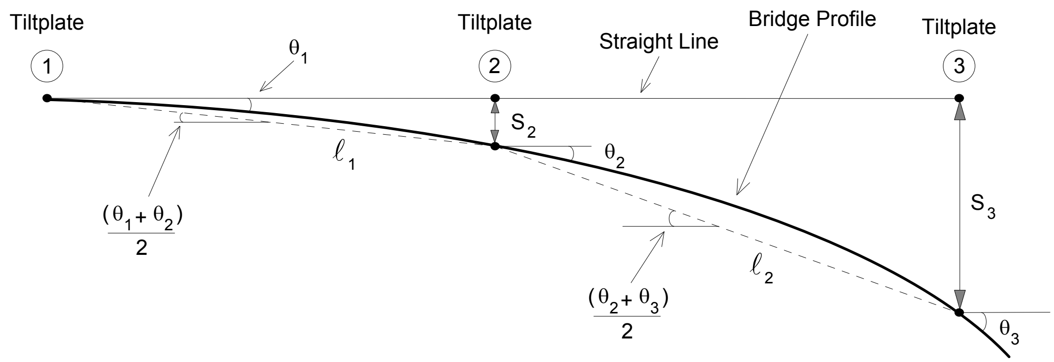
For example, let's calculate how many fixed interval data files consisting of 125 levels per file can be stored by the GK-603.

1. The header requires 1 sector.
2. Fixed intervals are used so no sectors are required for storing interval data.
3. With 125 levels, 16 sectors are required to store the readings. A portion (48 bytes) of the last sector will be wasted.
4. Each data file requires 17 sectors of memory so the GK-603 can store 52 (892/17) of the above described files. There will be 8 sectors left over that could be used to store up to 8 configuration files (fixed intervals that is).

APPENDIX H - USING THE GK-603 WITH THE MODEL 6201 TILTMETER

H.1. Theory

The GK-603 can be used to measure and display the deflection of bridges as measured by a series of Model 6201 tiltmeters placed at intervals in strings along the bridge. The calculation of deflection is performed as follows:



The vertical deflection of Tiltplate 1 is assumed to be zero
The vertical deflection of Tiltplate 2 is given by:

$$S_2 = \ell_1\left(\frac{\sin\theta_1 + \sin\theta_2}{2}\right)$$

The vertical deflection of Tiltplate 3 is given by:

$$S_3 = \ell_1\left(\frac{\sin\theta_1 + \sin\theta_2}{2}\right) + \ell_2\left(\frac{\sin\theta_2 + \sin\theta_3}{2}\right)$$

and the vertical deflection of Tiltplate 4 is given by:

$$S_4 = \ell_1\left(\frac{\sin\theta_1 + \sin\theta_2}{2}\right) + \ell_2\left(\frac{\sin\theta_2 + \sin\theta_3}{2}\right) + \ell_3\left(\frac{\sin\theta_3 + \sin\theta_4}{2}\right)$$

etc.

Notice that the method of analysis assumes that Tiltplate 1 suffers no vertical deflection. If there is any doubt about this then it should be confirmed by regular surveying techniques. It would probably be good practice to extend the tiltplate strings outwards onto the bridge abutments, i.e., onto solid ground at both ends, if possible.

Notice also that the method of analysis assumes that the bridge deflection is a series of straight line segments, and that the angular displacement of each segment is the average of the angular displacement measured at the two ends of the segment. Since the bridge does not really deflect in this way, there will be some error in this approximation. But the assumptions are necessary if a tiltmeter and tiltplates are to be used for measuring deflection in this way.

H.2. System Settings

First, the system settings (Option 5 of the Main Menu) should be adjusted. Follow the instruction to set the proper time and, using Option 4, set the Probe Type to "`10v/g`" if a Geokon Model 6201 Tiltmeter is being used. Using Option 5, set the System Units to either "`Metric`" or "`English`".

H.3. Setting Up the Configuration

The configuration of the tiltplates needs to be set into the GK-603 and specifically this means entering the measured distances between adjacent tiltplates in the string of tiltplates. So, the first task is to measure these distances to an accuracy of 0.1 meters or 0.1 ft.

