Operations Handbook

for

DMSP/SSM MAGNETOMETER

UNIT S/N: 001

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Table of Contents

1.0 Scope

This handbook describes the operation of the SSM triaxial fluxgate magnetometer, the content and interpretation of the data, use of the Ground Support Equipment, special handling requirements, and a test history of UNIT S/N: 001.

2.0 Introduction

The main body describes general performance characteristics of all major components of the SSM instrument. The SSM is a triaxial fluxgate magnetometer system used as a space environment sensor for the Defense Metereological Satellite Program (DMSP) spacecrafts 12 through 15. Detailed operational data is contained is a series of appendices. Appendix A contains photographs of the magnetometer, and a summary of the size, weight, and power of all components. The connector pin assignments are given in appendix B. Downlink data format and telemetry interpretation are provided in appendices C and D. Commands which can be sent to the instrument are contained in Appendix E. Appendix F contains detailed information on use of the Ground Support Equipment. Appendix G outlines instrument handling and safety requirements. A test history of the SSM UNIT S/N: 001 is provided in appendix H.

3.0 Major Component Characteristics

3.1 General

The major components of the SSM triaxial fluxgate magnetometer are: a) The sensor, b) The cable from the sensor to the electronics, and c) The magnetometer electronics, which includes the analog to digital converter and digital readout circuits, the bias offset generator, and the power converter. The sensor assembly consists of three mutually orthogonal ring cores, each located in a feedback coil. These coils are mounted on a frame, which is covered by a fiber glass cover. The sensor is connected to the magnetometer electronics by means of the cable. The magnetometer electronics box contains circuits for supplying the necessary signals to the coils, the analog to digital converter, the digital readout circuitry, the bias offset generator and the power converter. The magnetometer electronics box is connected to the DMSP spacecraft by cables provided by the spacecraft integrator.

The parameters measured by the SSM are the three components of the magnetic field vector. In addition a number of housekeeping parameters (temperatures, current, and some spacecraft information) are reported by the SSM to the telemetry system. The SSM magnetometer takes and reports 12 readings per second for the Y and Z axes. Only 10 readings of the 12 readings per second are reported for the X axis due to telemetry limitations. The range is from +65535 to -65535 Gamma for each axis, with a resolution of 2 Gammas, (1 Gamma = 10^{-5} gauss = 10^{-9} Tesla). The housekeeping parameters are monitored once per second.

3.2 The Triaxial Fluxgate Sensor

The fluxgate sensors are constructed utilizing the ring core geometery.

A schematic drawing showing the construction of each sensor is shown in Figure 1, while a photograph of the triaxial sensor assembly is shown Appendix A. Important elements in the design of the sensor are the feedback coil which nulls the ambient field within +/- 2000 Gamma, and the sensor core itself since they can be shown to be the most significant sources of error, both from the alignment stability point of view, as well as temperature stability.

Here individual axis nulling is utilized, that is, each axis is nulled independently in only one direction. This is the most common approach but suffers from extreme sensitivity to cross-fields since the ambient field is nulled only along the sensor axis. Thus any distortion or motion of the sensor core within the feedback coil represents an effective change due to the presence of the transverse field.

A rigid attachment of the sensor core to the feedback coil usually results in differential expansion stresses being transmitted to the sensor core which can produce significant alignment shifts, zero level changes as well as dramatic increases in sensor noise levels. These problems have been solved by carefully matching the thermal expansion coefficients of the elements involved (core, windings, support structure) to minimize differential stresses and changes in the relative geometry between the core and the feedback coil.

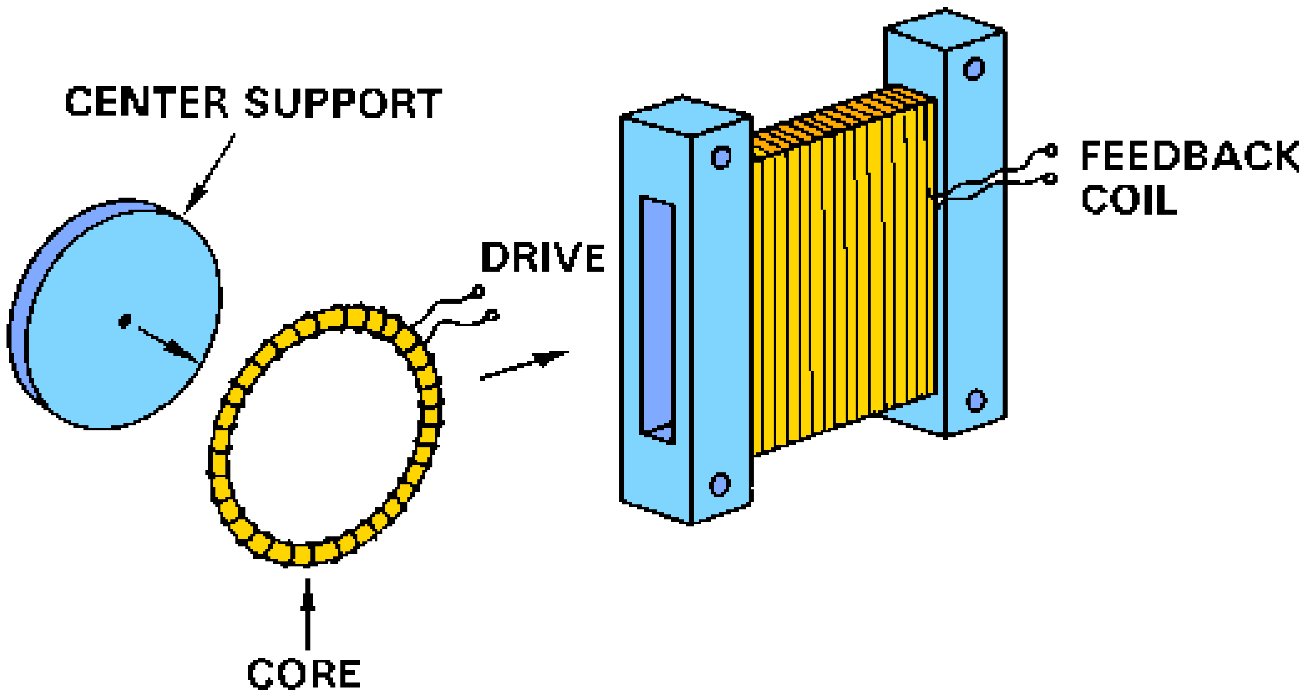


Figure 1 Schmatic drawing showing the construction of each sensor.

3.3 The Cable Assembly

The triaxial fluxgate sensor is connected to the electronics box by means of a cable assembly of approximately 1 meter in length. The cable is attached directly to the sensor, and is connected to the magnetometer electronics box by means of a 15 pin connector. The cable assembly consists of 5 individual coaxial cables, one for the X, Y and Z drive, one for each of the X, Y and Z sensors and in addition one for the temperature sensor. The cable assembly is covered with aluminized mylar tape for thermal protection, as well as providing an RF shield.

3.4 The Analog Circuitry

Figure 2 shows a block diagram of the basic fluxgate magnetometer. A 60 kHz synchronization signal is derived from a crystal clock, and divided down to 15 kHz to provide the excitation signal for the fluxgate senesors. A high efficiency 'capacitive discharge' circuit is utilized to drive the cores to over 100 times their coercive force with low average power requirements.

The signal processing electronics consists of an A.C. preamplifier tuned to the second harmonic of the drive signal (30kHz), a synchronous demodulator, an operational integrator and a transconductance feedback summing amplifier which takes the place of the feedback resistor in conventional designs. A low pass, 6db/octave filter is utilized at the output to limit the signal bandwidth to 6 Hz since the sampling rate is 12 samples per second.

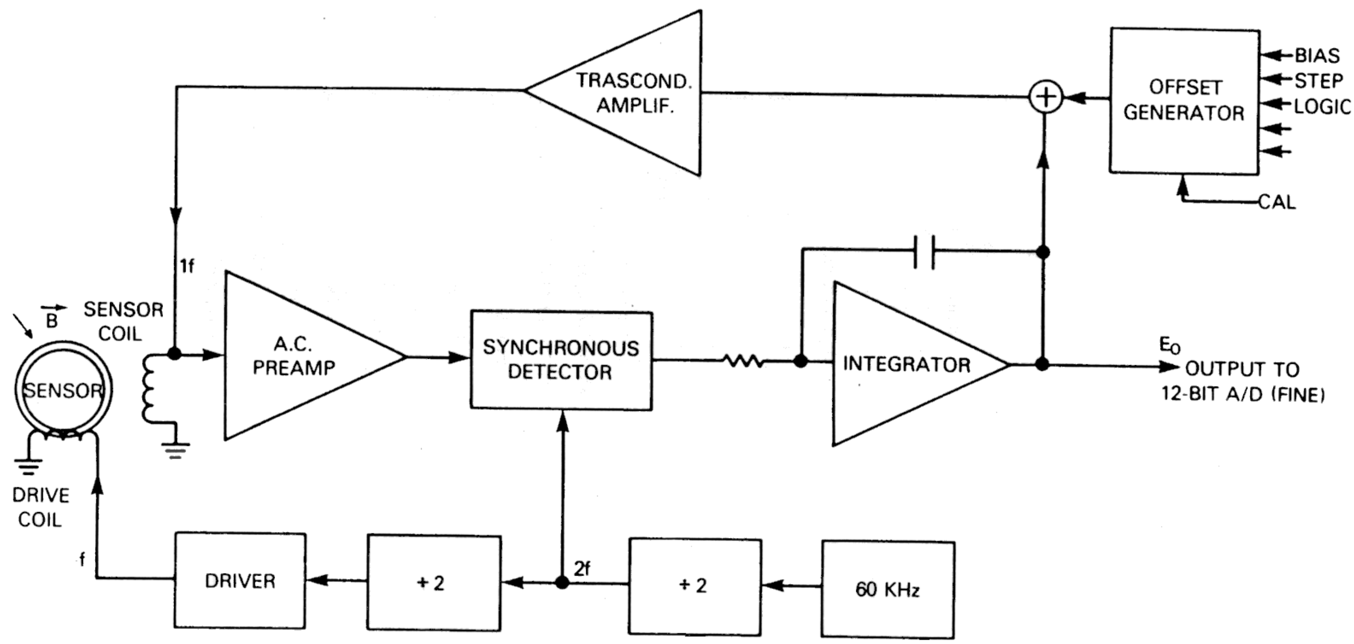


Figure 2BLOCK DIAGRAM OF BASIC FLUXGATE MAGNETOMETER

A simple preamplifier provides a gain of approximately 75. A low Q tuned circuit is included at the output to provide additional rejection to unwanted odd frequency components which could affect the .PN 8 (PAGE 7 IS FIG 2) performance of the non-ideal synchronous detector. After tuning, the electronics is unique to the sensor and cable.

