APPENDIX A

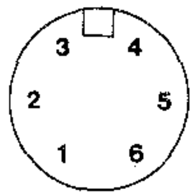
RS232 INTERFACE

A-1 Introduction

Data is output from the gradiometers via an asynchronous RS232 link which is implemented using the six-way connector labelled (3) in figure 2-2. This connector is also used for the battery charger and external LOG commands. The pins used for the RS232 link and suggested physical connections are described below. The actual format in which the data is stored and transmitted is covered in APPENDIX B, together with sample software for receiving and reconstructing the data. This appendix is relevant only to the FM18 and FM36 gradiometers.

A-2 Pin Connections

The pin connections of the six-way plug used for the RS232 link are shown below :



1 Charger +ve
2 Charger 0 V
3 RS232 GND - Signal ground
4 RS232 CTS - Clear to send (input)
5 RS232 RTS - Request to send (output)
6 RS232 TXD - Transmitted data

The RS232 link uses only the four pins 3,4,5, and 6. Pins 1 and 2 are used for the charger input.

Pin 6 - TXD

- Output signal line over which data is sent from the instrument. Data is output in negative logic (see illustration below). The TXD line will be at -5 V all the time the FM18/36 is switched on except when outputting data.

Pin 3 - GND

- Zero potential which acts as a reference for all other signals.

Pin 4 - CTS

- Input signal line that may be used to control the flow of data from the instrument. If it is at a positive potential then the data will be output continuously (active - binary 0). Taking CTS to a negative potential (binary 1) will terminate data output once the current character is completed. This may be used by an external device to temporarily halt the flow of data until it can clear its internal buffers of data.

Pin 5 - RTS

- Output signal line that is active continuously and is hard wired to a positive potential (binary 0). It may be used to indicate to a receiving device that the FM18/36 is ready to transmit data. Alternatively, RTS may be connected to CTS, thus allowing continuous data transmission from the insrument when the DUMP key is pressed.

In practise handshaking via RTS and CTS is not usually required since the computer buffer is often able to cope with data transferred at the maximum baud rate of 2400. The lead supplied to connect to IBM compatibles and the EPSON HX20 computer has a link inside the plug-in lead which connects RTS and CTS together on the instrument side, though other options are also available.

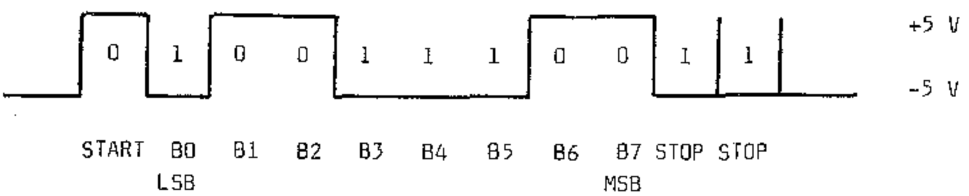
The CTS and RTS pins are also used by the external hand-held LOG key. Depression of this key momentarily connects CTS to RTS and this is detected by the microprocessor within the gradiometer, causing the reading to be logged.

A-3 Data Format

Each reading is output over the serial interface as a signed four digit number followed by a single digit number representing the range. These characters are output as ASCII code, and are enclosed by SPACE characters and terminated by CARRIAGE RETURN and LINE FEED, also in ASCII format, as shown below:

```
...SPACE sign dig1 dig2 dig3 dig4 SPACE CR LF SPACE range SPACE CR LF...
              (msd)          (lsd)
```

Each character consists of one start bit, eight data bits, and two stop bits. Parity is not transmitted. The baud rate may be set using the MENU KEY at 600, 1200, or 2400 baud. Signal levels are +/- 5V with respect to the GND connection. For example, the number 9 is shown below:



APPENDIX B

DATA OUTPUT

B-1 Introduction

Data is output from the gradiometers via an asynchronous RS232 link which is implemented using the six-way connector labeled (3) in figure 2-2. Details of the pin functions and suggested physical connections are described in APPENDIX A. The actual format in which the data is stored and transmitted is covered in this appendix, together with sample software for receiving and reconstructing the data. This appendix is relevant only to the FM18 and FM36 gradiometers.

B-2 Reading Representation

The FM18 and FM36 store a reading as a signed 12 bit digital number together with a 2 bit number which represents the range selected. Both the 12 bit and 2 bit numbers are output during data dump as decimal numbers which may be subsequently combined to form the actual reading. The 12 bit number can have any equivalent decimal value in the range +4095 to -4095 and the 2 bit number can have values of 0,1 or 2. For clarity, the following discussion refers only to the decimal number output.

The calibration is such that readings of, for example, +/-200.0 nT, +/-2000 nT or 20,000 nT will all be output as +/-4000, that is a value twice that of the reading if the position of the decimal point is ignored for the time being. This enables a reading to be stored with a resolution of 0.05 nT, 0.5 nT or 5 nT respectively even though it is displayed only with a resolution of 0.1 nT, 1 nT or 10 nT. The maximum reading that will be stored is +/-4095, equivalent to an input of +/-204.75 nT, +/-2047.5 nT or +/-20,475 nT.

The range information is output as a single digit decimal number between 0 and 2 and is used to recover the position of the decimal point and hence the actual reading. These numbers represent the following ranges and resolutions :

Range Digit	Display Resolution	Range
0	0.1 nT	200.0 nT
1	1 nT	2000 nT
2	10 nT	20,000 nT

Table B-1. Range Digit Representation

It can be seen therefore, that each reading is stored as a signed four digit number representing the reading and a single digit number representing the range. Thus 200.0 nT, 2000 nT, and 20,000 nT will all be stored as the number 4000 but will be differentiated between by the range digit stored. For example +2000 nT is stored as the signed four digit number +4000 and range digit 1. Insertion of a DUMMY LOG produces a stored number of +4095 and range digit depending on the range or resolution selected. Some examples of the way readings are represented are given below :

Range	Reading	Key pressed	Stored number and Range digit	
200.0 nT	+100.0 nT	LOG	+2000	0
2000 nT	+100 nT	LOG	+200	1
20,000 nT	-100 nT	LOG	-20	2
2000 nT	+2047 nT	DUMMY LOG	+4095	1
20,000 nT	+20,470 nT	DUMMY LOG	+4095	2

Table B-2. Examples of how readings are represented.