Once the distance has been measured, the following table should be constructed:

length between Tiltplate 1 and Tiltplate 2 = ℓ_1 =
length between Tiltplate 2 and Tiltplate 3 = ℓ_2 =
length between Tiltplate 3 and Tiltplate 4 = ℓ_3 =
length between Tiltplate 4 and Tiltplate 5 = ℓ_4 =
length between Tiltplate n-1 and Tiltplate n = ℓ_{n-1} =

where Tiltplate n is the last tiltplate.

Now it is necessary to calculate the distances between Tiltplate 1 and all the other tiltplates, i.e.:

distance between Tiltplate 1 and Tiltplate 2 = $D_1 = \ell_1$
distance between Tiltplate 1 and Tiltplate 3 = $D_2 = \ell_1 + \ell_2$
distance between Tiltplate 1 and Tiltplate 4 = $D_3 = \ell_1 + \ell_2 + \ell_3$
distance between Tiltplate 1 and Tiltplate 5 = $D_4 = \ell_1 + \ell_2 + \ell_3 + \ell_4$

distance between Tiltplate 1 and Tiltplate n = $D_n = \sum_{i=1}^{n} \ell_i$

These numbers are used later when entering the "Level" during configuration set-up.

The distances will take some time to enter, but it is a procedure that only needs to be done once and then saved. Also, it can be done in the office.

.

Use the following procedure:

1. Select "Take Readings" on the main menu.
2. Select "Reading Screen" and give the project a name, e.g., the name of the bridge.
3. Use the "Hole Number" prompt to assign a number to the string of tiltplates to be surveyed, e.g., "String 1".
4. The probe number can be the serial number of the Model 6201 Tiltmeter being used.
5. Leave the starting level at zero so that all vertical deflections will be calculated relative to Tiltplate 1.
6. "Interval Type" - here it is important to select "VARIABLE".
7. "Reading Interval" - select 0.1.

   This will allow the distance to be entered with an accuracy of 0.1 meter or 0.1 ft. depending upon the units selected earlier.
8. Save Configuration - leave this at "NO". Even though the configuration will be saved it will be done later after the distances have been entered.
9. The Readings Screen - will now be displayed and the level will be at zero and the Set Number (the number in the square top right) will be at 1. Now press Store. This will set Tiltplate number one at the zero starting point.

   The level will remain at zero, but the Set Number will increase to 2. Depress the Store button once again. The Set Number will go back to 1 and the level will now increase by 0.1, but it now needs to be increased further by holding the joystick upwards until the level number displayed is equal to the distance D_1 (i.e., the distance between Tiltplates 1 and 2). Now depress the Store button. The level will remain the same, but the Set Number will increase to 2. Depress the Store button again and the level will again increase by 0.1 and the Set Number will revert to 1. Increase the level by holding the joystick upwards until the level number displayed is equal to D_2 (i.e., the distance between Tiltplates 1 and 3). Now, depress the Store button twice.

   Repeat this process for D_3, D_4, etc. all the way to D_n.

   Be very careful not to make a mistake during this initial configuring or it will be necessary to go right back to the beginning and start over. Also, try not to overshoot the next level number or you will have to return to the preceding level.
10. When all the levels have been entered, use the joystick to confirm correct entry of all the values, then press Escape and then select Option 3, Modify Configuration, and keep pressing the Store button until "Save Config?" is displayed; now with the joystick, select "Yes" and press Store.
11. Give the file a name such as Bridge-1, i.e., one which identifies the Bridge and the number of the tiltplate string.
12. Again, press Store and now the configuration is stored in memory and can be recalled quickly at any time.
13. Repeat the process for all the strings of tiltplates on the bridge.

H.4. Taking Readings

Readings are taken by connecting the GK-603 Readout Box to a Model 6201 Tiltmeter which is then positioned on each of the tiltplates fastened to the bridge. It will be a good idea to write the level number on the tiltplate, i.e., write zero on Tiltplate 1, write the distance (level) D_1 on Tiltplate 2, etc. This will be helpful in avoiding confusion during the reading process.

1. Tiltplates should be positioned horizontally so that their 1.3 axis is aligned with the length of the bridge. Follow the instructions of the tiltmeter manual to position the tiltmeter on top of Tiltplate 1 with the + Axis next to the #1 pin.

   Switch on the GK-603 Readout Box and select the Take Readings option.

   Now select Option 2 "Load Config?".

   Now, select the previously stored configuration for that particular string of tiltplates and immediately the Readings screen will appear with the level at zero and the Set Number (the number in the top right-hand square) will be at "1". Store the tilt reading by pressing the Store button.

