Apollo 12 ALSEP ARCSAV Solar Wind Spectrometer Raw Cleaned ASCII Data Collection (1975-093 to 1975-182) Description

Overview

The astronauts on the Apollo missions deployed a set of scientific instruments that were collectively known as the Apollo Lunar Surface Experiments Package (ALSEP) at each of the Apollo 12, 14, 15, 16, and 17 landing sites [1]. The ALSEP instruments operated from the time of deployment to September 1977 at each site [2]. This collection from the Apollo 12 site consists of cleaned (corrected) ASCII tabular files of Solar Wind Spectrometer (SWS) raw data for the period of April 3, 1975 through July 1, 1975. These scientific, calibration, and command verification data were extracted from NASA's original ALSEP data archival tapes (also known as ARCSAV tapes) that recorded rearranged and time-edited, raw, unprocessed binary data transmitted from the moon.

ARCSAV Processing History

From April 1973 to February 1976, approximately 5000 ALSEP ARCSAV tapes were generated at the NASA Johnson Space Center. They were 7-track, digital, open-reel magnetic tapes. One ARCSAV tape contained a 24-hour, continuous recording of the raw data for all the ALSEP instruments deployed at one of the Apollo landing sites [3]. Data from several instruments were intermeshed into ALSEP data frames, each consisting of 64 ALSEP data words as shown in Appendix A.

In the years following the conclusion of the Apollo program, all of these tapes were lost. In the year 2010, 439 of these tapes, containing data from April 2, 1975 through July 1, 1975, were found at the Washington National Records Center [4]. Funding from the NASA Lunar Advanced Science & Exploration Research (LASER) and Planetary Data Archiving, Restoration, & Tools (PDART) programs NNH10ZDA001N-LASER and NNH14ZDA001N-PDART14 facilitated the extraction of data from ARCSAV tapes [4] and transformation to raw digital data sets of various levels of processing, some of which are archived at the NASA Space Science Data Coordinated Archive (NSSDCA) [5]:

- NSSDCA data set PSPG-00912 consists of daily binary files of raw, intermeshed Apollo 12 experiment data “as read” and extracted from those 439 ARCSAV tapes, but without corrections for obvious bit errors. These obvious bit errors and byte shifts and splits from tape reads were corrected to make cleaned, raw Apollo 12 daily binary files for NSSDCA data set PSPG-00917. Corrections were possible because the original ALSEP ARCSAV document is still available [3].
- NSSDCA data set PSFP-00714 consists of 90 daily files of raw binary SWS data extracted from the cleaned ARCSAV data set for Apollo 12 (PSPG-00917).
- This present collection is a transformation of 90 daily SWS raw binary files in NSSDCA data set PSFP-00714 into ASCII format. The Fortran programs used by the data provider for this transformation are included, for documentation purposes only, in same document collection as this data description.

Required Reading

The user should read several publications before using this archive.

Required: [3] provides a detailed description of the contents of the ALSEP ARCSAV tapes. Relevant sections in [3] are 1.0, 2.0, 6.3, and Appendix A including pages A-20 through A-35 that explain the SWS measurements. [6] provides detailed engineering and operations information about the Apollo 12 ALSEP station (also known as Array A and ALSEP 1) and the SWS experiment. The most relevant chapters in [6] are 6 - ALSEP Telemetry Subsystem and 10 - SWS Operations.

Strongly Recommended: [2] provides a very detailed operational history of each individual ALSEP experiment, including operational status, anomalies, and failures by date. [11] reports initial results from the SWS experiment. [12] and [13] present subsequent scientific results. [14] describes the data acquisition sequence, discusses data analysis, and lists the position and width of SWS energy steps in terms of positive ion (proton) velocity for normal incidence; this step information is captured in Appendix D of this data description document. Section 2.10 in [15] discusses how to deduce flux intensity, direction of mean velocity, energy of the particles, type of particles, density of particles, and article temperature from the data.

Additional detailed engineering and operations information on the Apollo 12 ALSEP station and the SWS are provided in [7], [8], and [9]. For a brief description of a specific Apollo scientific experiment together with its operational history and its data content, formats, and availability during the Apollo era, see [10].

Overview of Data Products

This collection contains three types of data products, where each type consists of a file of time-ordered, ASCII data in fixed-width tabular format (.tab) and a detached PDS label (.xml) that defines the format and contents of the data file:

- Raw Science Data: 90 daily products of raw SWS positive ion and electron flux measurements with filenames a12_sws_1975DDD_l1_arcsav_yz.tab/.xml, where DDD is the day of year,
- Raw Calibration/Engineering Data: 90 daily products of raw SWS calibration and engineering measurements with filenames a12_sws_1975DDD_l1_arcsav_w.tab/.xml, where DDD is the day of year, and
- Command Verification: One product containing a log of SWS Command Verifications with filename a12_sws_1975_l1_arcsav_cv.tab/.xml.

Raw Science Data Products

These products contain raw, unreduced SWS positive ion and electron flux readings at 21 energy levels for the 7 Faraday cups, identified by Measurement Numbers “DY-n” and “DZ-n” [3], that were converted within the SWS experiment to digital data numbers (DN) and stored in the designated ALSEP Main Frame Words 7, 23, 39 and 55 [3, 6] at the proper demand time in serial form for relay to Earth. ALSEP Main Frame Words are also known as ALSEP data words or simply as ALSEP words.

Each daily ASCII file (a12_sws_1975DDD_l1_arcsav_yz.tab) consists of one header record followed by two tables in this order:

1. Header: A single record that identifies the columns (fields) in the TimeOffsets and RawData tables.

2. TimeOffsets Table: A one-record fixed-width ASCII table that provides a derived sampling-rate-adjusted delay time as an offset in milliseconds for computing the time for each data measurement in each RawData Table record.

   To compute the time for a specific data measurement, add the milliseconds time offset found in this single-record table TimeOffset for the data measurement column of interest to the recorded time stamp (earth-received time) in the first column of the RawData record containing the data measurement of interest.

   These sampling-rate-adjusted delay times (offsets) were calculated specifically for this restoration using the mean duration for each daily set of ALSEP Main Frames. For example, some timing offsets in a12_sws_1975094_l1_arcsav_yz.tab, where the mean ALSEP Main Frame duration was 603.749 milliseconds (9.43358 milliseconds/ALSEP Word) for day of year 94, differ by one millisecond from the offsets in a12_sws_1975114_l1_arcsav_yz.tab, where the mean frame duration for day of year 114 was 603.760 milliseconds.

3. RawData Table: A multi-record fixed-width ASCII table containing the raw SWS positive ion and electron measurements extracted from one daily ALSEP ARCSAV tape. Each record contains all DY and DZ measurements for one SWS sequence, numbered from 0 to 15, for the given SWS data cycle. One SWS sequence is made every 28.1 seconds and consists of a complete set of plasma measurements. For each sequence, the positive ion flux is measured for each of the 7 Faraday cups at 14 increasing voltage levels or energy steps spaced a factor of square root of 2 apart from ~18 eV for Level 1 to ~9780 eV for Level 14. (Appendix D provides the position and width of energy steps in terms of positive ion velocity in km/s for normal incidence.) Then the electron flux is measured for each Faraday cup at 7 increasing energy steps a factor of 2 apart from ~6 eV for Level 15 to ~1330 eV for Level 21. For SWS sequences 0-13, a sum of the outputs of the 7 Faraday cups is provided for each of the 21 energy levels as shown on pages A-22 and A-26 to A-25 of [3]. Flux rates of 2.5E6 to 2.5E11 particles/cm^2/s could be measured.