B-3 Data Output Format

Each reading is output over the serial interface as a signed four digit number followed by a single digit number representing the range. These characters are output as ASCII code, and are enclosed by SPACE characters and terminated by CARRIAGE RETURN and LINE FEED, also in ASCII format, as shown below:

```
...SPACE sign dig1 dig2 dig3 dig4 SPACE CR LF SPACE range SPACE CR LF...
              (msd)           (lsd)
```

Each character consists of one start bit, eight data bits, and two stop bits. Parity is not transmitted. An example is shown in APPENDIX A. This output format is compatible with a number of popular computers such as the EPSON HX20 and IBM compatibles.

Readings are output sequentially in the same order as they were logged, ie on a first in, first out basis, with the zero drift, if selected, being output at the end of each grid in turn.

B-4 Receiving and Reconstructing the Data

The RS232 serial link between the FM18/36 and receiving device must first be set up correctly - see APPENDIX A for details. This includes connection of TXD,GND,CTS and RTS lines, choice of baud rate, number of start bits, data bits, stop bits and parity. Some of these may be set up by the software of the receiving device as shown in the example below for the EPSON HX20 computer. Other devices may use DIP switches and the manufacturers manual should be consulted for details.

In practice handshaking via RTS and CTS is not usually required since the computer buffer is often able to cope with data transferred at the maximum baud rate of 2400. The lead supplied to connect to IBM compatibles and the Epson HX20 computer has a link inside the plug-in lead which connects RTS and CTS together on the gradiometer side, though other options are also available.

The receiving software should consist of a loop to read in 4000 items of data (16000 for the FM36) in the format described in section B-3, that is a signed four digit number followed by a single digit number. In addition if the LOG ZERO DRIFT mode is in operation a further reading, plus its associated range, should be read in at the end of each grid.

The following BASIC program may be used to read in 1000 readings from the FM18, together with the Zero Drift for each grid. The data is stored in the Epson non-volatile RAM file. The Expansion Ram for the HX20 will be required if it is desired to read in the full 4000 readings of the FM18. The program shown is limited to 10 grids of 10 x 10, 2 grids of 20 x 20 or 1 grid of 30 x 30 readings.

(1) Data input - program lines 0-310

Line 10 defines the memory area used by BASIC for character string processing as 200 bytes and also defines the memory area to be used for RAM file storage as 4044 bytes. Line 20 defines the relative address of record 0 in the RAM file as 0 and the length of a single record as 4 bytes. Line 25 dimensions array DRIFT for the storage of intermediate reconstructed zero drift values. Logged readings are stored in memory locations 1-1000 whilst the initial zero drifts read in of up to 10 grids are stored in memory locations 1001-1010

Lines 60-110 are used to input grid dimension, number of grids and whether LOG ZERO DRIFT is in use. If it is LZD is set to 1.

An important point to note when using the RS232 link of the Epson HX20 is that power is only applied to the serial line when communication is actually being performed, that is, after the "OPEN" statement of line 220 has been executed. Therefore to prevent errors due to transients it is neccessary to add the four lines 150-180. The time delay between pressing space bar, which allows the program to proceed past line 180 to the "OPEN" statement, and the pressing of DUMP on the FM18 is sufficient to let the serial lines of the HX20 to settle before the FM18 transmits data. These four lines will not normally be needed by other computers.

Line 220 opens an I/O file for input of data via the RS232 serial link and sets the receiving conditions as :

Baud rate - 2400 baud
Word length - 8 bits
Parity - no parity
Stop bits - 2 bits
Control lines used - none used for HX20 - FM18/36 RTS/CTS tied together.

Line 230 disables the automatic insertion of line feeds every 80 characters by the HX20. Line 260 inputs the two parts of a reading from the HX20 RS232 buffer and places them in variables D% and R%. D% is the signed four digit number corresponding to the 12 bit reading and R% is the range number. Line 270 puts the variables D% and R% into a RAM file using the PUT% instruction. Loop 250-280 is used to input and store one grid of data whilst line 290 is used to input the zero drift, if selected, for that grid. Loop 240-300 is used to input each grid in turn. Line 310 closes the I/O file.

```
10  CLEAR 200,4044
20  DEFFIL 4,0
25  DIM DRIFT(10)
30  '
60  CLS : PRINT"Input Grid Dimension"
70  PRINT"10,20, or 30" : INPUT GR
80  G2 = GR * GR
90  CLS : PRINT"Input Number of Grids" : INPUT NMAX
100 CLS : PRINT"Log Zero Drift ? Y/N";:M$ = INPUT$(1)
110 IF M$ = "Y" THEN LZD = 1
120 '
150 CLS : PRINT"Switch logger on."
160 PRINT"Press space bar and"
170 PRINT"then DUMP on FM18";
180 M$ = INPUT$(1)
190 '
220 OPEN"I",£1,"COMO:(58N2F)"
230 WIDTH"COMO:",255
240 FOR Q = 1 TO NMAX
250 FOR X = 1 TO G2
260 INPUT£1,D%,R%
270 PUT%((Q-1)*G2+X),D%,R%
280 NEXT X
290 IF LZD = 1 THEN INPUT£1,D%,R% : PUT%(4000+Q),D%,R%
300 NEXT Q
310 CLOSE
320 '
330 '
340 GET%1,D%,R%
350 IF R% = 0 THEN MF = 20
360 IF R% = 1 THEN MF = 2
370 IF R% = 2 THEN MF = 0.2
380 '
400 IF LZD = 1 THEN 410 ELSE 420
410 FOR Q = 1 TO NMAX : GET%(1000+Q),D%,R% : DRIFT(Q) = D%/MF : NEXT
420 FOR Q=1 TO NMAX : SI% = (Q-1)*G2
430 DRSUM = 0 : LCOR = DRIFT(Q)/GR
440 FOR X = 1 TO GR
450 DRSUM = DRSUM + LCOR
460 FOR Y = 1 TO GR
470 GET%(SI%+((X-1)*GR)+Y),D%,R%
480 IF ABS(D%) = 4095 THEN READING = 2047.5 : GOTO 510
490 IF LZD = 0 THEN DRSUM = 0
500 READING = (D%/MF) - DRSUM
510 PUT%(SI%+((X-1)*GR)+Y),READING
520 NEXT Y : NEXT X : NEXT : Q
530 END
```