The synchronous detector is a conventional design utilizing a quad CMOS transmission gate driven by a second harmonic reference signal derived from the frequency divider chain in the drive electronics. The operational integrator provides the bulk of the gain in the loop and its time constant is selected to guarantee loop stability and the desired response bandwidth.

3.5 The A/D converter and Digital Readout Circuitry

A block diagram showing the main elements of the DMSP magnetometer is shown in Figure 3. The A/D converter takes 4 samples (X, Y and Z magnetic fields, and in addition the spacecraft current) 12 times per second. These outputs are fed to comparators. The ouput from the comparator in question, is fed to a 12 bit shift register (MM54C905). The parallel output from this register is fed to a 12 Bit D/A (AD7541A), the analog output of which is used as the other input to the comparators. Thus by a series of successive approximations the magnetic field inputs and spacecraft currents are digitized to 12 Bits. The 4 most significant bits from the shift register are used to control the Bias Offset Generator described in the next section.

The 12 bit output from the A/D is steered either directly to one of the dual ping-pong registers, or is first passed through a 6 bit differencing circuit as part of a data compression scheme. The 11th and 12 readings for the X axis are discarded. Also the spacecraft current output is only stored once per second, to a resolution of 8 bits.

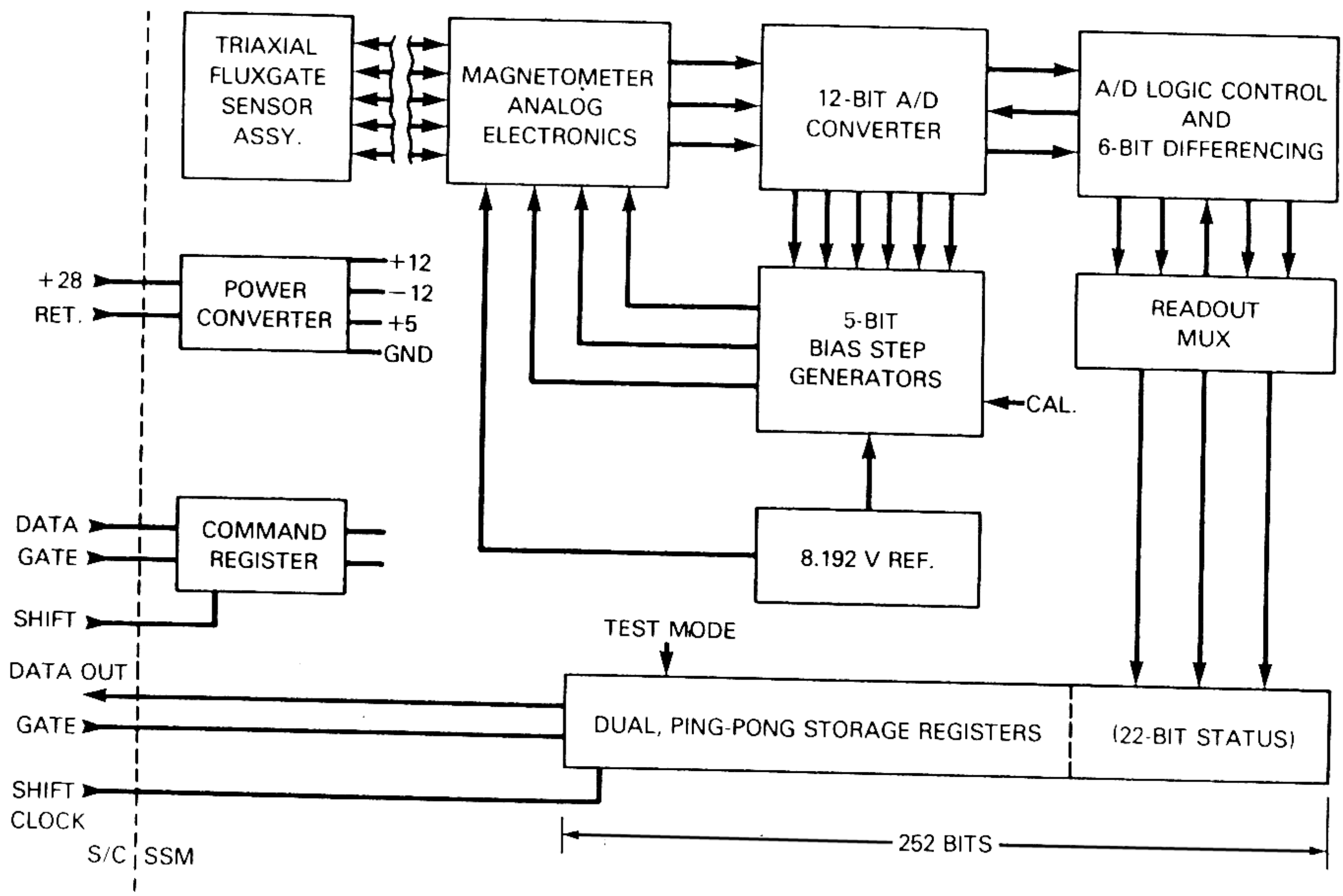


Figure 3 DMSP MAGNETOMETER - BLOCK DIAGRAM

A 16 bit status register stores the bias information (3 * 5 bits) .PN 10 (PAGE 9 IS FIG 3) in addition to CAL (1 bit). Another 8 bit register stores 6 additional bits of information, these are NORMAL/TEST (1 bit), the condition of the coils (4 bits) and DELTA EXCEEDED (1 bit), for a total of 22 status bits.

3.6 The Bias Offset Generator

A simplified diagram of the field offset generator is shown in Figure 4. This is a conventional design utilizing an R-2R resistor ladder network. The ladder is used in the current mode to minimize common mode errors associated with the amplifier.

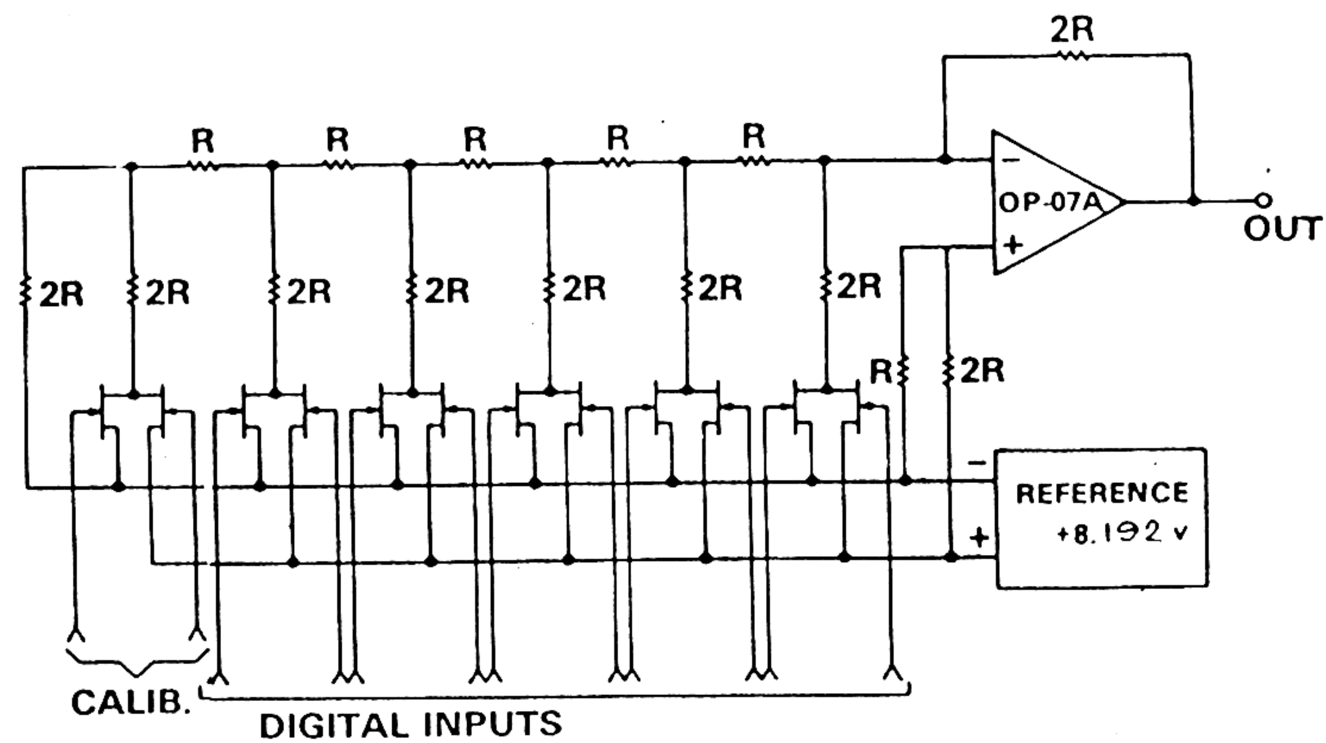


Figure 4 SIMPLIFIED DIAGRAM SHOWING THE FIELD OFFSET GENERATOR

The ladder resistors are precision units matched to a tolerance of +/- 0.01% to simplify the calibration and data reconstruction procedures. The voltage reference was implemented around a temperature stabilized precision zener (1N4569A).