   Each record begins with the earth-received reference time in UTC for the set of data in that record, followed by the 4-digit SWS cycle number and 2-digit SWS sequence number, then 96 DY measurements (DY-1 to DY-96) and 72 DZ measurements (DZ-1 to DZ-72) in the increasing order by measurement number. Therefore each record provides the two groups of scientific data, positive ion (proton) and electron fluxes, as shown on pages A-22 to A-24 in [3]. The first group consists of data columns DY-1 to DY-96 and DZ-1 to DZ-16 that contain 14 sets of positive ion measurements for energy levels 1-14 where the first data value in each set is a reading of the sum of the outputs of the 7 Faraday cups for the given energy level and the next 7 data values are the positive ion flux reading for each Faraday cup in ascending order from cup 1 to cup 7. For example, data columns DY-1 through DY-8 contain the measurements for positive ion energy level 1 where DY-1 is the sum of the outputs of the 7 Faraday cups at that level and DY-2 through DY-8 are the positive ion flux measurements for Faraday cups 1 through 7, respectively. The second group consists of data columns DZ-17 to DZ-96 that contain 7 sets of electron measurements for energy levels 15-21 where the first data value in each set is a reading of the sum of the outputs of the 7 Faraday cups for the given energy level and the next 7 data values are the electron flux readings for each Faraday cup in ascending order from cup 1 to cup 7. For example, data columns DZ-17 through DZ-24 contain the measurements for electron energy level 15 where DZ-17 is the sum of the outputs of the 7 Faraday cups at that level and DZ-18 through DZ-24 are the electron flux measurements for Faraday cups 1 through 7, respectively. A cross reference of each DY and DZ measurement number to a unique data sample ("Measurement Name") is provided on pages A-25 to A-35 of [3] and in Appendix B.

These raw measurements are provided in the RawData table as decimal integers with units of data number (DN) which is another name for digital unit (DU), the term typically used in ALSEP documentation. DN or DU, also known as digital count or instrument count, is the unit of measure for the raw digital number output by the experiment analog-to-digital converter. The label specifies units of DN which is the PDS convention.

The PDS data label defines for layout of this table and describes the contents of each column. Additional explanation of the contents is provided here:

- Records are ordered by the earth-received time in the first column. The format is YYYY-DDDTHH:MM:SS.sss, where DDD is day of year.

  This earth-received time is the time when the first word of the ALSEP frame containing the sequence of data measurements within the RawData record was received on earth, referenced to the standard time signal received at the Manned Space Flight Network station. When the operators had a problem reading the time signal, they substituted it with a computer-generated time, which they called the "software clock".

  The earth-received time is followed by a quality flag which is set to an asterisk "*" if the time value is from the software clock; if there is a suspected transmission, data synchronization or tape read error in the value; or if the time value is clearly outside the expected range for this restoration effort. A negative sign "-" indicates this value is the earth-received time, and the value does not have a suspected read or transmission error or that it is unknown if there was an error and therefore could still contain an error.

- The 2-digit SWS Sequence Number column is followed by a quality flag which is set to an asterisk "*" if the Sequence Number has a suspected transmission, data synchronization or tape read error. A negative sign "-" indicates this data measurement does not have a suspected read or transmission error or that it is unknown if there was an error.

- Each DY and DZ measurement is an 8-bit word, and therefore the raw integer values range from 0 to +255 DN. A value of integer -9 (negative nine) indicates that measurement is missing or not available. For example, DY-1 is set to -9 for SWS sequences 14 and 15 because a reading of the sum of the outputs of the 7 Faraday cups at energy level 1 is not performed for these two sequences.

  Table 6-XIV in Appendix B gives the sensor range, in physical units, for the DY and DZ measurements.

- Each DY and DZ data column is followed by a quality flag which is set to an asterisk "*" if that data value has a suspected transmission, data synchronization or tape read error. A negative sign "-" indicates this data measurement does not have a suspected read or transmission error or that it is unknown if there was an error and therefore the measurement could still contain an error.

- To facilitate plotting, the earth-received times can be reformatted from YYYY-DDDTHH:MM:SS.sss to decimal day by extracting the day of year (DDD), hour (HH), minute (MM), and seconds (SS.sss) strings from the timestamp, converting them to floating point, then performing this calculation:

  decimal day = DDD + (HH*3600. + MM+60. + SS.sss) / 86400.0

- where 86400.0 is the number of seconds in a day. Pay careful attention to the number of digits the computer carries. For example, to preserve the millisecond-resolution of the timestamps 11 decimal digits (or 35 binary digits) need be kept, and therefore the

variables DDD, HH, MM, and SS.sss may need to be defined as double-precision floating point. Using single-precision floating-point variables to reformat the timestamps would reduce the resolution to about a second.

Raw Calibration/Engineering Data Products

These products contain raw SWS calibration and engineering measurements, identified by Measurement Numbers "DW-n" [3], that were converted within the SWS experiment to digital data numbers (DN) and stored in the designated ALSEP Main Frame Words 7, 23, 39 and 55 [3, 6] at the proper demand time in serial form for relay to Earth.

Each daily ASCII file (a12_sws_1975DDD_l1_arcsav_w.tab) consists of one header record followed by two tables in this order:

1. Header: A single record that identifies the columns (fields) in the TimeOffsets and RawData tables.
2. TimeOffsets Table: A one-record fixed-width ASCII table that provides a derived sampling-rate-adjusted delay time as an offset in milliseconds for computing the time for each data measurement in each RawData Table record.

   To compute the time for a specific data measurement, add the milliseconds time offset found in this single-record table TimeOffset for the data measurement column of interest to the recorded time stamp (earth-received time) in the first column of the RawData record containing the data measurement of interest.

   The sampling-rate-adjusted delay times (offsets) were calculated using the mean duration for each daily set of ALSEP Main Frames.
3. RawData Table: A multi-record fixed-width ASCII table containing the raw SWS calibration and engineering measurements extracted from one daily ALSEP ARCSAV tape. Each record contains all 92 DW measurements for the given SWS data cycle.

   Each record begins with the earth-received reference time in UTC for the set of data in that record, followed by the 4-digit SWS cycle number given by DW-1 and DW-2, then measurements DW-3 to DW-92. A cross reference of each DW measurement number to a unique data sample ("Measurement Name") is provided on pages A-25 to A-35 of [3] and in Appendix B.

   These raw measurements are provided in the RawData table as decimal integers with units of data number (DN) which is another name for digital unit (DU), the term typically used in ALSEP documentation. DN or DU, also known as digital count or instrument count, is the unit of measure for the raw digital number output by the experiment analog-to-digital converter. The label specifies units of DN which is the PDS convention.

   The PDS data label defines for layout of this table and describes the contents of each column. Additional explanation of the contents is provided here:

   - Records are ordered by the earth-received time in the first column. The format is YYYY-DDDTHH:MM:SS.sss, where DDD is day of year.

     This earth-received time is the time when the first word of the ALSEP frame containing the sequence of data measurements within the RawData record was received on earth, referenced to the standard time signal received at the Manned Space Flight Network station. When the operators had a problem reading the time signal, they substituted it with a computer-generated time, which they called the "software clock".

The earth-received time is followed by a quality flag which is set to an asterisk "*" if the time value is from the software clock; if there is a suspected transmission, data synchronization or tape read error in the value; or if the time value is clearly outside the expected range for this restoration effort. A negative sign "-" indicates this value is the earth-received time, and the value does not have a suspected read or transmission error or that it is unknown if there was an error and therefore could still contain an error.