Program B-1. Data input and reconstruction using an FM18 and an HX20

(2) **Data reconstruction - program lines 340-530**

Reconstruction of the data consists of three steps :

1 The FM18/36 calibration is such that readings will be stored as numbers with a value twice that of the reading, if the position of the decimal point is ignored for the time being. To reconstruct readings correctly, it is therefore neccessary to divide the four digit number transmitted from the FM18/36 by 2 to give the correct reading.

2 The four digit number must also be divided by another factor, which depends on the range digit transmitted, in order to recover the position of the decimal point. The four digit number should therefore also be divided by 10,1 or 0.1 depending on the range digit.

3 Once the readings for each grid have been reconstructed the zero drift may be used to correct the data. Whilst the zero drift figure may be divided by the number of readings in the grid and this figure used to correct each reading in turn, in practise it is not usually neccessary to be that precise. Zero drift may be divided by the number of lines in the grid and this figure used to shift the level of each line in turn.

Line 340 retrieves the first variables D% and R% stored in the RAM file. In lines 350-370 the value of R% is then used to decide on the reconstruction factor, as defined in 1 and 2 above, for all successive readings. Line 410 is used to reconstruct the zero drift value for each grid (Q) and these are stored in array DRIFT(Q). LCOR is the correction factor to be applied per line of readings using loop 460-520. DRSUM is used to increment the amount of correction applied to each line using loop 440-520. After reconstruction and zero correction, the readings are restored in the non-volatile RAM in memory locations 1-1000 using line 510. DUMMY LOG values retain the maximum reading possible of 2047.5 and are unaffected by range or zero drift correction using line 480. They may therefore be identified during dot-density plots and given a special symbol, useful for defining areas not surveyed.

B-5 Further Processing of the Data

Suggestions for the final presentation of the data are given in section 5. Particular emphasis is given to the use of the dot-density presentation to aid interpretation and enhance anomalies. Such an approach is used by program GEOPLOT, described in the data sheet at the back of this manual. The program also incorporates, and further developes the routines introduced in this appendix to handle the data output from the FM18/36. Other useful facilities are outlined, providing a guide to those who are writing their own data processing software.

```
1    'Program listing for data transfer + reconstruction for FM gradiometers.
2    'Geoscan Research 19/11/93. Please distribute freely and modify it for
3    'your own use if you wish.

4    'Dimension arrays.
5    ' "reading (grid number,x%,y%)" is for storage of up to 10 grids of data.
6    ' x% increments for each reading in a traverse.
7    ' y% increments for each completed traverse.
8    ' "range" is for the storage of the range bit transfered with the first
9    ' reading of each grid (this is used for all other readings in the grid)
10   ' "drift" is for storage of the Log Zero Drift reading associated with
11   ' each grid (if Log Zero Drift is enabled)

15   'Enter Parameters
20   DIM reading(10, 30, 30), range(10), drift(10)
30   CLS : PRINT "Input Grid Size": PRINT "10, 20 or 30": INPUT gridsize%
40   PRINT : PRINT "Input Number of Grids": INPUT numbgrids%
50   PRINT : PRINT "Is Log Zero Drift on ?  (Enter Y or N)": INPUT lzd$
55   lzd$ = LCASE$(lzd$)

58   'Transfer Data
60   PRINT : PRINT "Switch FM18/36 on. (Baud rate should be 2400)"
65   PRINT "Press Enter to start reception - please wait"
70   DO: k$ = INKEY$: LOOP UNTIL k$ <> ""
90   OPEN "com1:2400,n,8,2,rb32767,rs,cs,ds,cd,asc" FOR INPUT AS #1
100   PRINT : PRINT "Waiting for data. Press DUMP on FM18/36"
120   FOR grid% = 1 TO numbgrids%
130      FOR y% = 1 TO gridsize%
140      FOR x% = 1 TO gridsize%
150         INPUT #1, dat$, ran$
160         IF x% = 1 AND y% = 1 THEN
170               reading(grid%, 1, 1) = VAL(dat$): range(grid%) = VAL(ran$)
180               PRINT : PRINT "Inputting grid "; grid%; " ..."
190         END IF
200         reading(grid%, x%, y%) = VAL(dat$)
210      NEXT x%
220      NEXT y%
225      IF lzd$ = "y" THEN
230         INPUT #1, d$, r$
235         drift(grid%) = VAL(d$)
240      END IF
245   NEXT grid%
250   CLOSE : BEEP: PRINT : PRINT "Transfer complete. Switch off FM18/36"

260   'Data Reconstruction
270   FOR grid% = 1 TO numbgrids%
280      PRINT : PRINT "Reconstructing data of grid "; grid%; " ..."
         SELECT CASE range(grid%)
            CASE 0                '0.1nT
               convfact = 20
            CASE 1                '1nT
               convfact = 2
            CASE 2                '10nT
               convfact = .2
         END SELECT

400      'Calculate zero drift compensation per traverse
405      drift(grid%) = drift(grid%) / convfact
407      IF lzd$ = "y" THEN
408         zdc = drift(grid%) / (gridsize% - 1)
409      ELSE
410         zdc = 0
411      END IF
```

```
412      'Apply conversion factor and log zero drift compensation (if enabled)
415      FOR y% = 1 TO gridsize%
420      FOR x% = 1 TO gridsize%
425         rd = reading(grid%, x%, y%)
            SELECT CASE rd
                 CASE 4095, -4095       'dummy reading
                    rd = 2047.5
                 CASE ELSE
                    rd = (rd / convfact) - (zdc * (y% - 1))
            END SELECT
            reading(grid%, x%, y%) = rd
490      NEXT x%
500      NEXT y%
510   NEXT grid%
515   BEEP: PRINT : PRINT "Reconstruction complete. Press Enter to continue."

520   'Data for all grids is now resident in array "reading (grid%,x%,y%)".
525   'Further reconstruction of the data might involve zig-zag correction if
528   'that survey method was used to gather the data. The next step would be
530   'to store the data on disk. It may then be listed or viewed graphically.

540   DO: k$ = INKEY$: LOOP UNTIL k$ <> ""

550   END
```