The digital inputs to the offset generator switches are derived from an up-down counter associated with the 12-bit A/D converter logic. When the 'fine' digitized signal for a given axis exceeds an upper threshold of 3584 counts, or goes below a lower threshold of 512 counts, the counter is allowed to count up or down respectively by 1 count at the end of a one second measurement interval, which will offset the field by 4000 Gammas thus maintaining the magnetometer within its operating range. The expected 'Fine' output readings for an increasing, and also for a decreasing, magnetic field, produces the saw-tooth wave form shown in Figure 5. Should the readings enter the "Guard Band" region, they will only be there until the beginning of the next one second sample period, when the bias offset will be changed appropriately.

During testing or calibration of the instrument, the Bias Offset generator may be manually commanded to any level, by attaching a 'Jam Box' to connector J5 on the magnetometer electronics box.

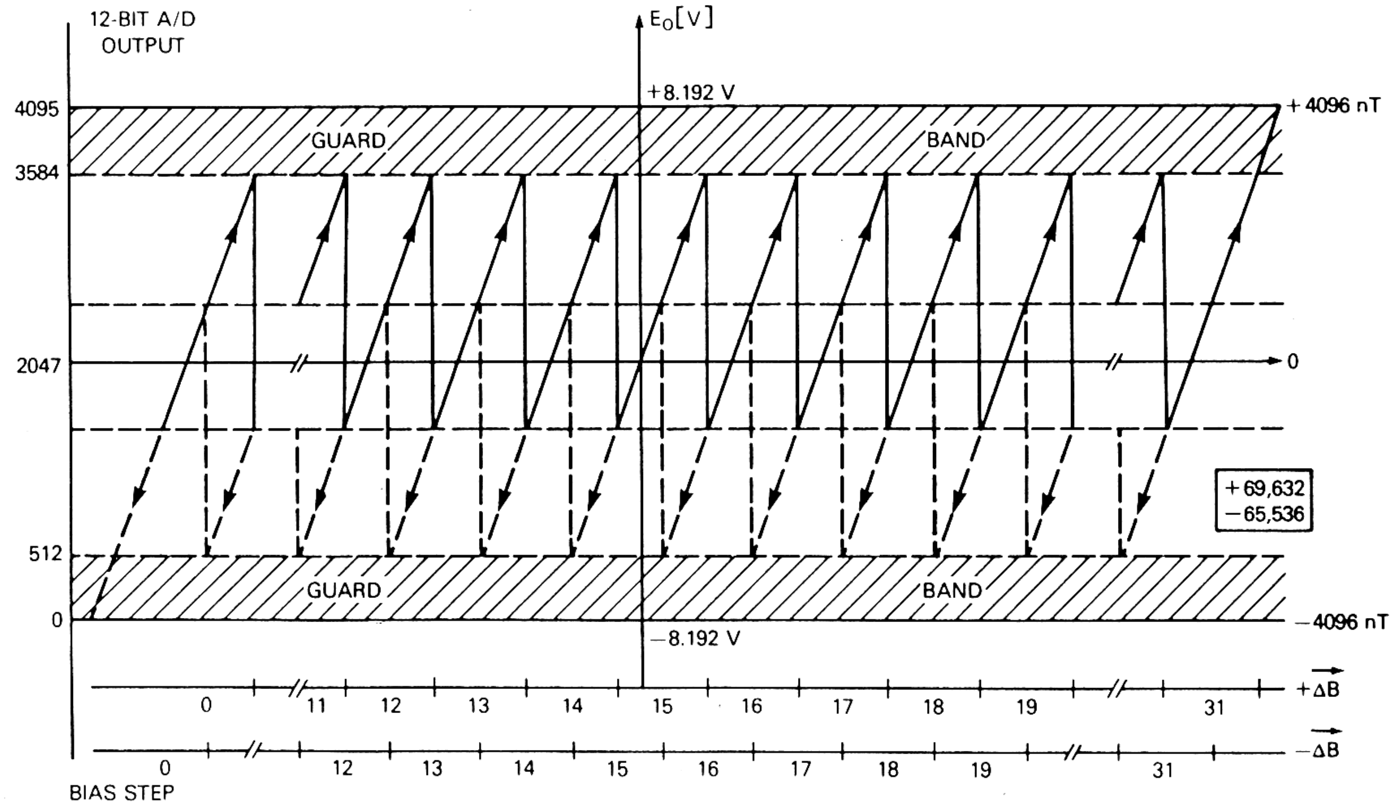


Figure 5 DMSP MAGNETOMETER RESPONSE

3.7 The Power Converter

The power converter is a high efficiency, two transformer, self oscillating design (operating at 40 kHz +/- 5%). The power converter uses linear regulation, resulting in a 0.5 to 0.7 volt drop. The input to the converter is 28 Volts, and the outputs are +/- 12 Volts and 5 Volts. Full protection is obtained through using foldback current limiting circuitry. The power convertor can be turned on and off either through the logical signal SSMPEN (POWER ENABLE), or the SSMPEN override signal. Also a current monitor is provided, the output of which is digitized and included as part of the spacecraft engineering data. In the OFF state, the current drawn is approximately 1 mA. In the ON state the current drawn is approximately 28 mA.

A photograph showing the turn-on transient for the instrument is given in Appendix A.

Appendix A

Photographs, size, weight and power summary

Summary of size, weight and power requirements of SSM magnetometer S/N 001.

Size of sensor = 112 * 90 * 67 mm
(without thermal blanket)