- Each DW measurement is an 8-bit word, and therefore the raw integer values range from 0 to +255 DN. A value of integer -9 (negative nine) indicates that measurement is missing or not available.
- Appendix B gives the sensor range and limits for the DW calibration and engineering measurements.
- Each DW data column is followed by a quality flag which is set to an asterisk "*" if that data value has a suspected transmission, data synchronization or tape read error. A negative sign "-" indicates this data measurement does not have a suspected read or transmission error or that it is unknown if there was an error and therefore the measurement could still contain an error.

Command Verification Data Product

This product provides a time-ordered log of commands specific to SWS operations that were received by Apollo 12 ALSEP and acted upon. These Command Verifications (CV) are stored in ALSEP Word 46 as Measurement Numbers DA-5 and DA-6 [3] for relay to Earth.

The ASCII CV file (a12_sws_1975_l1_arcsav_cv.tab) consists of one header record and one table in this order:

1. Header: A single record that identifies the columns (fields) in the CVLog table.
2. CVLog Table: A multi-record fixed-width ASCII table providing a log of time-ordered Command Verification (CV) messages for SWS operations. CV messages consist of a command counter code (the CV value) and its Message Acceptance Pulse (MAP) bit flag that reads out a "1" when the command parity error check was successful and the command was accepted and acted upon, as explained on page A-8 of [3]. Each record contains an earth-received time, a time status field, the command counter code as an octal integer, and its MAP for one CV message. The CV values for SWS operations are listed in Appendix C.

    - Records are ordered by the earth-received time in the first column.

      The time given here is not the command time. It is the earth-received time in UTC of the first word of the ALSEP frame in which the CV was recorded, referenced to the standard time signal received at the Manned Space Flight Network station. The command was received and acted upon sometime before the CV was recorded (+425 milliseconds after the earth-received time). When the operators had a problem reading the time signal, they substituted it with a computer-generated time, which they called "software clock".

      The earth-received time is followed by a quality flag which is set to an asterisk "*" if the time value is from the software clock; if there is a suspected transmission, data synchronization or tape read error in the value; or if the time value is clearly outside the expected range for this restoration effort. A negative sign "-" indicates this value is the earth-received time, and the value does not have a suspected read or transmission error or that it is unknown if there was an error and therefore could still contain an error.

- The status column, which follows the earth-received time, contains four 1-byte flags copied from the ARCSAV tapes. Each byte is one of the four 3-bit sync status flags for the ALSEP frame. The one-byte flags from left to right are: 1) unedited time sync status; 2) unedited data sync status; 3) edited time sync status; and 4) edited data sync status. The time sync status can be any value between 0 and 7, while the data sync status can only be 0, 4, 5, or 7 [3]. Although Section 2 of [3] explains the status values, it does not define the difference between unedited and edited status flags nor does ALSEP literature that was searched.
- The command counter code and its MAP parity bit are followed by a quality flag which is set to an asterisk "*" if the CV and/or its MAP has a suspected read or transmission error. A negative sign "-" indicates these values do not have a suspected read or transmission error or that it is unknown if there was an error and therefore could still contain an error.

Caveats/Confidence Level

Earth-Received Time vs. Data Acquisition Time

The earth-received times in the data products are approximately 1.19 to 1.37 seconds after the time when the data were acquired on the moon. This estimate, taken from ephemerides computed by the JPL Horizons System (https://ssd.jpl.nasa.gov/?horizons), is the minimum and maximum one-way down-leg light-time from the center of the moon (radius 1737 km) to a Manned Space Flight Network station on Earth (Canberra or Goldstone) for the time span of the data products.

Raw Data vs. Reduced Data

This collection contains only raw, unreduced data in units of DN (digital counts). Exact information about how to transform the raw DN to physical quantities and calibrate the data was not available when this archive was being prepared, and the effort of reducing these raw data was beyond the scope of this restoration. However Section 2.10 in [15] discusses how to deduce flux intensity, direction of mean velocity, energy of the particles, type of particles, density of particles, and article temperature from the raw data.

Data Gaps

Data gaps exist in the SWS source binary files and may be of any length, while those for this ASCII transformation are in the sequences, i.e., a multiple of 186 SWS words. As part of this transformation effort, a test was made to combine the partial sequence at the end of one binary file to that at the beginning of the next, but none of the combined sequences was of the proper length and could not be easily decoded to produce reliable ASCII data.

Data Quality

The goal for this restoration was to recover as much of the original data from tape as possible without overinterpreting and overcorrecting the values. The source binary files contain data that were corrected (cleaned) to remove byte shifts caused by missing, combined, extra, and split bytes that resulted from tape-reading errors. Only the obvious errors were corrected, and thus many bit errors may still remain in the source binary files and are carried over to the ASCII products in this archive. The user needs to aware of these errors and know that these could, if necessary, be corrected, but not always. Some known data quality issues most likely caused by a transmission, data synchronization or tape read errors are:

- Some values for earth-received time appear to be out of temporal order; may overlap with other timestamps; are outside the time range of this collection; or are an unreasonable value. These cases are likely caused by bit errors. Since this type of problem is always present in the ALSEP data, the restoration effort attempted to flag earth-received times whenever such a problem was suspected. Since the data that follow are likely to be correct, the incorrect times can often be interpolated from correct times before and after. Some bit errors, such as a single-bit error, can be corrected if it is obvious, but correcting other types errors, such as those already existed when the ARCSAV tapes were created and thus indicated with their time-sync status flags, can require subjective judgments, which can be false. One solution would be to ignore the data when an error is suspected, but this may not be appropriate.

  The user should aware that this attempt to evaluate the earth-received times was not perfect, and therefore there may be cases where the quality flag for is not turned on (not set to an asterisk "*") for a value that appears to be incorrect.

- Some values in the status column may be incorrect that most likely resulted from tape read or data synchronization errors. This is often reflected in the quality flags for the data columns, which are turned on (set to an asterisk "*") when the data are out of synchronization.

- The CV file excludes entries where both a CV and its associated time stamp were determined to be poor quality, mainly originating from tape read errors that caused both quality flags to be turned on (set to an asterisk "*").

Related Data Sets

Reduced, 28-second-resolution and 1-hour-averaged SWS data, in physical units, from the Apollo 12 and Apollo 15 landing sites are archived as ASCII tables in the NASA Planetary Data System, https://pds.nasa.gov/. These datasets are transformations of data originally provided on magnetic tape by the experiment team to the NSSDCA:

Snyder, C.W., M.M. Neugebauer, D.R. Clay, D.R. Williams, and H.K. Hills, APOLLO 12 ALSEP/SWS SOLAR WIND 28-SEC RESOLUTION TABLES V1.0, A12A-L-SWS-3-SOLAR-WIND-28S-RES-V1.0, NASA Planetary Data System, 2007. This data set contains ASCII tables of daily, time-ordered, 28-second-resolution plasma parameters, mainly of the solar wind, as observed on the Moon at the Apollo 12 ALSEP site by the Apollo 12 SWS from 19 November 1969 through 25 March 1976.

Snyder, C.W., M.M. Neugebauer, D.R. Clay, D.R. Williams, and H.K. Hills, APOLLO 12 ALSEP/SWS SOLAR WIND 1-HR AVG TABLES V1.0, A12A-L-SWS-4-SOLAR-WIND-1HR-AVG-V1.0, NASA Planetary Data System, 2007. This data set contains ASCII tables of time-ordered, hourly-averaged plasma parameters, mainly of the solar wind, as observed on the Moon at the Apollo 12 ALSEP site by the Apollo 12 SWS from 19 November 1969 through 25 March 1976.