APPENDIX C

ENCODER CIRCUIT

C-1 Introduction

Normally readings are logged by pressing the key of the external hand-held key, or from the instrument keyboard, but they may also be logged using pulses from an external distance encoder, such as a line together with hand held pulley/slotted wheel and optocoupler. This is especially useful if readings are required to be logged at 0.5m or 0.25m intervals at a walking pace. The gradiometers may be easily interfaced to such systems and can log readings at rates of up to 10 readings per second. The following appendix illustrates how a slotted wheel and optocoupler may be interfaced.

C-2 Interface Details

The RS232 connections, RTS, CTS and GND of the FM18/36 are also used as the encoder interface pins. RTS and GND provide power to external circuitry and CTS is used to input the trigger pulse to start a LOG cycle.

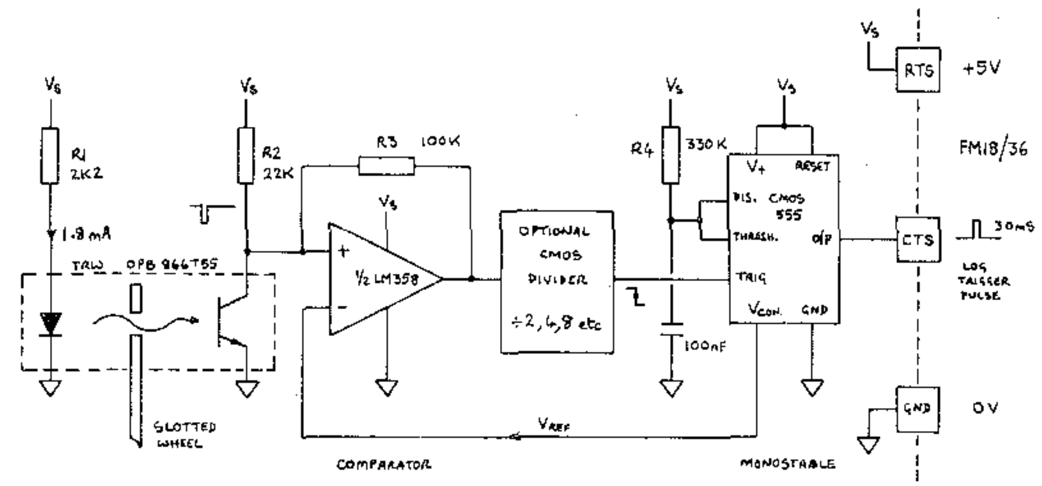


Figure C-1. Interface circuit for an opto-coupled distance encoder

A revolving slotted wheel is used as a measure of distance, breaking the beam of a slotted optocoupler for each revolution. A high sensitivity type optocoupler, TRW OPB886T55, is used to reduce power requirements. Only 1.8mA of transmitting diode current is required, set by R1. The value of R2 is chosen such that the input to opamp LM358 (used as a comparator with hysterisis to clean up the signal) swings between 5V and approximately 160mV referenced to ground. Use of a different optocoupler will require different values for R1 and R2. The optocoupler should be shielded from external light sources for correct operation.

The output from the LM358 is then fed to a CMOS 555 monostable which is used to provide the 25-50 mS input pulse required by the gradiometers. This pulse swings between 0V and +5V, with the log cycle being initiated on the leading positive edge. An additional CMOS divider may be required between the comparator and monostable if one revolution of the wheel does not correspond to the required logging interval. Overall mean current consumption is 2mA, easily supplied by the gradiometers.

APPENDIX D

SAMPLE TRIGGER ST1

D-1 Introduction

The ST1 Sample Trigger enables the FM18 and FM36 Fluxgate gradiometers to sample and record readings at 1m, 0.5m, 0.25m or 0.125m intervals. The unit sounds a "beep" every metre, whilst sending out trigger pulses to the gradiometer at a selectable rate of 1,2,4, or 8 per metre. The operator walks along the survey line at a pace that ensures the "beeps" coincide with 1m marks along a tape. The "beep" rate is continuously variable allowing traverse rates of 0.5 - 3 s/m. At a typical traverse rate of 1 s/m it is easy to keep pace and maintain sampling errors at less than 1/4m with 4 samples /m. The Sample Trigger has selectable line lengths of 10m, 20m, 30m and 50m and is powered by the gradiometer, drawing typically 1mA which will have negligable effect on battery life.