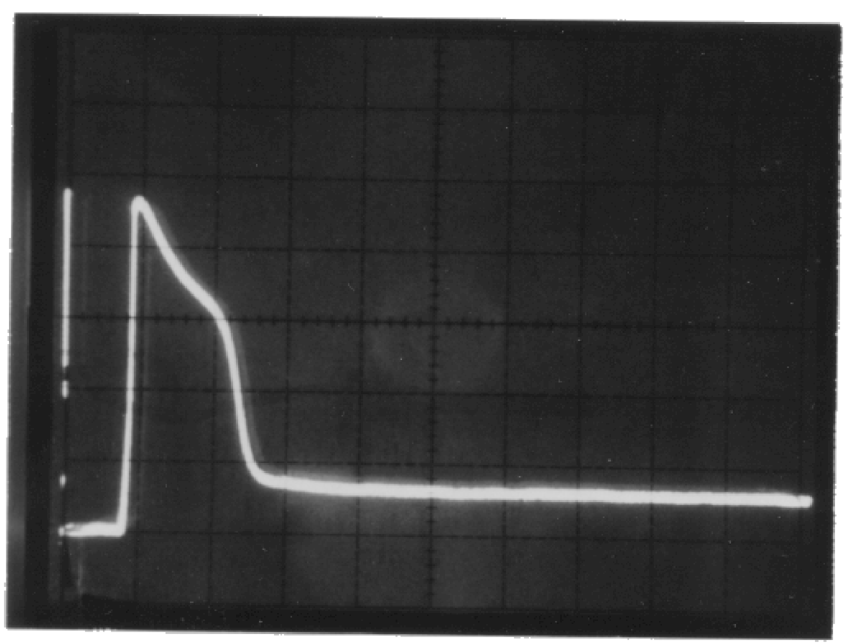
Length of cable = 1 meter

Size of electronics box = 292 * 241 * 63 mm

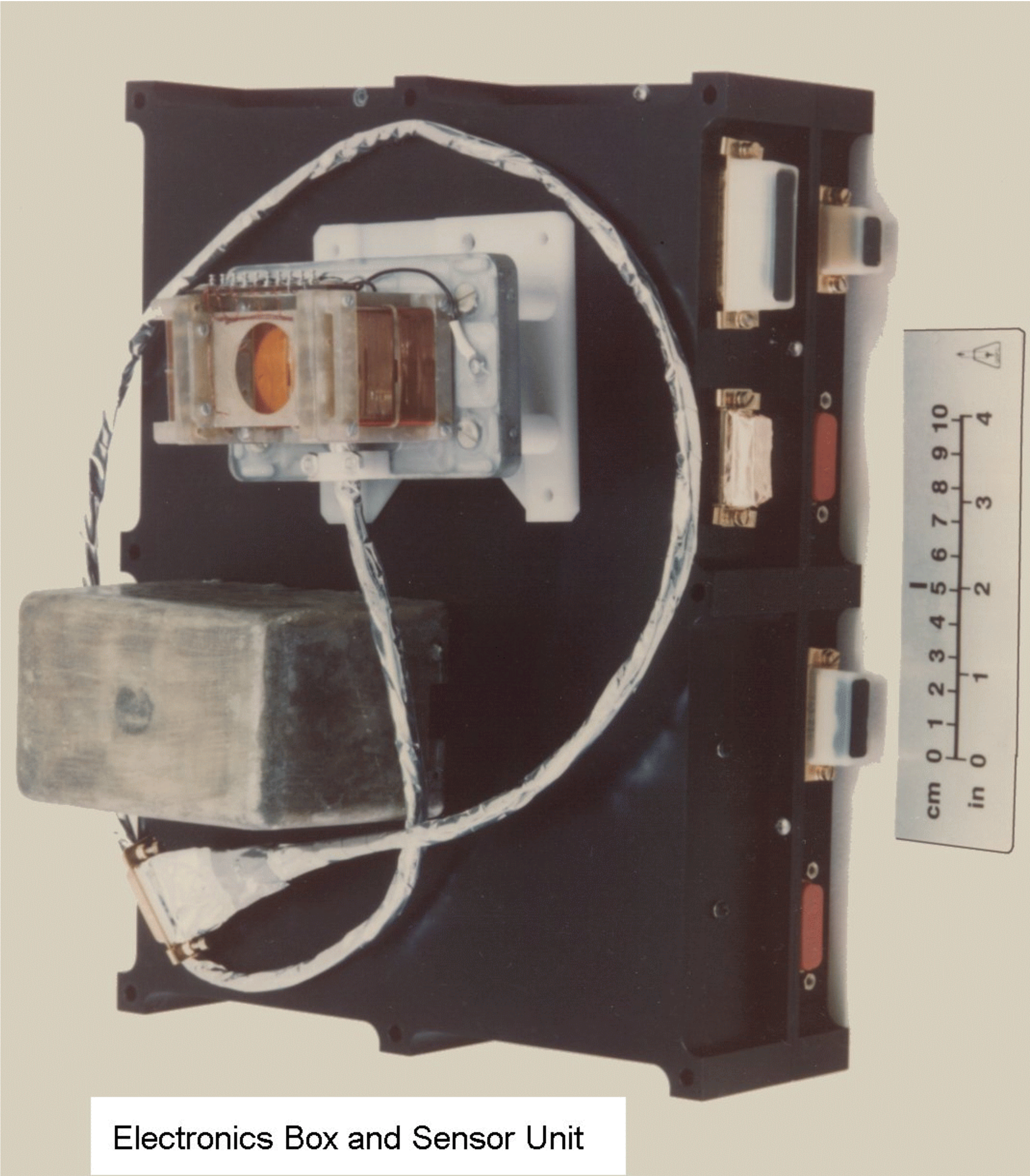
Mass of sensor + cable = 290 g.

Mass of electronics box = 2594 g.

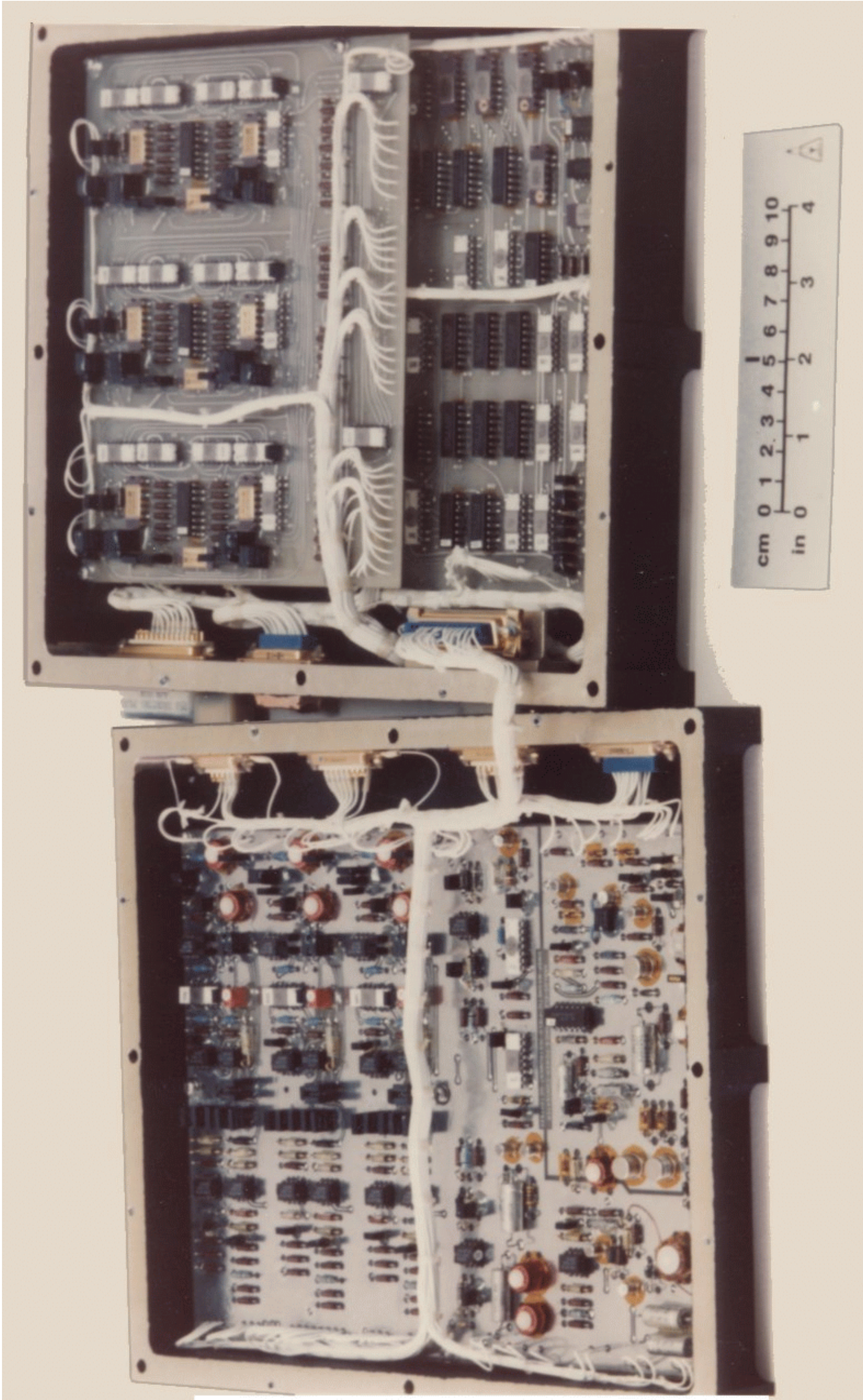
Power consumption = 28 mA at 28 Volts = 0.8 Watts



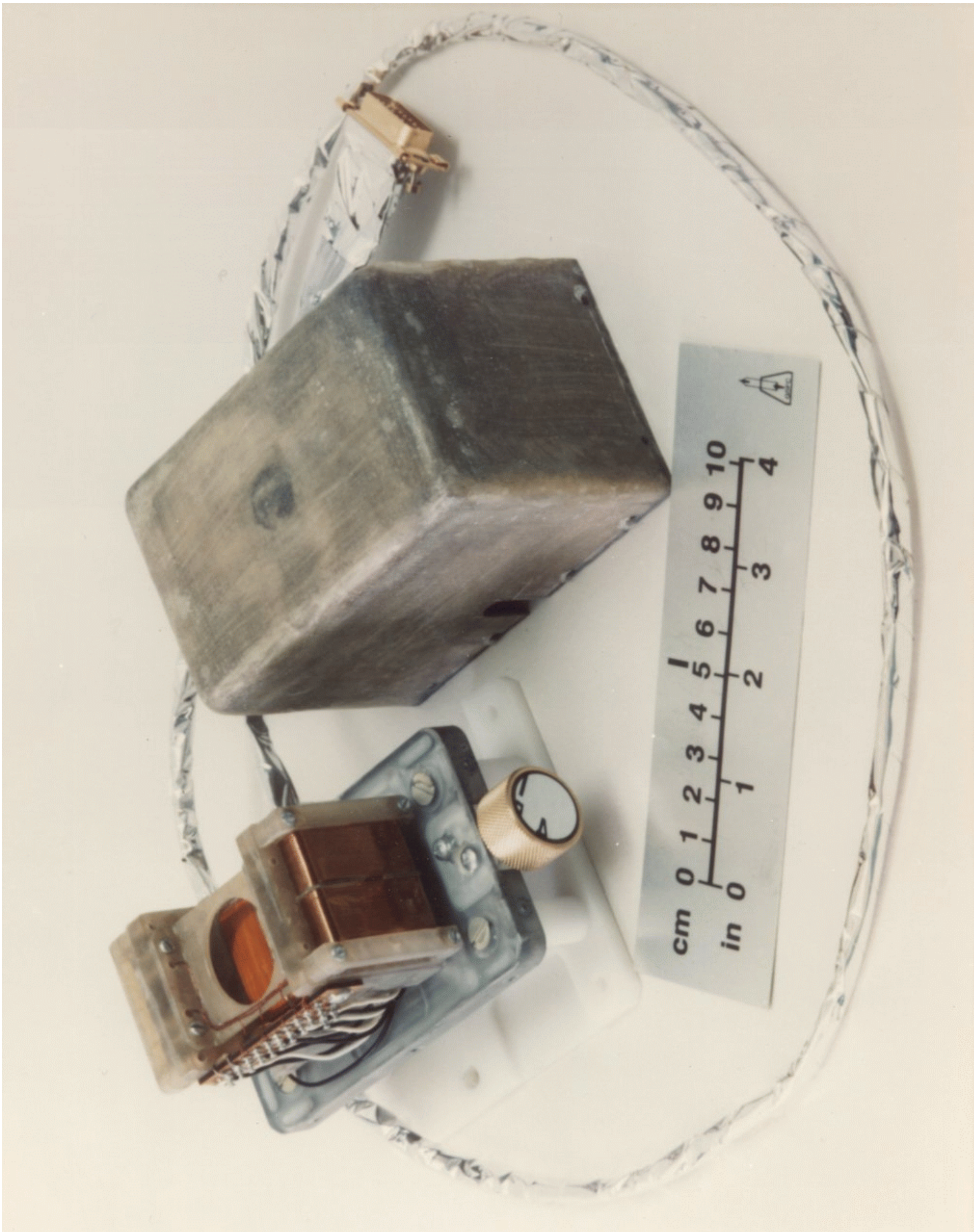
Turn on transient of the unit S/N : 002
Scale Horizontal - 2 mS per division
Vertical - 50 mA per division