2. The level will remain the same, but the Set Number will change to 2 in readiness for the 180° reading. Turn the tiltmeter through 180° and replace it once again on the tiltplate in the 1.3 direction, this time with the + sign next to Pin 3. Now, depress the Store button.

3. The level number will now jump to the next level and the Set Number will revert to 1 in readiness for the next pair of readings at the next tiltplate. **CAUTION: LEAVE THE GK-603 READOUT BOX SWITCHED ON** at all times during the survey of the string of tiltplates. DO NOT switch off the box or the tiltmeter readings stored in memory will be lost. If the survey is interrupted and the readout box needs to be switched off, always remember to save the data first following the procedures described in the GK-603 manual.

4. Move to the next tiltplate. Confirm that the level number written on the tiltplate is the same as that showing on the GK-603 display screen.

   Set the tiltmeter onto the tiltplate in the 1-3 direction with the + Axis next to Pin 1.

   Again, confirm that the Set Number is at 1 and that the level reading displayed is the same as that written on the tiltplate. Now, store the tilt reading.

5. Reverse the tiltmeter so that the +A direction is next to Pin 3. Confirm that the level reading is correct and that the Set Reading is at 2. Now, depress the Store Reading.

6. Repeat the process described in Sections 4.4 and 4.5 for all the tiltplates, being careful at all times to see that the correct Level Number and Set Number are displayed before storing the reading. Do not switch off the readout box at any time during the survey as all the data will be lost.

   If mistakes are made at any tiltplate it is always possible to go back to that tiltplate, manipulating the control so that the proper level and set readings are visible, and then depress the Store button, writing over and correcting any faulty readings already stored.

7. When all the readings have been correctly stored, depress the Escape button and select Save Data File, giving the file a unique name and number, and press Store button.

H.5. Analyzing the Data

The readings are analyzed in a way described in the GK-603 manual.

H.5.1. Profiles

Actual profiles of the bridge relative to a longitudinal straight line running through the first tiltplate station can be obtained by selecting:

Step	SCREEN	OPTION
a.	MAIN Menu	Option 2 - Data reduction
b.	Data Reduction	Option 1 - Load data files
c.	Profile Data	Select the file where the initial readings are stored
d.	Data Reduction	To print reports, select Option 2 To view or print profile, select Option 3
e.	View/Print Plots	Select A-axis profile
f.	View or Print	Select, view or press joystick for print

You will need to connect a printer to the RS232 connection to obtain plots.

H.5.2. Deflections

To calculate, print, and plot deflections, it is necessary first to go to the Data Reduction screen and select Option 5, Config Reduction. Now select Option 3, Type:- and hit the Select button to change from Profile to Deflection. Now escape back to the Load Data file option in the Data Reduction screen.

a. Select the Initial Data File

b. then Select the Present Data File

c. Now, print Reports or View/Print Plots of deflection as before.

APPENDIX I- CHECK-SUMS and "FACE ERRORS" ON INCLINOMETER PROBES

I-1 Introduction

Many users have expressed concern about **check-sums or "face errors"** on inclinometer probes. They are concerned with the affect of the "face error" on the accuracy of the readings. The purpose of this appendix is to show that under normal circumstances the affect of the "face error" or checksum is negligible even with check-sums as large as 2000. **The only time a problem would arise is if the face error or check-sum was to change between the two halves of a survey**. **This is why it is extremely important to not bang the probe on the bottom of the borehole between survey halves, and to not handle the probe roughly while out of the hole.**

The term "face error" comes from surveying terminology. It is normal for all theodolites to have a "face error" which is caused by imperfections of alignment of the collimation axis and other misalignments. These "face errors" are removed routinely by taking two readings of the theodolite: one angle is measured with the face of the vertical scale on the left of the theodolite and another with the face of the vertical scale on the right of the theodolite. The average of the two readings "face right" and "face left" gives the true angle since the "face error" cancels out.

Similarly with the inclinometer probe: the "face error" arises from the fact that the axis of the inclinometer probe is not parallel with the electrical axis of the internal, force-balance, servo-accelerometer transducer. Once again the "face error" is eliminated by taking two surveys of inclinometer readings one with the wheels of the inclinometer probe pointing in one direction and another with the wheels of the probe at 180° to the first direction. If the first set of readings are all too large by the amount of the "face error" then the second set of readings will be too small by the amount of the "face error" and the average or sum of the two readings will be a measure of the true inclination since the affect of the face error will be totally eliminated.