Snyder, C.W., M.M. Neugebauer, D.R. Clay, D.R. Williams, H.K. Hill, and D. Han, APOLLO 15 ALSEP/SWS SOLAR WIND 28-SEC RESOLUTION TABLES V1.0, A15A-L-SWS-3-SOLAR-WIND-28S-RES-V1.0, NASA Planetary Data System, 2007. This data set contains ASCII tables of daily, time-ordered, 28-second-resolution plasma parameters, mainly of the solar wind, as observed on the Moon at the Apollo 15 ALSEP site by the Apollo 15 SWS from 31 July 1971 through 30 June 1972.

Snyder, C.W., M.M. Neugebauer, D.R. Clay, D.R. Williams, H.K. Hill, and D. Han, APOLLO 15 ALSEP/SWS SOLAR WIND 1-HR AVG TABLES V1.0, A15A-L-SWS-4-SOLAR-WIND-1HR-AVG-V1.0, NASA Planetary Data System, 2007. This data set contains ASCII tables of

time-ordered, hourly-averaged plasma parameters, mainly of the solar wind, as observed on the Moon at the Apollo 15 ALSEP site by the Apollo 15 SWS from 31 July 1971 through 30 June 1972.

Equivalent data are available as Common Data Format (CDF) files from the Coordinated Data Analysis Web (CDAWeb) hosted by the NASA Space Physics Data Facility (SPDF), https://cdaweb.gsfc.nasa.gov/index.html/:

APOLLO12_SWS_28S: Apollo 12 Solar Wind measurements at the lunar surface for the available time range of 1969/11/19 18:42:13 to 1976/03/25 08:35:57.

APOLLO12_SWS_1HR: Apollo 12 Solar Wind measurements at the lunar surface for the available time range of 1969/11/19 19:30:00 to 1976/03/25 08:30:00.

APOLLO15_SWS_28S: Apollo 15 Solar Wind measurements at the lunar surface for the available time range of 1971/07/31 19:38:38 to 1972/06/30 18:14:35.

APOLLO15_SWS_1HR: Apollo 15 Solar Wind measurements at the lunar surface for the available time range of 1971/07/31 19:30:00 to 1972/06/30 17:30:00.

References

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[15] Final Report for ALSEP Arrays A, B, C, and A-2, NASA-CR-134202, BSR 4096, The Bendix Corporation, Ann Arbor, MI, USA, September 1973. (https://repository.hou.usra.edu/handle/20.500.11753/713 or https://ntrs.nasa.gov/search.jsp?R=19740009979)

Appendix A

The Apollo 12 ALSEP main frame word assignments from page 6-4 of [6].

ALSEP 1

1 x	2 x	3 x	4 X	5 o	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 o	18 X	19 o	20 X	21 o	22 X	23 S	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 I	48 X
49 o	50 X	51 o	52 X	53 o	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

WORD TOTALS	LEGEND
3	x = Sync
29	X = Passive Seismic - Short Period
12	- = Passive Seismic - Long Period
2	• = Passive Seismic - Long Period Tidal and one Temperature
7	o = Magnetometer
4	S = Solar Wind
5	I = Suprathermal Ion Detector
1	CV = Command Verification
1	H = Housekeeping

Each box contains one 10-bit word

Total bits per frame = 10 x 64 = 640 bits

Data rate = 1060 bits/second or 530 bits/second

Figure 6-1.- ALSEP 1 main frame format.

6-4

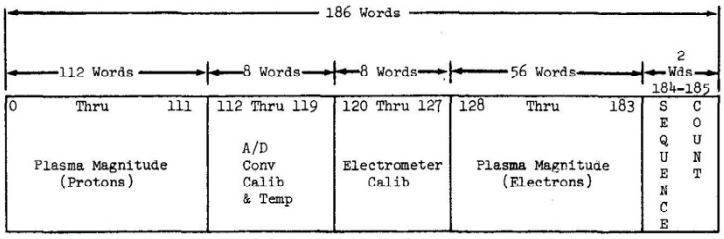
Appendix B

Descriptions of the SWS science measurements DY and DZ and the DW calibration and engineering measurements from pages 6-16 to 6-21 in [6]. Sensor ranges and the limits of calibration and engineering measurements are provided in physical units, such as picoamperes (pA), or pulse count modulation (PCM) which should be equivalent to DN.

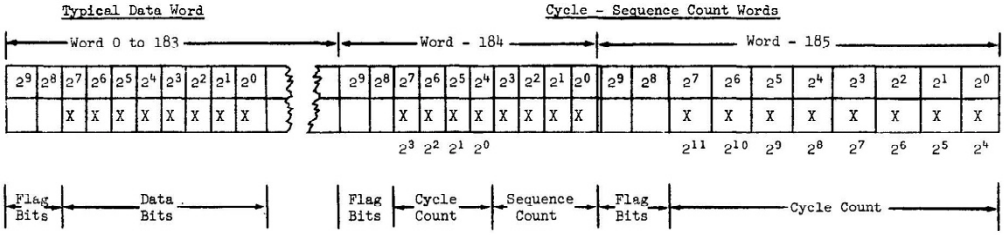
TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1

NOTE: The SWS uses ALSEP Words 7, 23, 39 and 55 (in that order) to convey experiment data. The data is organized into 16 sequences of 186 words per sequence. Since the position of any element of data (Word) is indeterminate with respect to ALSEP Frames and Words, the channel designation is determined internally from information carried in the data. Therefore, in the following data, channel designation is not used but the data is identified by the SWS Word and by the first two bits (FB) which have been provided for Word identification within the sequence; and the sequence is identified by the Least Significant Bits (LSB) of Word 184 lying in the sequence being identified.

Basic Sequence, Repeated 16 times per cycle



Typical Data Word



Cycle - Sequence Count Words

Flag Bits: 00 Scientific Data Word
01 Calibration Data Word
10 Sequence Counter Word

TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1 - Continued

SWS Sequences	Symbol	Location/Name	Flag Bit (FB)	SWS Word	Sensor Range
		Science Data			
		Plasma Magnitude (Positive Ions)			
		Subcommutated as follows: a reading is made of the sum of the outputs of the 7 Faraday cups and then there are 7 consecutive readings of the individual Faraday cups. This set of 8 is repeated for 14 different settings of the analyzer plate voltage.			
		SWS Proton Flux			
0-15; dc HiV Cal and ac HiV Cal in Sequence 14 and 15	DY- 1	Positive Ions - Sum - Lev 1	00	0	Log 0.4 to 6200 pA
	DY- 2	Positive Ions - Cup 1 - Lev 1	00	1	Log 0.4 to 6200 pA
	DY- 3	Positive Ions - Cup 2 - Lev 1	00	2	Log 0.4 to 6200 pA
	DY- 4	Positive Ions - Cup 3 - Lev 1	00	3	Log 0.4 to 6200 pA
	DY- 5	Positive Ions - Cup 4 - Lev 1	00	4	Log 0.4 to 6200 pA
	DY- 6	Positive Ions - Cup 5 - Lev 1	00	5	Log 0.4 to 6200 pA
	DY- 7	Positive Ions - Cup 6 - Lev 1	00	6	Log 0.4 to 6200 pA
	DY- 8	Positive Ions - Cup 7 - Lev 1	00	7	Log 0.4 to 6200 pA
	DY- 9	Positive Ions - Sum - Lev 2	00	8	Log 0.4 to 6200 pA
	DY-10	Positive Ions - Cup 1 - Lev 2	00	9	Log 0.4 to 6200 pA
	DY-11	Positive Ions - Cup 2 - Lev 2	00	10	Log 0.4 to 6200 pA
	DY-12	Positive Ions - Cup 3 - Lev 2	00	11	Log 0.4 to 6200 pA
	DY-13	Positive Ions - Cup 4 - Lev 2	00	12	Log 0.4 to 6200 pA
	DY-14	Positive Ions - Cup 5 - Lev 2	00	13	Log 0.4 to 6200 pA
	DY-15	Positive Ions - Cup 6 - Lev 2	00	14	Log 0.4 to 6200 pA
	DY-16	Positive Ions - Cup 7 - Lev 2	00	15	Log 0.4 to 6200 pA
	DY-17	Positive Ions - Sum - Lev 3	00	16	Log 0.4 to 6200 pA
	DY-18	Positive Ions - Cup 1 - Lev 3	00	17	Log 0.4 to 6200 pA
	DY-19	Positive Ions - Cup 2 - Lev 3	00	18	Log 0.4 to 6200 pA
	DY-20	Positive Ions - Cup 3 - Lev 3	00	19	Log 0.4 to 6200 pA
	DY-21	Positive Ions - Cup 4 - Lev 3	00	20	Log 0.4 to 6200 pA
	DY-22	Positive Ions - Cup 5 - Lev 3	00	21	Log 0.4 to 6200 pA
	DY-23	Positive Ions - Cup 6 - Lev 3	00	22	Log 0.4 to 6200 pA
	DY-24	Positive Ions - Cup 7 - Lev 3	00	23	Log 0.4 to 6200 pA
	DY-25	Positive Ions - Sum - Lev 4	00	24	Log 0.4 to 6200 pA
	DY-26	Positive Ions - Cup 1 - Lev 4	00	25	Log 0.4 to 6200 pA
	DY-27	Positive Ions - Cup 2 - Lev 4	00	26	Log 0.4 to 6200 pA
	DY-28	Positive Ions - Cup 3 - Lev 4	00	27	Log 0.4 to 6200 pA
	DY-29	Positive Ions - Cup 4 - Lev 4	00	28	Log 0.4 to 6200 pA
	DY-30	Positive Ions - Cup 5 - Lev 4	00	29	Log 0.4 to 6200 pA
	DY-31	Positive Ions - Cup 6 - Lev 4	00	30	Log 0.4 to 6200 pA
	DY-32	Positive Ions - Cup 7 - Lev 4	00	31	Log 0.4 to 6200 pA
	DY-33	Positive Ions - Sum - Lev 5	00	32	Log 0.4 to 6200 pA
	DY-34	Positive Ions - Cup 1 - Lev 5	00	33	Log 0.4 to 6200 pA
	DY-35	Positive Ions - Cup 2 - Lev 5	00	34	Log 0.4 to 6200 pA
	DY-36	Positive Ions - Cup 3 - Lev 5	00	35	Log 0.4 to 6200 pA
	DY-37	Positive Ions - Cup 4 - Lev 5	00	36	Log 0.4 to 6200 pA
	DY-38	Positive Ions - Cup 5 - Lev 5	00	37	Log 0.4 to 6200 pA
	DY-39	Positive Ions - Cup 6 - Lev 5	00	38	Log 0.4 to 6200 pA
	DY-40	Positive Ions - Cup 7 - Lev 5	00	39	Log 0.4 to 6200 pA
	DY-41	Positive Ions - Sum - Lev 6	00	40	Log 0.4 to 6200 pA
	DY-42	Positive Ions - Cup 1 - Lev 6	00	41	Log 0.4 to 6200 pA
	DY-43	Positive Ions - Cup 2 - Lev 6	00	42	Log 0.4 to 6200 pA
	DY-44	Positive Ions - Cup 3 - Lev 6	00	43	Log 0.4 to 6200 pA
	DY-45	Positive Ions - Cup 4 - Lev 6	00	44	Log 0.4 to 6200 pA
	DY-46	Positive Ions - Cup 5 - Lev 6	00	45	Log 0.4 to 6200 pA
	DY-47	Positive Ions - Cup 6 - Lev 6	00	46	Log 0.4 to 6200 pA
	DY-48	Positive Ions - Cup 7 - Lev 6	00	47	Log 0.4 to 6200 pA
	DY-49	Positive Ions - Sum - Lev 7	00	48	Log 0.4 to 6200 pA
	DY-50	Positive Ions - Cup 1 - Lev 7	00	49	Log 0.4 to 6200 pA
	DY-51	Positive Ions - Cup 2 - Lev 7	00	50	Log 0.4 to 6200 pA
	DY-52	Positive Ions - Cup 3 - Lev 7	00	51	Log 0.4 to 6200 pA
	DY-53	Positive Ions - Cup 4 - Lev 7	00	52	Log 0.4 to 6200 pA
	DY-54	Positive Ions - Cup 5 - Lev 7	00	53	Log 0.4 to 6200 pA
	DY-55	Positive Ions - Cup 6 - Lev 7	00	54	Log 0.4 to 6200 pA
	DY-56	Positive Ions - Cup 7 - Lev 7	00	55	Log 0.4 to 6200 pA
	DY-57	Positive Ions - Sum - Lev 8	00	56	Log 0.4 to 6200 pA
	DY-58	Positive Ions - Cup 1 - Lev 8	00	57	Log 0.4 to 6200 pA
	DY-59	Positive Ions - Cup 2 - Lev 8	00	58	Log 0.4 to 6200 pA
	DY-60	Positive Ions - Cup 3 - Lev 8	00	59	Log 0.4 to 6200 pA
	DY-61	Positive Ions - Cup 4 - Lev 8	00	60	Log 0.4 to 6200 pA

TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1 - Continued

SWS Sequences	Symbol	Location/Name	Flag Bit (FB)	SWS Word	Sensor Range
0-15; dc HiV Cal and ac HiV Cal in Sequence 14 and 15	DY-62	Positive Ions - Cup 5 - Lev 8	00	61	Log 0.4 to 6200 pA
	DY-63	Positive Ions - Cup 6 - Lev 8	00	62	Log 0.4 to 6200 pA
	DY-64	Positive Ions - Cup 7 - Lev 8	00	63	Log 0.4 to 6200 pA
	DY-65	Positive Ions - Sum - Lev 9	00	64	Log 0.4 to 6200 pA
	DY-66	Positive Ions - Cup 1 - Lev 9	00	65	Log 0.4 to 6200 pA
	DY-67	Positive Ions - Cup 2 - Lev 9	00	66	Log 0.4 to 6200 pA
	DY-68	Positive Ions - Cup 3 - Lev 9	00	67	Log 0.4 to 6200 pA
	DY-69	Positive Ions - Cup 4 - Lev 9	00	68	Log 0.4 to 6200 pA
	DY-70	Positive Ions - Cup 5 - Lev 9	00	69	Log 0.4 to 6200 pA
	DY-71	Positive Ions - Cup 6 - Lev 9	00	70	Log 0.4 to 6200 pA
	DY-72	Positive Ions - Cup 7 - Lev 9	00	71	Log 0.4 to 6200 pA
	DY-73	Positive Ions - Sum - Lev 10	00	72	Log 0.4 to 6200 pA
	DY-74	Positive Ions - Cup 1 - Lev 10	00	73	Log 0.4 to 6200 pA
	DU-75	Positive Ions - Cup 2 - Lev 10	00	74	Log 0.4 to 6200 pA
	DY-76	Positive Ions - Cup 3 - Lev 10	00	75	Log 0.4 to 6200 pA
	DY-77	Positive Ions - Cup 4 - Lev 10	00	76	Log 0.4 to 6200 pA
	DY-78	Positive Ions - Cup 5 - Lev 10	00	77	Log 0.4 to 6200 pA
	DY-79	Positive Ions - Cup 6 - Lev 10	00	78	Log 0.4 to 6200 pA
	DY-80	Positive Ions - Cup 7 - Lev 10	00	79	Log 0.4 to 6200 pA
	DY-81	Positive Ions - Sum - Lev 11	00	80	Log 0.4 to 6200 pA
	DY-82	Positive Ions - Cup 1 - Lev 11	00	81	Log 0.4 to 6200 pA
	DY-83	Positive Ions - Cup 2 - Lev 11	00	82	Log 0.4 to 6200 pA
	DY-84	Positive Ions - Cup 3 - Lev 11	00	83	Log 0.4 to 6200 pA
	DY-85	Positive Ions - Cup 4 - Lev 11	00	84	Log 0.4 to 6200 pA
	DY-86	Positive Ions - Cup 5 - Lev 11	00	85	Log 0.4 to 6200 pA
	DY-87	Positive Ions - Cup 6 - Lev 11	00	86	Log 0.4 to 6200 pA
	DY-88	Positive Ions - Cup 7 - Lev 11	00	87	Log 0.4 to 6200 pA
	DY-89	Positive Ions - Sum - Lev 12	00	88	Log 0.4 to 6200 pA
	DY-90	Positive Ions - Cup 1 - Lev 12	00	89	Log 0.4 to 6200 pA
	DY-91	Positive Ions - Cup 2 - Lev 12	00	90	Log 0.4 to 6200 pA
	DY-92	Positive Ions - Cup 3 - Lev 12	00	91	Log 0.4 to 6200 pA
	DY-93	Positive Ions - Cup 4 - Lev 12	00	92	Log 0.4 to 6200 pA
	DY-94	Positive Ions - Cup 5 - Lev 12	00	93	Log 0.4 to 6200 pA
	DY-95	Positive Ions - Cup 6 - Lev 12	00	94	Log 0.4 to 6200 pA
	DY-96	Positive Ions - Cup 7 - Lev 12	00	95	Log 0.4 to 6200 pA
	DZ- 1	Positive Ions - Sum - Lev 13	00	96	Log 0.4 to 6200 pA
	DZ- 2	Positive Ions - Cup 1 - Lev 13	00	97	Log 0.4 to 6200 pA
	DZ- 3	Positive Ions - Cup 2 - Lev 13	00	98	Log 0.4 to 6200 pA
	DZ- 4	Positive Ions - Cup 3 - Lev 13	00	99	Log 0.4 to 6200 pA
	DZ- 5	Positive Ions - Cup 4 - Lev 13	00	100	Log 0.4 to 6200 pA
	DZ- 6	Positive Ions - Cup 5 - Lev 13	00	101	Log 0.4 to 6200 pA
	DZ- 7	Positive Ions - Cup 6 - Lev 13	00	102	Log 0.4 to 6200 pA
	DZ- 8	Positive Ions - Cup 7 - Lev 13	00	103	Log 0.4 to 6200 pA
	DZ- 9	Positive Ions - Sum - Lev 14	00	104	Log 0.4 to 6200 pA
	DZ-10	Positive Ions - Cup 1 - Lev 14	00	105	Log 0.4 to 6200 pA
	DZ-11	Positive Ions - Cup 2 - Lev 14	00	106	Log 0.4 to 6200 pA
	DZ-12	Positive Ions - Cup 3 - Lev 14	00	107	Log 0.4 to 6200 pA
	DZ-13	Positive Ions - Cup 4 - Lev 14	00	108	Log 0.4 to 6200 pA
	DZ-14	Positive Ions - Cup 5 - Lev 14	00	109	Log 0.4 to 6200 pA
	DZ-15	Positive Ions - Cup 6 - Lev 14	00	110	Log 0.4 to 6200 pA
	DZ-16	Positive Ions - Cup 7 - Lev 14	00	111	Log 0.4 to 6200 pA
		Plasma Magnitude (Electrons)		128-183	Log 0.4 to 6200 pA
		Subcommutated in a manner similar to above except that here the set of 8 is repeated for 7 different settings of the analyzer plate voltage.			
		SWS Electron Flux			
	DZ-17	Electrons - Sum - Lev 15	00	128	Log 0.4 to 6200 pA
	DZ-18	Electrons - Cup 1 - Lev 15	00	129	Log 0.4 to 6200 pA
	DZ-19	Electrons - Cup 2 - Lev 15	00	130	Log 0.4 to 6200 pA
	DZ-20	Electrons - Cup 3 - Lev 15	00	131	Log 0.4 to 6200 pA
	DZ-21	Electrons - Cup 4 - Lev 15	00	132	Log 0.4 to 6200 pA
	DZ-22	Electrons - Cup 5 - Lev 15	00	133	Log 0.4 to 6200 pA
	DZ-23	Electrons - Cup 6 - Lev 15	00	134	Log 0.4 to 6200 pA
	DZ-24	Electrons - Cup 7 - Lev 15	00	135	Log 0.4 to 6200 pA
	DZ-25	Electrons - Sum - Lev 16	00	136	Log 0.4 to 6200 pA
	DZ-26	Electrons - Cup 1 - Lev 16	00	137	Log 0.4 to 6200 pA

TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1 - Continued

SWS Sequences	Symbol	Location/Name	Flag Bit (FB)	SWS Word	Sensor Range
0-15; dc HiV Cal and ac HiV Cal in Sequence 14 and 15	DZ-27	Electrons - Cup 2 - Lev 16	00	138	Log 0.4 to 6200 pA
	DZ-28	Electrons - Cup 3 - Lev 16	00	139	Log 0.4 to 6200 pA
	DZ-29	Electrons - Cup 4 - Lev 16	00	140	Log 0.4 to 6200 pA
	DZ-30	Electrons - Cup 5 - Lev 16	00	141	Log 0.4 to 6200 pA
	DZ-31	Electrons - Cup 6 - Lev 16	00	142	Log 0.4 to 6200 pA
	DZ-32	Electrons - Cup 7 - Lev 16	00	143	Log 0.4 to 6200 pA
	DZ-33	Electrons - Sum - Lev 17	00	144	Log 0.4 to 6200 pA
	DZ-34	Electrons - Cup 1 - Lev 17	00	145	Log 0.4 to 6200 pA
	DZ-35	Electrons - Cup 2 - Lev 17	00	146	Log 0.4 to 6200 pA
	DZ-36	Electrons - Cup 3 - Lev 17	00	147	Log 0.4 to 6200 pA
	DZ-37	Electrons - Cup 4 - Lev 17	00	148	Log 0.4 to 6200 pA
	DZ-38	Electrons - Cup 5 - Lev 17	00	149	Log 0.4 to 6200 pA
	DZ-39	Electrons - Cup 6 - Lev 17	00	150	Log 0.4 to 6200 pA
	DZ-40	Electrons - Cup 7 - Lev 17	00	151	Log 0.4 to 6200 pA
	DZ-41	Electrons - Sum - Lev 18	00	152	Log 0.4 to 6200 pA
	DZ-42	Electrons - Cup 1 - Lev 18	00	153	Log 0.4 to 6200 pA
	DZ-43	Electrons - Cup 2 - Lev 18	00	154	Log 0.4 to 6200 pA
	DZ-44	Electrons - Cup 3 - Lev 18	00	155	Log 0.4 to 6200 pA
	DZ-45	Electrons - Cup 4 - Lev 18	00	156	Log 0.4 to 6200 pA
	DZ-46	Electrons - Cup 5 - Lev 18	00	157	Log 0.4 to 6200 pA
	DZ-47	Electrons - Cup 6 - Lev 18	00	158	Log 0.4 to 6200 pA
	DZ-48	Electrons - Cup 7 - Lev 18	00	159	Log 0.4 to 6200 pA
	DZ-49	Electrons - Sum - Lev 19	00	160	Log 0.4 to 6200 pA
	DZ-50	Electrons - Cup 1 - Lev 19	00	161	Log 0.4 to 6200 pA
	DZ-51	Electrons - Cup 2 - Lev 19	00	162	Log 0.4 to 6200 pA
	DZ-52	Electrons - Cup 3 - Lev 19	00	163	Log 0.4 to 6200 pA
	DZ-53	Electrons - Cup 4 - Lev 19	00	164	Log 0.4 to 6200 pA
	DZ-54	Electrons - Cup 5 - Lev 19	00	165	Log 0.4 to 6200 pA
	DZ-55	Electrons - Cup 6 - Lev 19	00	166	Log 0.4 to 6200 pA
	DZ-56	Electrons - Cup 7 - Lev 19	00	167	Log 0.4 to 6200 pA
	DZ-57	Electrons - Sum - Lev 20	00	168	Log 0.4 to 6200 pA
	DZ-58	Electrons - Cup 1 - Lev 20	00	169	Log 0.4 to 6200 pA
	DZ-59	Electrons - Cup 2 - Lev 20	00	170	Log 0.4 to 6200 pA
	DZ-60	Electrons - Cup 3 - Lev 20	00	171	Log 0.4 to 6200 pA
	DZ-61	Electrons - Cup 4 - Lev 20	00	172	Log 0.4 to 6200 pA
	DZ-62	Electrons - Cup 5 - Lev 20	00	173	Log 0.4 to 6200 pA
	DZ-63	Electrons - Cup 6 - Lev 20	00	174	Log 0.4 to 6200 pA
	DZ-64	Electrons - Cup 7 - Lev 20	00	175	Log 0.4 to 6200 pA
	DZ-65	Electrons - Sum - Lev 21	00	176	Log 0.4 to 6200 pA
	DZ-66	Electrons - Cup 1 - Lev 21	00	177	Log 0.4 to 6200 pA
	DZ-67	Electrons - Cup 2 - Lev 21	00	178	Log 0.4 to 6200 pA
	DZ-68	Electrons - Cup 3 - Lev 21	00	179	Log 0.4 to 6200 pA
	DZ-69	Electrons - Cup 4 - Lev 21	00	180	Log 0.4 to 6200 pA
	DZ-70	Electrons - Cup 5 - Lev 21	00	181	Log 0.4 to 6200 pA
	DZ-71	Electrons - Cup 6 - Lev 21	00	182	Log 0.4 to 6200 pA
	DZ-72	Electrons - Cup 7 - Lev 21	00	183	Log 0.4 to 6200 pA

TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1 - Continued

SWS Sequence	Symbol	Location/Name	Flag Bit (FB)	SWS Word	LSB's Word 184	Sensor Range
		Engineering Data				
		Sequence Counter				
0-15	DW- 1	LSB (1 bit per sequence)	10	184	All	0-256
	DW- 2	MSB (1 bit per 256 sequences)	10	185	All	0-256
		A/D Converter Calibration, Repeated Every Other SWS Sequence				
0						
2						
4	DW- 3	9 mV ± 2%	01	112, 117	0	Log 0.6 to 10,000 mV
6	DW- 4	90 mV ± 2%	01	113	0	Log 0.6 to 10,000 mV
8	DW- 5	900 mV ± 2%	01	114, 118	0	Log 0.6 to 10,000 mV
10	DW- 6	3000 mV ± 2%	01	115	0	Log 0.6 to 10,000 mV
12	DW- 7	9000 mV ± 2%	01	116,119	0	Log 0.6 to 10,000 mV
14						
1	DW-11	Temperature Sensor Mod 100	01	112	1	-50 to +150°C
3	DW-12	Temperature Sensor Mod 200	01	113	1	-50 to +150°C
5	DW-13	Temperature Sensor Mod 300	01	114	1	-50 to +150°C
7	DW-14	Temperature Sensor Cup Assembly	01	115	1	-185 to +150°C
9	DW-15	Sun Angle Sensor	01	116	1	One Value
11	DW-16	Programer Voltage	01	117	1	0 to 9 V
13	DW-17	Step Generator Voltage	01	118	1	0 to 9 V
15	DW-18	Modulation Monitor	01	119	1	PCM counts
		Current Calibrate, Repeated Every Fourth SWS Sequence				PCM Count
	DW-19	0 Ampere	01	120	00	014 ± 6
	DW-20	0 Ampere Cup 1	01	121	00	016 ± 4
0	DW-21	0 Ampere Cup 2	01	122	00	016 ± 4
4	DW-22	0 Ampere Cup 3	01	123	00	016 ± 4
8	DW-23	0 Ampere Cup 4	01	124	00	016 ± 4
12	DW-24	0 Ampere Cup 5	01	125	00	016 ± 4
	DW-25	0 Ampere Cup 6	01	126	00	016 ± 4
	DW-26	0 Ampere Cup 7	01	127	00	016 ± 4
	DW-27	$7x5.76x10^{-12}$ Ampere	01	120	01	037 ± 6
	DW-28	$5.76x10^{-12}$ Ampere Cup 1	01	121	01	019 ± 4
1	DW-29	$5.76x10^{-12}$ Ampere Cup 2	01	122	01	019 ± 4
5	DW-30	$5.76x10^{-12}$ Ampere Cup 3	01	123	01	019 ± 4
9	DW-31	$5.76x10^{-12}$ Ampere Cup 4	01	124	01	019 ± 4
13	DW-32	$5.76x10^{-12}$ Ampere Cup 5	01	125	01	019 ± 4
	DW-33	$5.76x10^{-12}$ Ampere Cup 6	01	126	01	019 ± 4
	DW-34	$5.76x10^{-12}$ Ampere Cup 7	01	127	01	019 ± 4
	DW-35	$7x5.76x10^{-11}$ Ampere	01	120	10	119 ± 4
	DW-36	$5.76x10^{-11}$ Ampere Cup 1	01	121	10	050 ± 4
2	DW-37	$5.76x10^{-11}$ Ampere Cup 2	01	122	10	050 ± 4
6	DW-38	$5.76x10^{-11}$ Ampere Cup 3	01	123	10	050 ± 4
10	DW-39	$5.76x10^{-11}$ Ampere Cup 4	01	124	10	050 ± 4
14	DW-40	$5.76x10^{-11}$ Ampere Cup 5	01	125	10	050 ± 4
	DW-41	$5.76x10^{-11}$ Ampere Cup 6	01	126	10	050 ± 4
	DW-42	$5.76x10^{-11}$ Ampere Cup 7	01	127	10	050 ± 4
	DW-43	$7x5.76x10^{-9}$ Ampere	01	120	11	254 ± 1
	DW-44	$5.76x10^{-9}$ Ampere Cup 1	01	121	11	246 ± 3
3	DW-45	$5.76x10^{-9}$ Ampere Cup 2	01	122	11	246 ± 3
7	DW-46	$5.76x10^{-9}$ Ampere Cup 3	01	123	11	246 ± 3
11	DW-47	$5.76x10^{-9}$ Ampere Cup 4	01	124	11	246 ± 3
15	DW-48	$5.76x10^{-9}$ Ampere Cup 5	01	125	11	246 ± 3
	DW-49	$5.76x10^{-9}$ Ampere Cup 6	01	126	11	246 ± 3
	DW-50	$5.76x10^{-9}$ Ampere Cup 7	01	127	11	246 ± 3
		dc HiV Calibrate, Repeated Once Every 16 SWS Sequences				PCM Count: Low Gain / High Gain
	DW-51	Level #1 (Proton)	01	0	1110	11 ± 10 / 30 ± 10
	DW-52	Level #2	01	8	1110	13 ± 7 / 43 ± 7
	DW-53	Level #3	01	16	1110	31 ± 5 / 60 ± 5
14	DW-54	Level #4	01	24	1110	51 ± 4 / 78 ± 4