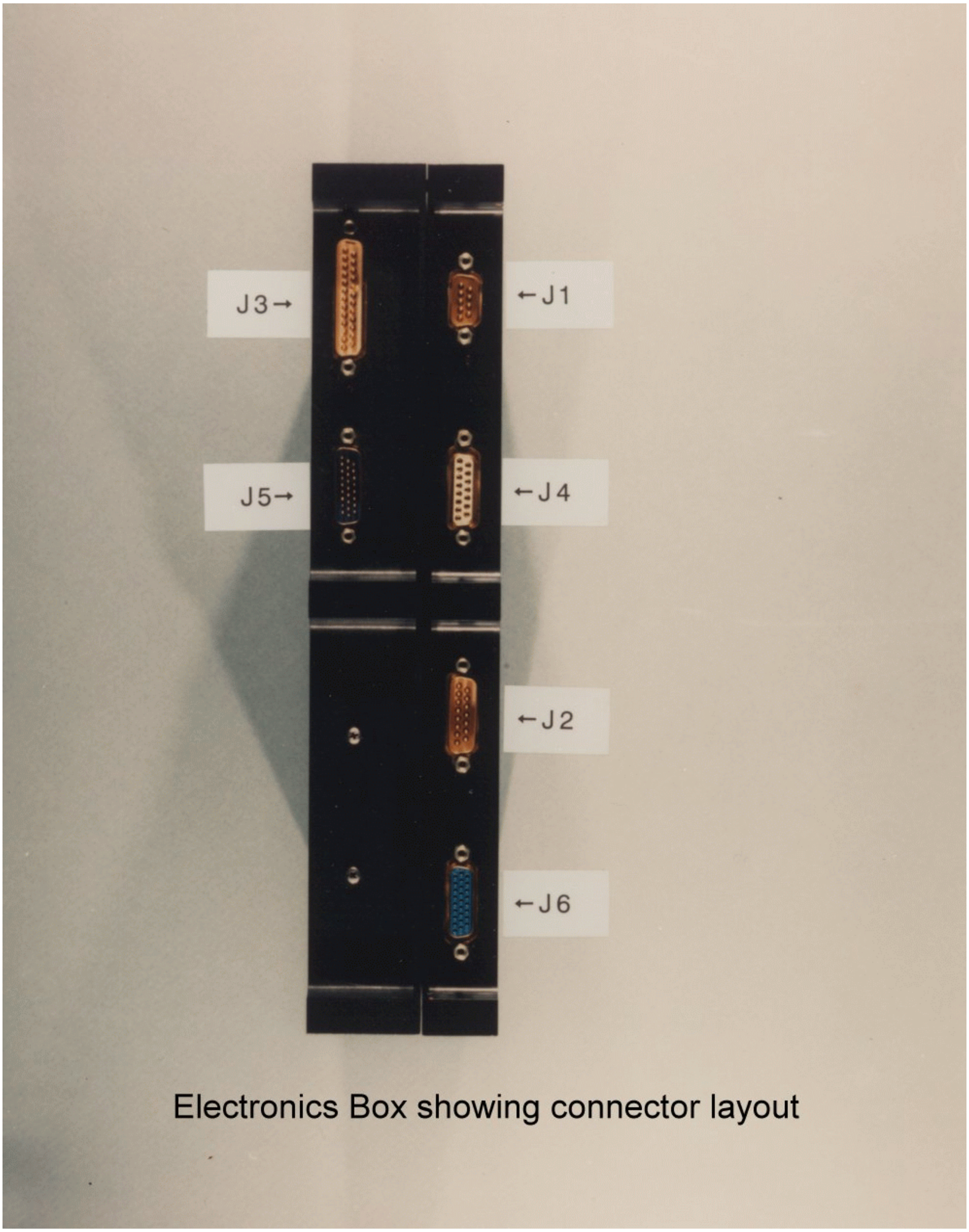
Electronics Box and Sensor Unit



Electronics Box Unit S/N 001



Sensor Unit with Alignment Mirror Attached



Electronics Box showing connector layout

Appendix B
DMSP SSM Connector Pin Assignments

DMSP SSM CONNECTOR PIN ASSIGNMENTS

J1 (S/C POWER - Electronics)
DEM-9P-NMB-K56

PIN NUMBER	FUNCTION
1	+28 VOLT POWER
2	+28 VOLT POWER
3	SPARE
4	SPARE
5	SPARE
6	POWER RETURN
7	POWER RETURN
8	SSMPEN OVERRIDE
9	CHASSIS GROUND

J2 (S/C - Electronics)
DAM-15P-NMB-K56

PIN NUMBER	FUNCTION
1	SIGNAL RETURN
2	X MAGNETOMETER (VOLTS)
3	Y MAGNETOMETER (VOLTS)
4	Z MAGNETOMETER (VOLTS)
5	SENSOR TEMPERATURE
6	+5 VOLT SUPPLY (NOT USED)
7	CURRENT MONITOR
8	ELECTRONICS TEMPERATURE
9	CALIBRATION CURRENT MONITOR
10	COIL 1
11	COIL 2
12	COIL 3
13	COIL 4
14	RETURN
15	SPARE

J3 (OLS - Electronics)
DBM-25P-NMB-K56

PIN NUMBER	FUNCTION
1	SPARE
2	SSMDAT (DATA)
3	SSMDAT RET (DATA RET)
4	SSMBCK (BIT CLOCK)
5	SSMBCK RET (BIT CLOCK RET)
6	SSMRED (READ GATE)
7	SSMRED RET (READ GATE RET)
8	SPARE
9	SPARE
10	SPARE
11	SPARE
12	SPARE

13	SPARE
14	SPARE
15	SSMOFF (ON-OFF INDICATOR)
16	SSMOFF RET (ON-OFF INDICATOR RET)
17	SSMPEN (POWER ENABLE)
18	SSMPEN RET (POWER ENABLE RET)
19	SSMMD1 (NORMAL-TEST)
20	SSMMD1 RET (NORMAL-TEST RET)
21	SSMMD2 (CAL ON-OFF)
22	SSMMD2 RET (CAL ON-OFF RET)
23	SPARE
24	SPARE
25	SPARE

J4 (Sensor - Electronics)
DAM-15S-NMB

PIN NUMBER	FUNCTION
1	X,Y,Z DRIVE
2	X SENSOR SIGNAL
3	Y SENSOR SIGNAL
4	Z SENSOR SIGNAL
5	TEMPERATURE SIGNAL
6	SPARE
7	SPARE
8	SPARE
9	X,Y,Z DRIVE RETURN
10	X SENSOR SIG. RETURN
11	Y SENSOR SIG. RETURN
12	Z SENSOR SIG. RETURN
13	TEMPERATURE SIG. RETURN
14	SPARE
15	STRUCTURE GROUND

J5 (Electronics - Jam Box)
311P407-2P-12

PIN NUMBER	FUNCTION
1	GROUND
2	X MODE SELECT
3	X BIT 4
4	X BIT 3
5	X BIT 2
6	X BIT 1
7	X BIT 0
8	X OFFSET VOLTAGE
9	Y OFFSET VOLTAGE
10	GROUND
11	GROUND
12	Y MODE SELECT
13	Y BIT 4
14	Y BIT 3
15	Y BIT 2
16	Y BIT 1

17	Y BIT 0
18	Z OFFSET VOLTAGE
19	Z MODE SELECT
20	Z BIT 4
21	Z BIT 3
22	Z BIT 2
23	Z BIT 1
24	Z BIT 0
25	SPARE
26	ANALOG RETURN

J6 (TEST CONNECTOR, Electronics - GSE)
311P407-28-2S-12

PIN NUMBER	FUNCTION	
1	X COARSE	(+/-8V 8V=64000 Gamma
2	X COARSE RET	nominal)
3	Y COARSE	
4	Y COARSE RET	
5	Z COARSE	
6	Z COARSE RET	
7	SPARE	
8	SPARE	
9	SPARE	
10	READ GATE	(TEST)
11	READ GATE RET	
12	BIT CLOCK	(TEST)
13	BIT CLOCK RET	
14	DATA	(TEST)
15	DATA RET	
16	SPARE	
17	SPARE	
18	SPARE	
19	X FINE	(+/-8V 8V=4000 Gamma
20	X FINE RET	nominal)
21	Y FINE	
22	Y FINE RET	
23	Z FINE	
24	Z FINE RET	
25	SSMPEN OVERRIDE	
26	SPARE	

Appendix C

Commands

COMMANDS

The SSM fluxgate magnetometer can be commanded on by either setting SSMPEN (Power Enable) (J3 pin 17) or SSMPEN OVERRIDE (J1 pin 8).