I-2 The Effect of the "Face Error" on the accuracy of the readings

The "face error" or check-sum can only affect the accuracy of the readings if it affects the calibration of the probe. This is possible because the output of the probe transducer is proportional to the sine of the inclination from the vertical and the sine function is non-linear.

Imagine, for a moment, that the electrical axis of the transducer is five degrees away from being parallel with the axis of the inclinometer. This would give rise to a "face error" of 01743. (The inclinometer reader displays 20,000 sin ∅). So, one set of readings would be all too large by this amount and the other set of readings from a normal inclinometer survey would be too small by this amount, but the sum of the two readings would be accurate. The "face errors" having canceled out. However, if we assume that the hole is almost vertical then the transducer will be tilted at an angle of 5 °. The difference in the slope of the sine function at any point is equal to the cosine of the angle at that point. The cosine of 0 ° is 1.0000 the cosine of 5 ° is 0.996 so that the effect of this "face error" on the calibration of the probe is to increse it by a factor of 1/0.996 = 1.004.

The practical implication of this would mean that if the apparent deflection of a borehole was 100 mm, the true deflection would be 100.4 mm. For practically all applications, in the real world, the difference is insignificant and is a lot less than the differences which normally occur from survey to survey i.e. a lot less than the precision of the inclinometer probe survey. (Lack of precision is caused by a failure to position the wheels of the probe in exactly the same place from survey to survey; failure to wait sufficiently long to allow the probe transducer to come to rest before reading; and random dirt in the inclinometer casing).

Note that the normal system accuracy of an inclinometer probe is ± 7 mm in 30 meters. By comparison it can be seen that the normal system accuracy or precision is very much larger than the calibration error caused by the "face error" and that for all practical purposes the "face error" is of no consequence and can be completely discounted if it is less than 2000 digits.

(As another example , supposing the check-sum was as large as 5000 digits. This is equivalent to a gross angular error of misalignment of almost 15 degrees. The effect on the calibration would be a little over 3 % so that the apparent deflection of 100 mm would be out by 3 mm which again is smaller than the normal data spread due to imprecision).

I-3 Measurement of the "Face Error"

The "face error" is the reading shown by the inclinometer probe when it is perfectly vertical. In practice , the easiest way to obtain the "face error" is to run a normal inclinometer survey, with the two sets of readings at 180 °, and then to run a "check sum" report. (see section 3.2.2.1) Examination of the data will reveal **the average check sum which is equal to twice the "face error."**

I-4 Setting of the "Face Error" to zero

There are three ways of setting the "face error" to zero. None of them are necessary from the point of view of improving accuracy.

I-4.1 Mechanically

At the time of manufacture the electrical axis of the transducer is adjusted by means of shims etc., until it points parallel to the axis of the inclinometer probe. This method suffers from the disadvantage that if the "face error" changes due to wear and tear on the probe and rough handling, shock loading of the transducer then the probe needs to be returned to the factory for dismantling and re-adjustment.

I-4.2 Electrically

Electronic circuitry can be included in the probe so that the output of the transducer can be adjusted to zero when the probe is vertical. The disadvantage of this method is that it introduces electronic components into the inside of the probe which may alter with time, temperature and humidity and which, if the "face error" changes due to wear and tear or rough handling, will require the probe to be dismantled and the electronic circuitry readjusted. Also, this form of correction only masks the "face error". It does not really remove it and if the "face error" is very large the calibration will be affected as described in Section I-2.

I-4-3 By software

The best way for setting the "face error" to zero is by applying an automatic correction to the measured readings using the software capabilities of the inclinometer readout box.

The procedure for setting the face error to zero is described in section 3.5.4.3 and 3.5.4.4 which covers the subject of "Zero shifts" which are the same as "face errors". The advantage of this method lies in it's simplicity and the ability to set the "face error" to zero at any time without dismantling the probe. This is the method chosen by Geokon.

Another advantage of this method is that it is possible by judicious choice of the "face error" entered into the software program to make one probe give exactly the same digits output as another probe. This is sometimes thought to be desirable where probes are switched and unbroken continuity of the raw data is desired. It is not necessary for reason of accuracy as has already been explained.

The disadvantage of this method is that, if the probe is changed, the operator must remember to change the zero shift offset in the program to accommodate the "face error" of the new probe.