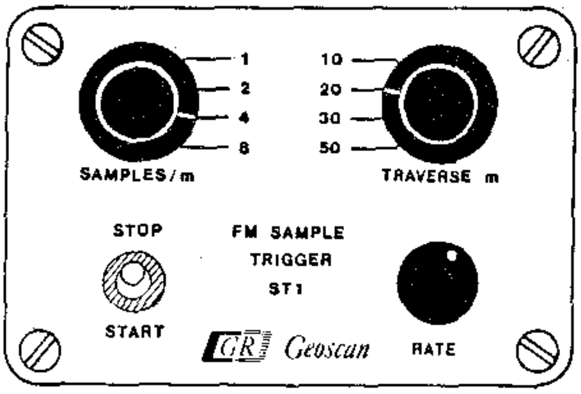


Figure D-1. The ST1 Sample Trigger unit.

The increased sampling, obtained without any increase in survey time, greatly enhances data quality and interpretation. Even sampling at 1/m is faster using the ST1 than by using the external hand-held log key normally supplied. The ST1 replaces bulky external distance encoders such as tripod, line and slotted wheel systems and provides much greater ease of use, improved reliability and repeatability.

The ST1 clips onto the front of the FM18/36 using a mounting bracket and quick release screws. This fixes onto a small mounting bar permanently attached to the underside of the gradiometer instrument housing. The mounting components are supplied with the Sample Trigger and may be very quickly retrofitted. Like the gradiometers, the ST1 is constructed using waterproof components.

D-2 Assembly Instructions

If an ST1 is supplied with your gradiometer the mounting bar will already have been fitted. In addition the carrying case foam will also have been cut out to take the ST1. In this case the following two sub-sections, (1) and (2) can be ommitted and you should procede directly to sub-section (3). If the ST1 is supplied separately you should follow the instructions of sub-sections (1) and (2).

(1) Fitting the mounting bar

The mounting bar is fitted underneath the front of the main instrument housing, figure D-2. You will need a flat bladed screwdriver with blade 1/4 inch wide and at least 3 inches long.

1 Switch the gradiometer off.

2 Rest the gradiometer on a table top, next to the edge, so that the sensor tube hangs vertically over the edge and the handle is nearly horizontal and resting on the table.

3 Undo the four screws on the instrument front panel - there is no need to remove them entirely.

4 Carefully lift the front panel lid about one inch away from the main housing and then move it one inch towards the sensor tube and rest it gently back onto the main housing.

5 This should expose two slots at the front of the main housing down which the two bolts may be dropped to protrude from the underside. Nudge them with the screwdriver if neccessary so that they do protrude.

6 Slide the mounting bar under the main housing, orientated as shown in figure D-2, with the notches uppermost and facing towards the sensor tube. Tighten up the two screws, making sure that the front face of the main housing and the front edge of the mounting bar align.

7 Replace the front panel lid taking great care to feed the connecting wires back into their correct positions - see section 2-4 on battery installation and replacement.

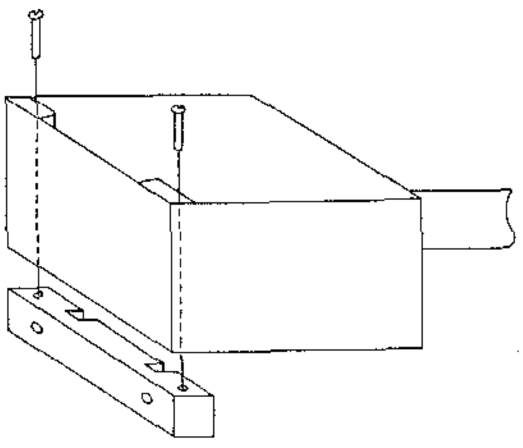


Figure D-2. Fitting the mounting bar to the gradiometer.

(2) Carrying-case cut-out

Details of the carrying case cut-out are shown in figure D-3. The main cut-out, 140 by 140 mm is needed only in the bottom foam whereas the smaller slots to take the mounting bar and quick release screws are required in both the top and bottom foams. Mark out the required slots with adhesive tape as a guide and then use a new, sharp scalpel to cut out the slots.

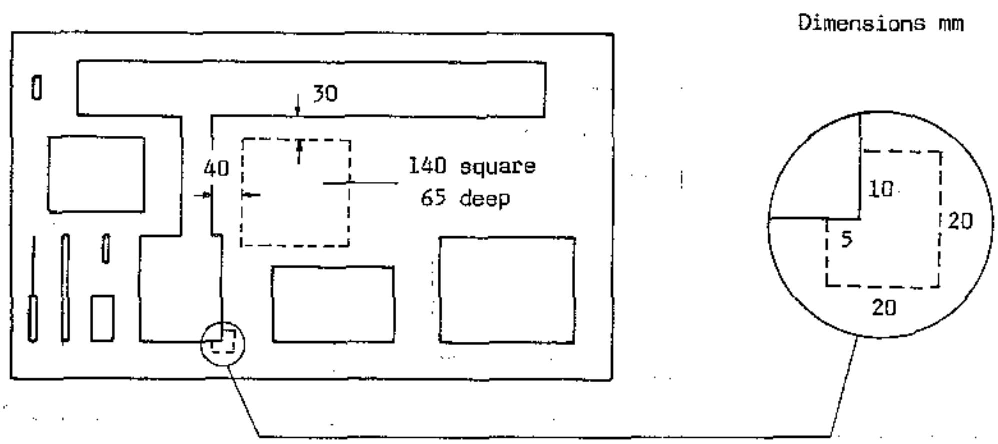


Figure D-3. Carrying-case cut-out.