The SSM magnetometer will then function in the normal manner, as described later, or will respond to either of the two following commands.

SSMMD1 (NORMAL/TEST) (J3 pin 19) This will command the magnetometer into either its NORMAL operating mode, or a TEST mode. When in the TEST mode, the magnetometer sends out a predetermined pattern. An example of the expected output is given in Appendix G (Ground Support Equipment).

SSMMD2 (CALIBRATE ON/OFF) (J3 pin 21) This will put the magnetometer into a calibrate mode. When set, this should increment the output counts by the following amounts:-

X-axis 1007 counts

Y-axis 996 counts

Z-axis 1059 counts

Appendix D
Downlink Data Format

DMSP MAGNETOMETER - BIT ALLOCATION

BIT #	READOUT
1 - 7	STATUS
8 - 12	Z BIAS, 5-BIT
13 - 17	Y BIAS, 5-BIT
18 - 22	X BIAS, 5-BIT
23 - 34	Z FINE, 12-BIT \
35 - 46	Y FINE, 12-BIT > SAMPLE #1
47 - 58	X FINE, 12-BIT /
59 - 64	Z, 6-BIT DIFF \
65 - 70	Y, 6-BIT DIFF > SAMPLE #2
71 - 76	X, 6-BIT DIFF /
77 - 82	Z, 6-BIT DIFF \
83 - 88	Y, 6-BIT DIFF > SAMPLE #3
89 - 94	X, 6-BIT DIFF /
95 - 100	Z, 6-BIT DIFF \
101 - 106	Y, 6-BIT DIFF > SAMPLE #4
107 - 112	X, 6-BIT DIFF /
:	:
:	:
:	:
185 - 190	Z, 6-BIT DIFF \
191 - 196	Y, 6-BIT DIFF > SAMPLE #9
197 - 202	X, 6-BIT DIFF /
203 - 208	Z, 6-BIT DIFF \
209 - 214	Y, 6-BIT DIFF > SAMPLE #10
215 - 220	X, 6-BIT DIFF /
221 - 226	Z, 6-BIT DIFF \
227 - 232	Y, 6-BIT DIFF > SAMPLE #11
233 - 238	Z, 6-BIT DIFF \
239 - 244	Y, 6-BIT DIFF > SAMPLE #12
245 - 252	SPACECRAFT CURRENT, 8-BIT

Appendix E

Downlink Data Interpretation

DOWNLINK DATA INTERPRETATION (Page 1 of 2)

BIT #	READOUT	NOTES
1	MODE	1 = NORMAL OPERATING MODE, 0 = TEST MODE - SEND TEST PATTERN When commanded to be in the TEST mode, (via the control signal SSMMD1), the SSM magnetometer sends a continous TEST pattern, shown elsewhere in this document.
2	COIL 1	1 = TORQUING COIL #1 ON 0 = TORQUING COIL #1 OFF The spacecraft supplies logic signals, indicating when the four torquing coils are active, these are monitored and included in the SSM data stream. (Always 0 if torquing coil signal is not supplied by S/C.)
3	COIL 2	1 = TORQUING COIL #2 ON 0 = TORQUING COIL #2 OFF
4	COIL 3	1 = TORQUING COIL #3 ON 0 = TORQUING COIL #3 OFF
5	COIL 4	1 = TORQUING COIL #4 ON 0 = TORQUING COIL #4 OFF
6	DELTA	1 = DELTA EXCEEDED 0 = DELTA IN RANGE If the DELTA EXCEEDED flag is set, this indicates that at least one of the 6-bit differences in the data for the current second has been exceeded.
7	CALIBRATE	1 = CALIBRATE OFF 0 = CALIBRATE ON Commanding the SSM magnetometer into the CALIBRATE mode (via the control signal SSMMD2), has the affect of increasing by approximately 2000 gammas, the readings in each of the X, Y and Z channels. (For unit SN001 the increases are -1007 COUNTS for the X axis 996 COUNTS for the Y axis 1059 COUNTS for the Z axis)

BIT #	READOUT	NOTES
8 - 12 13 - 17 18 - 22	Z BIAS, 5-BIT Y BIAS, 5-BIT X BIAS, 5-BIT	Each of the 32 bias steps is approximately 4096 Gammas. (MSB first.). For SCAN # (I+1)
23 - 34 35 - 46 47 - 58	Z FINE, 12-BIT Y FINE, 12-BIT X FINE, 12-BIT	SAMPLE #1
		Each of the fine bits represents approximately 2 Gammas. (MSB first). The full 17 bits for each axis are transmitted once per second.
59 - 64 65 - 70 71 - 76	Z, 6-BIT DIFF Y, 6-BIT DIFF X, 6-BIT DIFF	SAMPLE #2
		After sending the 12 fine bits, the SSM magnetometer sends 11 subsequent 6-BIT differences for each of the Z and Y axes, and 9 6-BIT differences for the X axis. The 6-BIT difference represents a number ranging from -32 to +31, which is to be added to the previous reading to get the current reading. (MSB first).
77 - 82 83 - 88 89 - 94	Z, 6-BIT DIFF Y, 6-BIT DIFF X, 6-BIT DIFF	SAMPLE #3
		Likewise for the subsequent difference readings
221 - 226 227 - 232	Z, 6-BIT DIFF Y, 6-BIT DIFF	SAMPLE #11
233 - 238 239 - 244	Z, 6-BIT DIFF Y, 6-BIT DIFF	SAMPLE #12
245 - 252	SPACECRAFT CURRENT, 8-BIT	The SSM magnetometer digitizes an analog signal supplied by the spacecraft, proportional to the total spacecraft current, (for use when interpretating the data, always 0 if signal is not supplied by spacecraft).

Appendix F
The Ground Support Equipment

THE GROUND SUPPORT EQUIPMENT

The GSE hardware for the DMSP magnetometer consists of a COMPAQ personal computer, a card mounted in one of the available expansion slots, and various interconnecting cables.

Photographs and schematics for the GSE card are given in Figures F1 through F4.

The latest software program written to test the various functions is called "DMSPV3.EXE". It is executed automatically during the power up procedure of the COMPAQ. The card may be located in any of the available slots.

ELECTRICAL CONNECTIONS BETWEEN THE GSE AND THE EXPERIMENT

A cable approximately 6 feet long is plugged into the 50 way CANNON D-type connector on the GSE card. The other end of the cable is split into 4 bundles, each terminating in a different D-type connector, which are plugged into the magnetometer electronics box.

CONNECTIONS FOR THE TEST MODE

If the GSE is being used for monitoring the TEST signals only, then attach the appropriate cable from connector J6 on the experiment to the 26 pin connector on the cable from the GSE card.

CONNECTIONS FOR THE OLS SIMULATOR MODE

The TEST mode cable may be left attached during OLS simulation runs. In addition, cables must also be attached to the GSE card from connectors J1, J2 and J3 on the experiment. During normal use, the internal 28V power supply located on the card is used to power the experiment.

Once the cable connections have been made, the COMPAQ may be powered up. It takes approximately 30 seconds for the PC to boot up. On completion of the boot up procedure, the GSE software is run automatically. This is a compiled BASIC program called DMSPV3.EXE (here V3 corresponds to version #3). The compiler is Microsoft's QuickBASIC.

Alternatively the uncompiled version may be run, by first entering BASICA, and then loading DMSPV3.BAS.

Note:- The uncompiled version of the program runs much slower than the compiled version, and is therefore unable to update and process the digital information received from the experiment in real time. Under normal conditions the compiled version of the program should be used.

RUNNING DMSPV3.EXE

To run the program from DOS, simply type DMSPV3. Once loaded, the program will prompt the user to enter the relevant calibration file for the instrument under test. This is so that magnetic fields measured will have their values displayed in Gammas as well as in counts. If there is no available calibration file, simply hit <RETURN>, this will load the calibration constants obtained for UNIT S/N: 001, which are stored in the porgram. The calibration file is an ASCII file created using a word-processor program in a non-document mode. An example showing the format for this file is given in Table F-1.

TABLE F-1 Calibration Constants File for Unit S/N: 001

```
----------------------------------------------------------------
Calibration constants for DMSP/SSM MAGNETOMETER UNIT S/N 001
Constants             X-axis        Y-axis        Z-axis
Ki [gammas/count]     1.995278      1.9986        1.99634
ZEROi  [Counts]       2022          2083          2033
ao     [gammas]       -64386.68     -63720.23     -67553.96
a1     [gammas]       64385.13      63720.64      67566.31
a2     [gammas]       32196.75      31860.76      33772.81
a3     [gammas]       16098.63      15931.39      16888.81
a4     [gammas]       8048.88       7966.26       8447.56
a5     [gammas]       4024.48       3982.76       4221.14
CALi   [counts]       1007          996           1059
f3db   [Hz.]          6.63          6.63          6.63

EST Connector (J2) Output Constants
-2.56        24496
-2.56        24193
-2.56        25841
24.5098      -49.32
24.5098      -51.15
-2.48        8.77        27.6
-------------------------------------------------------------------
```

Note: First line of file begins "Calibration Constants ...... "

After the constants have been loaded, the MAIN MENU will be displayed, presenting the user with a number of options. The desired option is selected by hitting the corresponding function key F1 - F9. The opening screen and the MAIN MENU screens are given in Figures F5 and F6 respectively.