I-5 Conclusion

It has been shown that for most practical purposes check-sumsof less than 2000 digits are of no consequence and can be completely ignored providing the inclinometer survey is conducted in the normal way. (i.e.2 sets of readings at 180°) It has further been shown that the best method by far, for setting the "face error" to zero, is by means of the software capabilities in the inclinometer reader. This is the method chosen by Geokon.

APPENDIX J- ELECTRONIC SPIRAL INDICATOR PROBE / ZERO OFFSET

J-1 Introduction

The GK-603 Readout with software versions 2.8 and higher support the Geokon Model 6005 Electronic Spiral Indicator Probe. When System Settings | Configure Probe | Type is selected there will be a “Compass” entry. A number of changes are made to the way the readout operates when selecting “Compass”. A Zero Offset will need to be applied for the output of the probe to read 0°- 360°.

J-2 A-axis Zero Shift

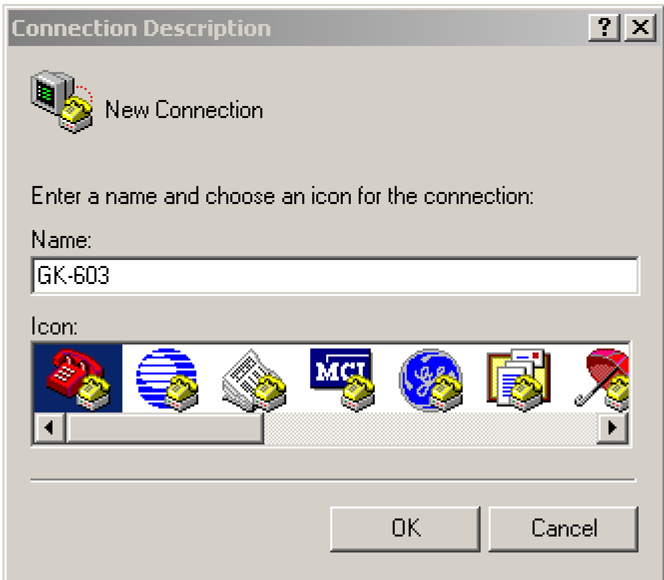
Under the Main Menu select “System Settings”. In System Settings Screen select “Configure Probe”. In the Configure Probe screen change Type: to “Compass” by pressing the Select button. Move down to A-Axis Zero Shift and push the Select button. The A-Axis Zero Shift must be entered to account for the 0.100 V output of the Electronic Spiral Indicator Probe at 0°. Enter +1000 and push the Select button. Escape to the Reading Screen and continue your setup in the usual manner. *See section 3.5.4.3. A-Axis Zero Shift on page 34.*

J-3 Reading Screen

The display in the Reading Screen for channels A and B now includes a decimal point. The normal range of display for A and B is 0.0 to +360.0, indicating degrees. The B channel reading is calculated by adding 90° to the A channel compass measurement.

Appendix K: Transferring Data from GK-603 via Hyperterminal

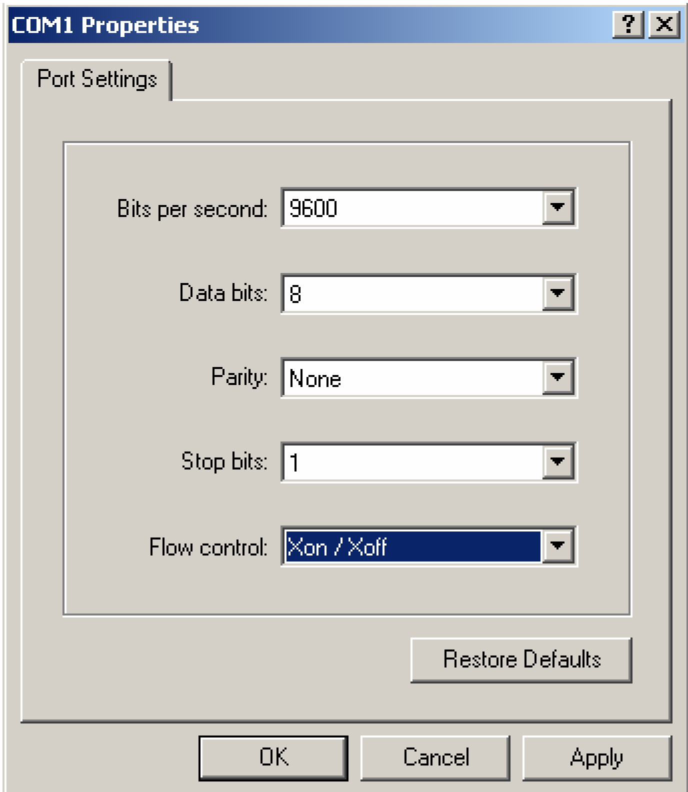
Start Hyperterminal: Start | Programs | Accessories | Communications
Enter a name for the Connection