(3) Assembling for field use

The ST1 clips onto the front of the FM18/36 using the mounting bracket and quick release screws - figure D-4. The flying lead of the ST1 plugs into the external log connector, labelled as (3) in figure 2-2. The gradiometer should be switched off before plugging in the flying lead.

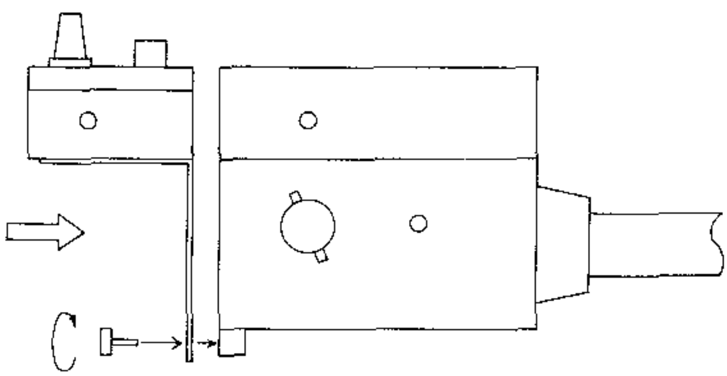


Figure D-4. Mounting the ST1 Sample Trigger to the gradiometer.

D-3 Operating Instructions

(1) Switching on

Set the STOP/START switch of the ST1 to the off position before switching on. When the gradiometer is switched on both the ST1 and the gradiometer issue a beep of about 1 second duration.

(2) ST1 switch settings and Gradiometer menu settings

Set the required number of samples/m and traverse length on the ST1 using the switch controls. Select the corresponding sample interval and grid size using the menu sequence of the gradiometer. For example an FM18/36 menu setting for LOG INTERVAL of 0.25m corresponds to an ST1 setting of 4 samples per metre and an FM18/36 menu setting for GRID SIZE of 30m corresponds to a traverse length of 30m. If you wish to sample at 8 samples/m with the ST1 then you will have to set the FM18/36 to a LOG INTERVAL of 0.25m and bear in mind that the survey tracking will show two traverses for every one actually completed.

Select "Encoder" mode for the External Trigger Type on the FM18/36 menu sequence and ensure that the Digital Averaging Mode is NOT selected. The resolution may be set to 0.1 nT, 1 nT or 10 nT. Select LOG ZERO DRIFT on the FM18/36 menu if required with 1,2, or 4 samples/m. If you are sampling at 8 samples/m and you wish to use LOG ZERO DRIFT then the grid will have to be surveyed in two halves since the survey tracking will prompt you to LOG ZERO DRIFT halfway through. It is recommended that LOG ZERO DRIFT is used at all times.

Set the required ST1 "beep" rate by switching the STOP/START switch to on and adjusting the RATE Knob - when the gradiometer is first switched on it will not be in the logging mode so there is no danger of readings being logged whilst setting the "beep" rate. Rotating the knob anticlockwise will slow the rate down, turning the knob clockwise will speed it up. The typical setting of 1 beep per second, corresponding to a traverse rate of 1 s/m, is obtained with the knob rotated clockwise by approximately 2/3. Note that if you are using 8 samples/m then the traverse rate should not be set faster than 1.25 s/m since the gradiometer may not be able to log readings fast enough, leading to missing readings.

(3) Doing a traverse

Once the FM18/36 and ST1 are set up put the gradiometer into the logging mode by pressing ENABLE LOG, making sure that the STOP/START switch is in the OFF position. Setting the STOP/START switch to START will start the logging sequence. The ST1 will beep every 1m, including a beep when the switch is first set to START and also at the very end of a line. Thus, for example, on a 10m traverse the ST1 will beep eleven times - figure D-5. In between the beeps trigger pulses will be sent to the gradiometer, causing the FM18/36 to log a reading. The gradiometer sounds a short "click" each time it does this.

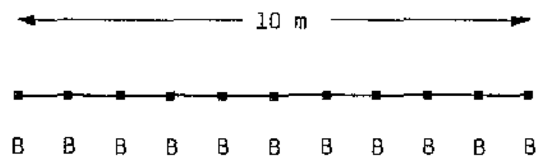


Figure D-5. ST1 "beep" or 1m markers, B, on a 10m traverse.

The various sampling patterns and their relationship to the metre marks are shown in figure D-6. The ST1 will automatically stop sending log trigger pulses at the end of the line. It is not possible to stop the ST1 halfway through a traverse in order to insert a dummy reading since setting the STOP/START switch to STOP will reset the internal traverse counter. The traverse can be stopped, however, to complete the rest of the line with a FINISH LINE command, though to do this you should enter the MANUAL encoder mode before pressing FINISH LINE otherwise you will probably obtain several completed lines. Note that since the gradiometer is in the encoder mode it will not give end of line or grid "beeps".

D-4 Field Procedure

Field procedure is virtually identical to that described in section 4, except that the central perpendicular guide line or tape, figure 4-5, must be marked differently. Instead of marks being at the centre of each 1m square the marks must be at the edges of each square as shown in figure D-5. Of course this means that now you must ensure that the ST1 beeps when the sensor tube is directly over the edge of each square, rather than at the centre of each square.