OPTION 1 The MAIN MENU

On selecting OPTION 1, the MENU shown in Fig. F7 is displayed. Option 1 is used to select between an internal or external power supply, and also to supply or remove this power to the experiment when the GSE is being used as the OLS simulator.

The action of the function keys is to TOGGLE relays located on the GSE card mounted in the COMPAQ.

On initial power up of the COMPAQ, the default settings should be INTERNAL, and POWER OFF.

OPTION 2 Test Mode Routines

The menu displayed on selecting option 2 is shown in Fig. F8. OPTION 2 would is used to monitor signals from the experiment TEST connector designated J6.

OPTION 2.1 Set Auto Dump Parameters

The screen corresponding to this option is shown in Fig. F9. The AUTO DUMP option enables large amounts of data to be AUTO-matically DUMP-ed on to hard disc or floppy disc, with out requiring the operator to be present. Under normal conditions the COMPAQ can collect and store internally 12068 scans of data. This corresponds to approximately 3 hours and 21 minutes in real time. Once this is reached, the operator is presented with the option of storing this data. Alternatively, using the AUTO DUMP option, allows the operator to create any number of files (limited only by the available space on the storage devcice) of up to 12068 scans each.

The default condition of this feature is that it is OFF. If the feature is OFF and it is desired to turn it on, answer Y to the first question. The operator is then asked to enter the number of scans per .pn 43
dump (MAX = 12068), followed by the number of dumps. Finally the operator

enters the ROOT name to be used for the files to be created. The files created will be named e.g. C:ROOT1.DAT -- C:ROOT2.DAT .... to C:ROOTndmax.DAT, where

ndmax = max number of dumps specified previously.

If the feature is on, and it is required to turn it off, then simply answer N to the first question.

OPTION 2.2 Display Incoming Digital Data in TABULAR Form

When selected, this option displays the screen shown in Fig. F10. The serial bit stream from the experiment is decoded, stored in RAM in the COMPAQ and displayed on the screen in a tabular form. The last line indicates various program settings as follows :-

AD Indicates AUTO DUMP feature on or off

CD Indicates current dump #

NDMAX Max # of dumps

CS Indicates Current Scan

NSMAX Max # of Scans

TIME Indicates time of last screen update

To exit the routine at any time hit F9. This will first ask the operator if it is required to store the data accumulated thus far, then return to the MAIN MENU. If the program is not in the AUTO DUMP mode, and the max # of scans that can be stored in RAM has been reached, then the options shown in Fig. F11 will appear. These are self explanatory. Selecting F2 - Store data on disk will display OPTION 2.2.1 shown in Fig. F12. The time and date of when the data was collected is displayed, together with the number of scans stored in .pn 44
memory.

Note: It is possible to store only a part of the data if desired.

OPTION 2.3 Display Incoming Data in Graphical Form

This option displays the incoming data on the screen, as if the COMPAQ were a strip chart recorder. During the set up procedure the operator has the choice of chosing MAX and MIN values for each of the three channels, X, Y and Z. Thus it is possible to choose a different offset and gain setting for each of the pens.

The default values appearing are such that each pixel corresponds to 1 count. The range for each channel is centered about 2048, which corresponds to a nominal 0 volts in the analog signal that is being digitized.

If there are no changes to be made, then the screen displays the data as shown in Fig. F13. The "paper" moves in an upward direction. Tic marks are shown, indicating the MAX and MIN positions on the paper. Also, every other scan number is shown on the LHS of the screen. Should "DELTA" be exceeded during a scan, this is indicated by an "E" displayed on the LHS of the screen. Finally an AUTO SCROLL fearture is included in the program. If the value of any particular channel exceeds the range specified by the MIN and MAX values, then these values are automatically changed to shift the plot back on the screen. (The gain is not changed i.e. ZMAX-ZMIN remains constant). If AUTO SCROLL has occured, then depending on the direction, either a "<" or ">" is shown at the location where this took place, together with the number of scrolls taken place.

The bottom line on the screen displays the MIN and MAX values for each of X, Y and Z.

Hitting F9 once will cause the program to pause, enabling closer inspection of the data, however incoming data will be lost. Hit F9 again to exit the routine and enter OPTION 2.3.1. (which is equivalent to the store data on disk routine in OPTION 2.2.1.). Hitting any other key will cause the program to continue collecting and displaying the incoming data. When the max # of scans has been reached the routine will stop and ask the operator for whether or not to store the data collected on to disk.

OPTION 3 OLS Simulator Mode

In the OLS simulator mode, the COMPAQ monitors and sends various control signals to the experiment, in addition to receiving the digital data stream, as in the case of the TEST MODE.

OPTION 3.1 Set Auto Dump Parameters

This is identical to OPTION 2.1

OPTION 3.2 Display Incoming Digital Data in Tabular Form

The screen shown in Fig. F14 is displayed. This option incorporates all the features found in OPTION 2.2, in addition to the following:-

Each time the screen is updated, various analog signals from J2 are also measured to 8 bit resolution and displayed. Also the status of the digital signal SSMOFF coming from the magnetometer is displayed.

The function keys F1 through F5 may be used to change the various digital signals being sent to the magnetometer bye the OLS.

e.g. SSMPEN (Power Enable)

SSMPOV (Power Enable Override)

SSMMD1 (Normal/Test)

SSMMD2 (Cal On/Off)

COIL1, COIL2, COIL3 and COIL4

These changes should then be reflected in the digital information sent back by the experiment. For example hitting F3 will cause the experiment to enter the test mode, which should then cause the output displayed in Fig. F15 to be sent back. Hitting F5 repeatedly will cause the a COIL levels to change following a binary count up manner sequence. Fig. F16 shows the screen displayed when no power is suplied to the experiment.

OPTION 3.3 Display Incoming Digital Data In Graphical form

This option is functionally equivalent to OPTION 2.3, with the addition of being able to change the various digital levels mentioned in the previous section.

OPTION 4 Review Data

The screen shown in Fig. F17 is displayed. The number of scans stored in memory is indicated. This option allows the user to review data currently stored in memory, or from a disk file. If data is read in from a disk file, then this will overwrite the current contents stored in the memory. The data may be reviewed in any of the 4 modes indicated, as shown in Fig. F18.

OPTION 4.1 Review Data - Display data in tabular mode

Here the data is displayed as shown in Fig. F19. It is possible to step forwards or backwards through the file by hitting the + or - keys respectively. Larger jumps of 20 steps may be made, by hitting the > or < keys.

OPTION 4.2 Review Data - Display data in HEX mode

This option displays the data in a HEX format, enabling a comparrison to be made with data received by the spacecraft. An example of this is shown in Fig. F20.

OPTION 4.3 Review Data - Display data in Graphical format

This option will display the data on the screen in the same 'strip chart recorder' fashion shown in Fig. F13. The display may be started from any desired scan. To pause hit F9, to continue, hit any key, or F9 to exit.

OPTION 4.4 Review Data - Graphical review & data processing

This option allows more flexibility in displaying the data. It is possible to specify an initial range of scans to be displayed, the number of scans over which to average the data, and the values for ZMIN, ZMAX etc. These parameters may be changed at will, either as the data is being processed and displayed, or after completion. An example of the display is shown in Fig. F21. Fig. F22 shows the same data, but averaged over 5 second periods. Also the data points are joined together. The information indicated on the LHS of the screen is as follows :-

Name of FILE being displayed

NS = # of scans in file

CS = Current Scan being processed/displayed

Av. = # of seconds data is averaged over

Z - Bias (0-31) = Z BIAS Value
Y - Bias (0-31) = Y BIAS Value
X - Bias (0-31) = X BIAS Value

The available commands are as follows :-

+ Increases # of scans over which to average by 1
- Decreases # of scans over which to average by 1
D Toggles - display data as DOTS, or join with LINES
L Shift window range to Left
R Shift window range to Right
E Expand display
C Contract display
ZU (Z followed by U) Shift Z display window Up
ZD Shift Z display window Down
ZE Z window Expand
ZC Z window Contract (Similarly for Y and X channels.)

NOTES ON USE OF THE COMPAQ, THE PROGRAMS, AND THE DATA FILES

On power on, after memory checks etc. have been made the AUTOEXEC.BAT file is executed. This accomplishes several tasks:-

1) The type of prompt to be used by DOS is set,
2) The PATH to be followed is defined,
3) The GRAPHICS driver is loaded to enable printer graphics dumps,
4) AUTOTIME automatically loads the time and date, obtained from a battery driven clock located on the RS 232 interface card. (The time stored by this clock may be changed using the program SETTIME.EXE found in the main directory).
5) The date and time stored in the computer during a session may be changed if required.
6) Finally the current directory is set to DMSP, and the GSE program DMSPV3 is run.

DIFFERENCES BETWEEN DMSPV1, DMSPV2 AND DMSPV3

DMSPV1 can store only 1200 seconds of data. The 252 bit serial bit stream is first converted to 32 8-bit bytes, and stored in a temporary array W(32). These are then transformed to 16 16-bit words, and stored in a 2 dimensional array Q(1200,16).

DMSPV1 FILE NOTES:- Data files created by DMSPV1 consist of a date and time tag, (obtained form the time when the data was obtained), followed by two lines each of 8 words, for each seconds worth of data. The files written to the disk are sequential, and the data is stored in an ASCII format.