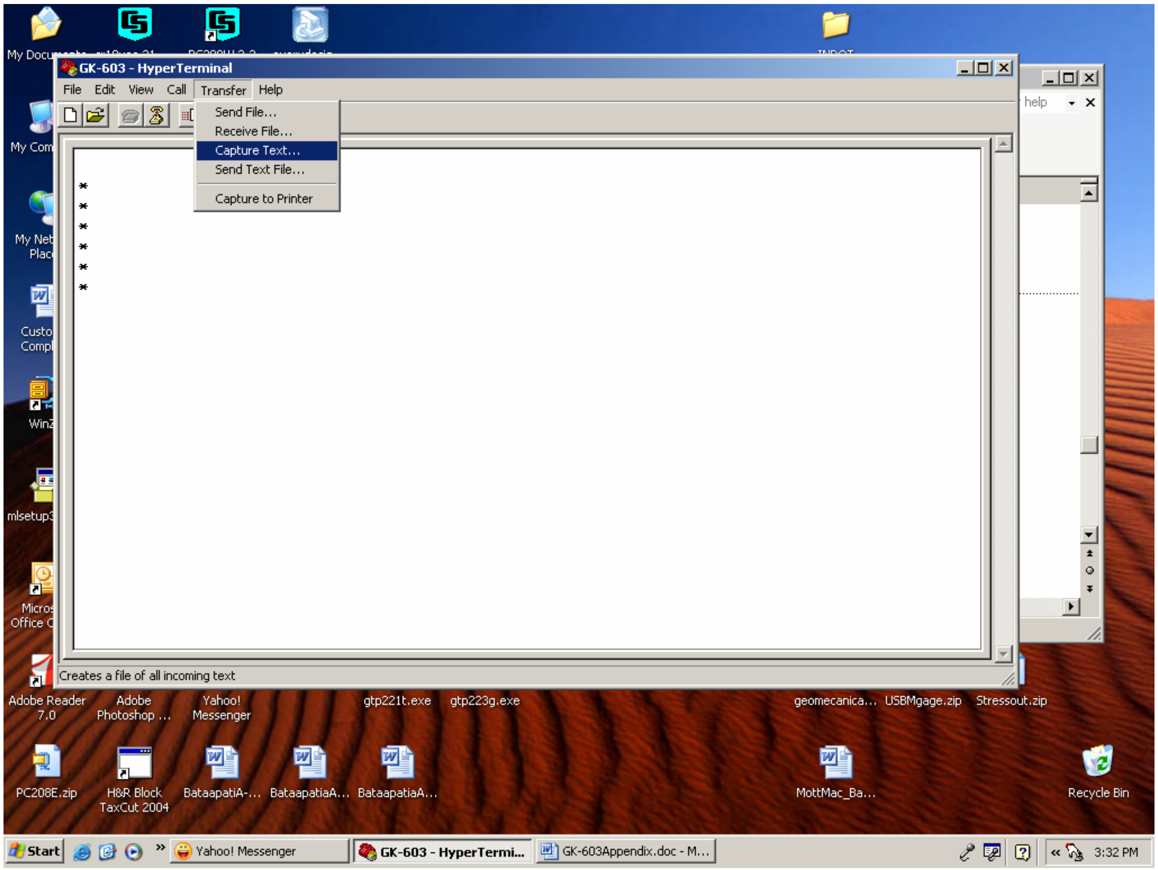
Select OK.

Change the Connect Using setting to the appropriate COM port for the computer being used.
Select OK.