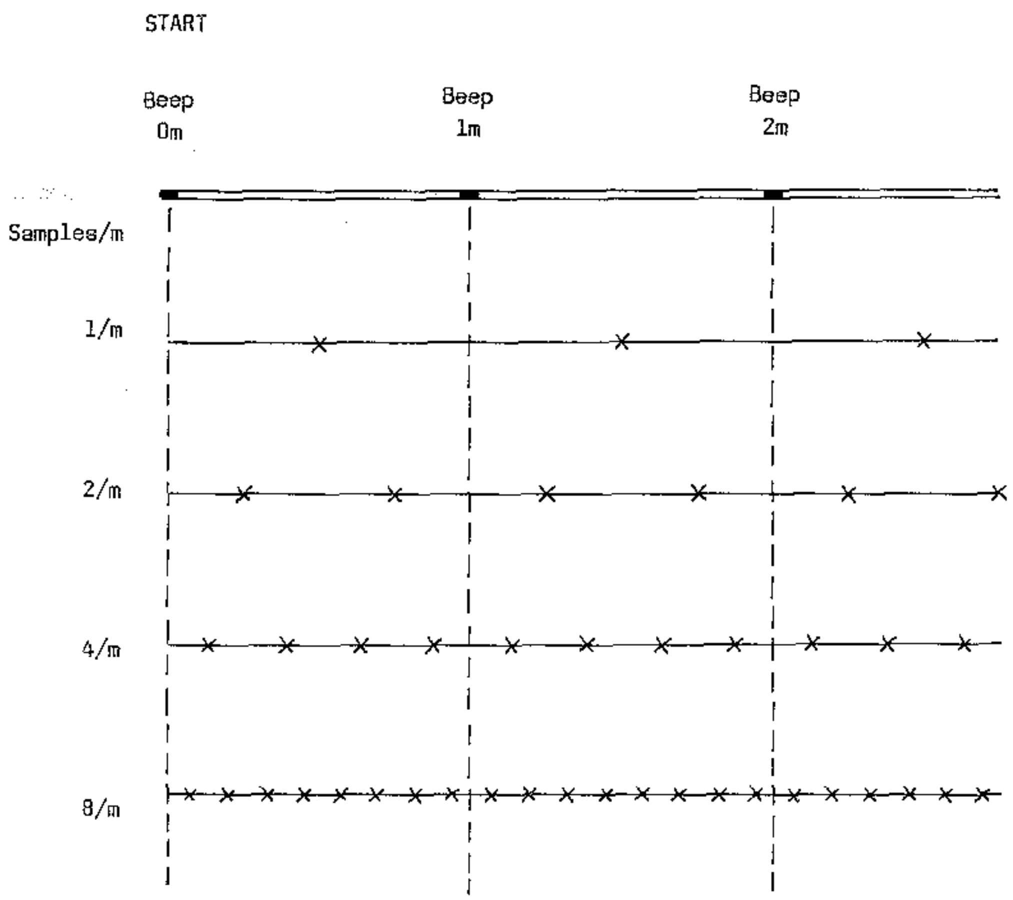


Figure D-6. ST1 sampling pattern - a cross indicates a reading position.

In order to achieve accurate sampling you must ensure that :

1 The STOP/START switch is initially set to the START position when the gradiometer sensor tube is directly over the start of the traverse line, figure D-6.

2 Ensure that subsequent beeps occur when the sensor tube is directly over the tape marks.

This requires that you travel at a constant speed, both at the start and during the traverse. Therfore it is advisable to adopt the following procedure. Position yourself initially about 1m away from the traverse start. Set off walking and as the sensor tube passes over the start of the traverse line set the STOP/START switch to the START position to initiate sampling.

D-5 Sampling Interval Selection

Figure D-7 compares profiles taken at sampling intervals of 1,2,4 and 8/m over ridge and furrow (ridges at A,C and D) and a boundary bank, B. Whilst these features show up in all the plots, sampling at 2,4 and 8/m also reveals a negative anomally in the boundary bank and a sharp positive anomally at E, caused by a piece of surface iron. Sampling at 1/m gives a slight response over the iron but the sharp peaked response that distinguishes surface iron from archaeological deposits is absent, leaving the response open to mis-interpretation. Repeated traverses confirmed the poor response of the 1/m sampling. Sampling at 2/m or 4/m should therefore be considered for routine work. Whilst sampling at 8 samples/m produces results approaching that of a chart recorder system, being virtually a smooth curve, (and in this case is best able to show the narrowness of the iron peak) bear in mind that much more data is generated and should therefore be considered only for more complex sites. See also section 4-4 (3) for more details on selection of sampling interval.

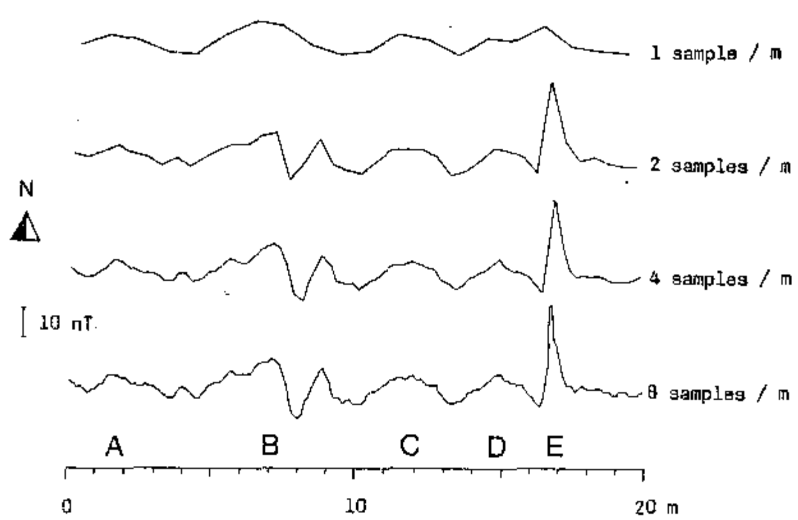


Figure D-7. Comparison of sampling intervals of 1,2,4,8 samples per metre.