DMSPV2 and DMSPV3 FILE NOTES:- these versions of the program can store 1724*7 or 12068 seconds worth of data. (NB the 1724 comes from 65536/38 bytes per second). The 252 bit serial stream is converted to 32 8-bit bytes as before, and together with 6 additional bytes of analog data, are stored in a temporary array W(38). This is then stored in memory using DEF SEG, PEEK and POKE statements, starting at segment Hex 3000. This program may be run on another PC, only if it has 640k RAM. It may not function on an "AT" type machine due to the absolute addresses used.

FILE NOTES Files are written using the random access mode. They are considerably shorter (less than 1/3 the length of an equivalent one created by

DMSPV1) and take only half the time to be written or read, as they are stored in a binary format. The record length is chosen to be 38, corresponding to the 32 bytes of digital information + 6 bytes of analog information obtained each second during the OLS mode. In the TEST mode these 6 bytes are simply set to 0. The first record of the file contains the DATE + TIME tag, + the number of scans stored.

Up to 9537 scans (corresponding to 2 hrs and 38 minutes) may be stored on single DS DD floppy disk.

DMSPV3 has options included so that files written by either DMSPV1 or DMSPV2 may alsp be read. Only random type files may be created.

Should it be desired to read the data files with other programs, e.g for data manipulation etc, then the file reading routine found begining at line 9100, and the file writing routine begining at line 6360 of the program, may be copied.

DMSPV2 and DMSPV3 also calculate and displays 1 second averages of the digital data.

DMSPV3 also has facilities to include calibration constants. Thus the actual field vaules in terms of GAMMAS are also displayed, following the 1 second averages.

COMPILER NOTES

Should it be desired to make any changes to the program, the following procedure is recommended :-

First enter the sub-directory QBASIC (standing for QuickBasic). Load BASICA (just type BASICA), then load "DMSPV3". This will take some time (2 minutes) as the program is long and also has to be stored in ASCII format. Make the desired changes, also remembering to change the first line, and any others which contain the name and date of creation of the program. If desired the program may then be run in the interpreter mode, though execution will be slow!. Also the program is very near the maximum size allowed before "memory full" type messages appear. (Type PRINT FRE(1) to see how many bytes are free). In order to free up more spcae, comments could be deleted, or unnecessary subroutines.

If all seams O.K. store the file in an ASCII format e.g.

SAVE "NEWPROG.BAS",A

When completed type "SYSTEM" to get back to DOS.

To compile the program type BASCOM NEWPROG/O followed by RETURNS in answer to the following questions. The /O option means that stand alone programs will be created, which can simply be copied and transferred to other PC's. Also the programs run a little faster using this option. On completion, type LINK NEWPROG, followed by RETURNS to the following questions. When complete a file will be created neamed NEWPROG.EXE. Copy this to the working sub-directory, which will use it, in this case DMSP. To run the program, simply type NEWPROG.

Appendix G

Special Handling Procedures

SSM MAGNETOMETER HANDLING AND SAFETY

The following lists some of the procedures/cautions that should be taken when handling the instrument.

1. Care must be taken not to bring magnetic tools in the proximity (12") of the sensor.

2. Care must be taken not to introduce stress to the electronics-sensor cable, e.g. the sensor must not be carried suspended by the cable.

3. All cables must be connected to electronics box before applying power, particularly the sensor cable. Under no circumstances must power be applied to the instrument without the sensor cable being attached.

Appendix H

TEST HISTORY for UNIT S/N: 001

H-1 Calibration Report

1.0 General

This section documents the calibration constants derived for the DMSP SSM Magetometer, unit S/N: 001, from calibrations performed at the Laboratory for Extraterrestrial Physics and the Magnetic Test Facility of the Goddard Space Flight Center. The various environmental tests and calibration procedures were performed during the latter part of December 1986 and continued into January 1987.

The constants given are best estimates obtained by fitting appropriate functions to the test data in a least squares sense, where appropriate. The detailed test data are documented in the instrument logbook and/or stored in the Ground Support Equipment magnetic storage system.

2.0 Sensor Alignment Constants

The measurements obtained in the sensor coordinate system reflect small angular deviations from true orthogonal positions for the sensors. The following expression can be used to transform the measurements to an ideal orthogonal system referenced to the calibration mirrors attached to the SSM Sensor Assembly and baseplate.

$$B \text{ orth.} = [\, Mx \,] \cdot B \text{ meas.}$$

where B orth. is the transformed field in a true orhtogonal system, and B meas. the field measured in the SSM sensor coordinate system. [Mx] is the transformation matrix.

For the DMSP/SSM S/N: 001 Instrument, Mx has the following value:-

$$[Mx] = \begin{bmatrix} 1 & 0.0071684 & 0.0080457 \\ 0.0052302 & 1 & 0.0087878 \\ -0.0020398 & -0.0082503 & 1 \end{bmatrix}$$

2.1 Sensor Axes Definition

The SSM sensor axes are defined in Fig. H-1 and are designed to be parallel to the DMSP spacecraft principal axes. When the external magnetic field is applied in the direction of the reference axes, the output voltage at the EST connector (J2) will become more positive while the output voltage at the TEST connector (J6) will become more negative.

3.0 EST Connector (J2) Output Constants

The following reconstruction formulas and constants are associated with the signals and monitoring functions present at the EST connector (spacecraft interface):

X MAGNETOMETER OUT. (COARSE):

Bx [gammas] = (Vx - 2.56) * 24,496 [3.1]

Y MAGNETOMETER OUT. (COARSE):

By [gammas] = (Vy - 2.56) * 24,193 [3.2]

Z MAGNETOMETER OUT. (COARSE):

Bz [gammas] = (Vz - 2.56) * 25,841 [3.3]

SENSOR TEMPERATURE:

T [deg. C] = 24.5098 * Ve - 49.32 [3.4]

ELECTRONICS TEMPERATURE:

T [deg. C] = 24.5098 * Ve - 51.15 [3.5]

CURRENT MONITOR:

I [mA] = (Vi - 2.48) * 8.77 + 27.6 [3.6]

The remaining signals and/or inputs are not used in SSM S/N 001.

4.0 Digital Signals Reconstruction Constant

The general formula for the calculation of the measured field from the digital data, is as follows:

$$Bi = - Ki * (FINEi - ZEROi) + ao + \sum_{1}^{5} (aj * bj)$$

where the following definitions apply:

Bi = measured field along i th component

Ki = FINE calibration constant in [gammas/count]

FINEi = Number of fine digital counts read from telemetry for the i th axis.

ZEROi = Number of fine output counts for zero field applied along the i th axis.

CALi = Output increment [counts] when CAL is ON.

a0 through a5 = calibration constants given below. These correspond to the "weights" of the COARSE bias step bits described below.

b1 through b5 = COARSE bias step digital word in binary notation (e.g. 0 1 0 0 1 or decimal 9), MSB to LSB order.

f3db = Rolloff frequency of FINE data output filter.
Slope = 6dB/oct.

Table H-1

Calibration constants for DMSP/SSM MAGNETOMETER UNIT S/N 001

Constants	X-axis	Y-axis	Z-axis
Ki [gammas/count]	1.995278	1.9986	1.99634
ZEROi [Counts]	2022	2083	2033
ao [gammas]	-64386.68	-63720.23	-67553.96
a1 [gammas]	64385.13	63720.64	67566.31
a2 [gammas]	32196.75	31860.76	33772.81
a3 [gammas]	16098.63	15931.39	16888.81
a4 [gammas]	8048.88	7966.26	8447.56
a5 [gammas]	4024.48	3982.76	4221.14
CALi [counts]	1007	996	1059
f3db. [Hz.]	6.63	6.63	6.63

H-2 Random Vibration Test

The vibration test of unit S/N: 001 was conducted at the vibration test facility, Goddard Spaceflight Center, on 12 to 16 December 1986, in accordance with MIL-STD-1540B. 10 Oct 82, para. 6.4.5 and 7.3.4, with the following levels for each axis:-

Increasing 6dB/octave from 10 Hz to 16 Hz

0.20 / 0.13 g^2/Hz from 16 Hz to 1500 Hz

Decreasing 6dB/octave from 1500 to 2000 Hz

The electronics package and sensor unit received a 3 minute exposure in each of 3 axes at a power spectral density (PSD) of 0.2 g^2 /Hz.

A functional test after vibration indicated that the unit operated normally.

H-3 Environmental Test

A thermal vacuum test of unit S/N: 001 was conducted at the environmental test facility, Goddard Spaceflight Center, on 9 to 14 January 1987, in accordance with MIL-STD-1540B. The electronics package and sensor were subjected to 3 thermal cycles (at a low pressure of 2 x10^{-6}Torr), at a low temperature of -5 Deg. C and a high temperature of 55 Deg. C. The instrument spent a total of approximately 19 hours at -5 Deg. C and 16 hours at 55 Deg. C.

Functional tests during and after the enviromental test indicated that the unit operated normally.

H-4 Electromagnetic Interference (EMI) Test

Tests were performed on unit S/N:001 to determine if the levels of extraneous emissions from the unit and the susceptibility of the system to externally generated emissions met the requirements of MIL-STD-461A. The tests were performed in the RFI enclosure, located in Building 7, Room 10, at the Goddard Space Flight Center, during the period 31 December 1986 to 8 January 1987.

The test results indicated that the system exceeded the applicable specification limits in radiated electric field emissions, line conducted emissions, radiated susceptibility, and conducted susceptibility.