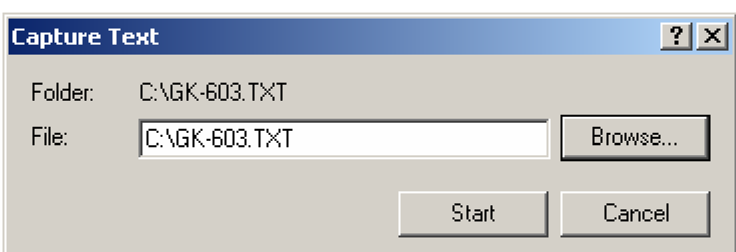
Enter the Port Settings as shown. Select Apply. Select OK.



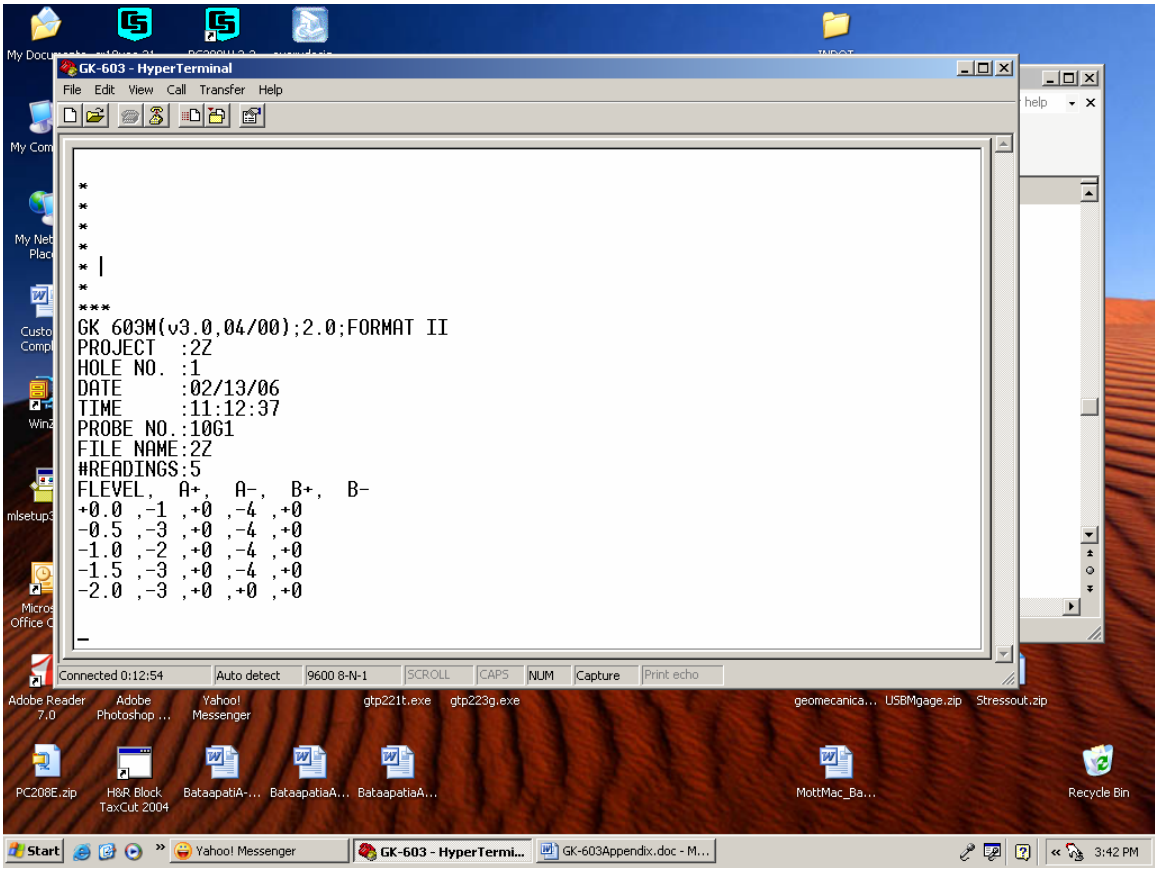
With the cursor in the display screen push the Enter key a few times to verify communications has been established. A series of asterisks (*) will appear on the screen. Upon confirmation of communications select Transfer | Capture Text.



Enter the Path and name of the file you wish to create, either directly or with the Browse button. Select Start.



From the Main Menu of the GK-603 select (3) Transmit/Receive. Select (1) Send Data File. Select the date file of interest. Then push the Select/Store button. The data file will scroll across the screen.



The download is now complete. A text file now exists as specified by the User. You can open this file in NotePad or WordPad. It can also be opened in Excel.

Select Exit the File Menu. Save the settings as appropriate.