D-6 Reproducibility

Excellent reproducibility is shown in five repeated traverses over the same line, figure D-8. Traverse rate was set at 1s/m and sampling at 4/m. It can be seen that positional repeatability is excellent, with the negative peak of the bank anomally being in line for all five traces. There is a slight positional error of 0.25m over the iron but this still represents good performance over such a difficult target. Fine structure on the rest of the traverses reproduces well on all traces. To achieve such good results you should pay particular attention to keeping good coincidence of the beep over the tape marker.

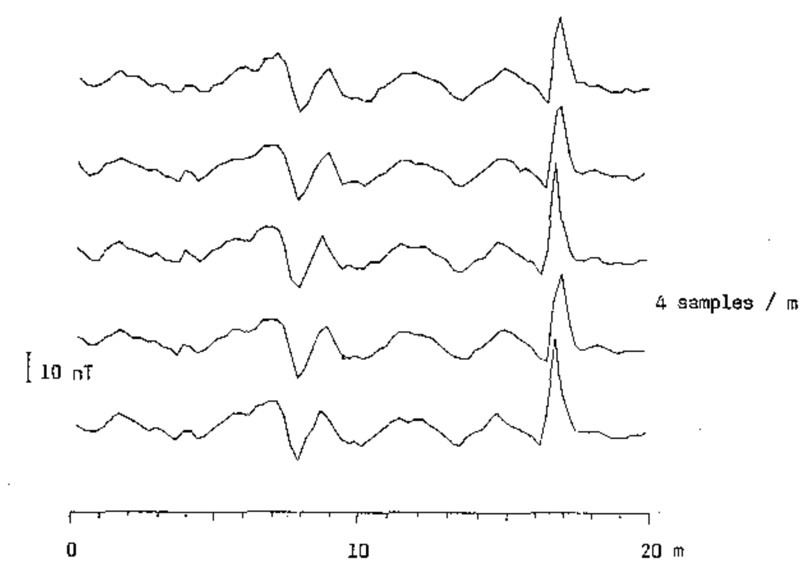


Figure D-8. Repeated traverses over the same line. Traverse rate 1s/m at 4 samples/m.

APPENDIX F

SURVEY GUIDE LINES

F-1 Introduction

The survey guide lines are intended for surveying on 20m grids and are marked for taking readings at 1m and 0.5m intervals. The lines should be used only as guide lines for surveying and not for marking out survey grids since the nylon lines will stretch.

F-2 Colour Coding

The central perpendicular line, along which traverses are made is terminated at each end with a **BLACK** band.

The two outer parallel lines are terminated at each end with **BLUE** bands.

The centre of each line is marked by a **BLACK** band, and indicates when 20 readings have been taken at 0.5m intervals.

Marker points for surveying at a 1m reading interval are **YELLOW.**

Marker points for surveying at a 0.5m reading interval are **RED.**

APPENDIX G

SURVEY SHEETS

GR Geoscan Research

GEOPHYSICAL SURVEY

SITE	SHEET NUMBER
	DATE
	MAP REF.
SOIL	SURVEY TYPE
SUBSOIL	
GROUND COVER	
WEATHER	INSTRUMENT
SHEET ORIENTATION N / ADJACENT SHEETS	STATION INTERVAL
	UNITS
	SURVEYORS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
A																					A
B																					B
C																					C
D																					D
E																					E
F																					F
G																					G
H																					H
I																					I
J																					J
K																					K
L																					L
M																					M
N																					N
O																					O
P																					P
Q																					Q
R																					R
S																					S
T																					T
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

Geoscan Research

GEOPHYSICAL SURVEY

SITE	SHEET NUMBER
	DATE
	MAP REF.
SOIL	SURVEY TYPE
SUBSOIL	
GROUND COVER	
WEATHER	INSTRUMENT
SHEET ORIENTATION N	STATION INTERVAL
	UNITS
	SURVEYORS

APPENDIX H

INTERFERENCE

H-1 Introduction

Usually you should experience very few problems with interference and your FM9, FM18 or FM36 fluxgate gradiomter. However, there are some circumstance when this may be a problem and the following sections attempt to help you avoid these in the first place, or if they do occur, suggest ways of overcoming the problem.

Note that the instrument is not designed for laboratory use so if you try to operate in such an environment you may observe interference in the form of flickering readings. This is usually due to the magnetic fields generated by mains operated devices, in particular, mains transformers such as those found in uninteruptable power supplies for PC's.

H-2 Interference whilst Surveying

You may experience interference in the form of flickering readings during some surveys. On urban sites this is likely to be due to the magnetic fields from underground mains power earth currents, telephone earth return currents, or currents conducted along underground pipes. On rural sites interference is likely to occur when operating in the vicinity of radar, radio or television transmitters or booster stations. Interference will increase as you get nearer the source, though it is difficult to give a precise indications of the level of interference. But as an example, you may observe fluctuations of more than 1nT at distances less than 50m from a radio booster station, though of course the distance and degree of fluctuation will vary from situation to situation.

You can try to improve the signal to noise ratio by using the gradiometer in its digital averaging mode; start with the averaging period set to the minimum of 16 conversions first and if this does not improve matters then increase the averaging period step by step to the maximum of 128 conversions. If this does not effect a cure then either move further away from the interfering source or reduce the sensitivity of the gradiometer.

H-3 Interference whilst Dumping Data

Though you may successfully transfer data from the FM18 and FM36 to a PC in most environments (using the DUMP key), we strongly recommend you avoid doing this inside, or adjacent to, a motor vehicle which has its engine running (or similar noisy environments). If the vehicle electrical system is badly suppressed then the interference may corrupt the data transferred. Always check that the data transfered to a PC is sensible BEFORE clearing the memory. If you find the data has been corrupted, and you suspect it is because of a noisy environment then move to another location and then repeat the data transfer.