TABLE 6-XIV.- SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS LIST, ALSEP 1 - Concluded

SWS Sequences	Symbol	Location/Name	Flag Bit (FB)	SWS Word	LSB's Word 184	PCM Count Low Gain	PCM Count High Gain
	DW-55	Level #5	01	32	1110	68 ± 4	95 ± 4
	DW-56	Level #6	01	40	1110	86 ± 4	112 ± 4
	DW-57	Level #7	01	48	1110	103 ± 4	130 ± 4
	DW-58	Level #8	01	56	1110	119 ± 4	163 ± 4
	DW-59	Level #9	01	64	1110	136 ± 4	163 ± 4
	DW-60	Level #10	01	72	1110	153 ± 4	186 ± 4
	DW-61	Level #11	01	80	1110	170 ± 4	197 ± 4
	DW-62	Level #12	01	88	1110	188 ± 4	215 ± 4
	DW-63	Level #13	01	96	1110	205 ± 4	231 ± 4
	DW-64	Level #14	01	104	1110	223 ± 4	247 ± 4
14	DW-65	Level #15 (Electron)	01	128	1110	016 ± 10	047 ± 10
	DW-66	Level #16	01	136	1110	046 ± 7	075 ± 7
	DW-67	Level #17	01	144	1110	082 ± 5	110 ± 5
	DW-68	Level #18	01	152	1110	117 ± 4	144 ± 4
	DW-69	Level #19	01	160	1110	152 ± 4	178 ± 4
	DW-70	Level #20	01	168	1110	187 ± 4	214 ± 4
	DW-71	Level #21	01	176	1110	222 ± 4	250 ± 4
		ac HiV Calibrate, Repeated Once Every 16 SWS Sequences					
	DW-72	Level #1 (Proton)	01	0	1111	031 ± 3	058 ± 3
	DW-73	Level #2	01	8	1111	044 ± 3	064 ± 3
	DW-74	Level #3	01	16	1111	055 ± 3	076 ± 3
	DW-75	Level #4	01	24	1111	069 ± 3	090 ± 3
	DW-76	Level #5	01	32	1111	082 ± 3	104 ± 3
	DW-77	Level #6	01	40	1111	095 ± 3	119 ± 3
	DW-78	Level #7	01	48	1111	111 ± 3	135 ± 3
	DW-79	Level #8	01	56	1111	126 ± 3	150 ± 3
	DW-80	Level #9	01	64	1111	141 ± 3	166 ± 3
15	DW-81	Level #10	01	72	1111	157 ± 3	182 ± 3
	DW-82	Level #11	01	80	1111	173 ± 3	199 ± 3
	DW-83	Level #12	01	88	1111	190 ± 3	217 ± 3
	DW-84	Level #13	01	96	1111	207 ± 3	233 ± 3
	DW-85	Level #14	01	104	1111	224 ± 3	248 ± 3
	DW-86	Level #15 (Electron)	01	128	1111	038 ± 3	058 ± 3
	DW-87	Level #16	01	136	1111	063 ± 3	086 ± 3
	DW-88	Level #17	01	144	1111	092 ± 3	116 ± 3
	DW-89	Level #18	01	152	1111	123 ± 3	148 ± 3
	DW-90	Level #19	01	160	1111	155 ± 3	181 ± 3
	DW-91	Level #20	01	168	1111	189 ± 3	215 ± 3
	DW-92	Level #21	01	176	1111	224 ± 3	249 ± 3

TABLE 6-XV.- LIMITS OF SWS ENGINEERING DATA

Symbol	Location/Name	Red Line Low	Nominal Low	Nominal	Nominal High	Redline High
DW-3	9mV A/D Calibration	1mV	8mV	9mV	10mV	20mV
DW-4	90mV A/D Calibration	50mV	80mV	90mV	100mV	150mV
DW-5	900mV A/D Calibration	500mV	800mV	900mV	1000mV	1500mV
DW-6	3000mV A/D Calibration	1650mV	2650mV	3000mV	3300mV	5000mV
DW-7	9000mV A/D Calibration	5000mV	8000mV	9000mV	9800mV	10,500mV
DW-11	Temperature, Mod 100	-25°C	-10°C	+25°C	+80°C	+100°C
DW-12	Temperature, Mod 200	-25°C	-10°C	+25°C	+80°C	+100°C
DW-13	Temperature, Mod 300	-25°C	-10°C	+25°C	+80°C	+100°C
DW-14	Temperature, Sensor Cup Assembly	-150°C	-101°C	+25°C	+93°C	+120°C
DW-15	Sun Angle Sensor	-1V	-.1V	0V	5.0V	9.8V
DW-16	Programer Voltage	4.0V	4.6V	4.95V	5.1V	6.0V
DW-17	Step Generator Voltage	.60V	.85V	.88V	.91V	1.2V
DW-18	Modulation Monitor	120 PCM	144 PCM	152 PCM	158 PCM	187 PCM

Appendix C

Command Verification values and their actions for the SWS instrument, excerpted from pages 5-6, 5-8 and 5-14 in [6]. SWS commands are octal integers 33, 45, 46, 50, and 122.

033 TIMER OUTPUT INHIB COMMAND DECODER

Command 033 inhibits the 12-hour and the 1-minute timer output pulses which in turn will disable the following automatic commands generated in the delayed command sequencer.

A. One-Time Commands	Normal Time of Execution after PET-zero
1. Set CCIG seal break and arm PSE uncage circuit	96 hours + 2 minutes
2. Execute CCIG seal break	96 hours + 3 minutes
3. Remove SWS dust cover and set SIDE remove dust cover	96 hours + 4 minutes
4. Execute SIDE remove dust cover	96 hours + 5 minutes

B. Repetitive Commands	Normal Time of Execution after PET-zero
1. Magnetometer flip calibrate	108 hours + 1 minute and every 12 hours thereafter.
2. Restore power to lowest priority experiment (SIDE)	108 hours + 7 minutes and every 12 hours thereafter.

This command will also disable the following automatic commands generated by the timer:

C. Repetitive Commands (every 12 hours after PET-zero)

1. Command receiver reset
2. Short period calibrate PSE
3. Uncage PSE
   a. Arm uncage PSE (at PET-zero +12 hours)
   b. Execute uncage PSE (at PET-zero +24 hours)

045 EXP 3 OPER SEL (SWS) POWER DISTRIBUTION UNIT

Command 045 actuates relay K-10, in the PDU, applying +29 Vdc to activate the SWS instrument. This command simultaneously deactivates the SWS standby heater.

046 EXP 3 STBY SEL (SWS) POWER DISTRIBUTION UNIT

Command 046 actuates relays K-10 and K-11, in the PDU, applying +29 Vdc to the SWS standby heater. This command simultaneously deactivates the SWS instrument. EXP 3 STBY SEL (SWS) is the lunar surface initial condition.

050 EXP 3 STBY OFF (SWS) POWER DISTRIBUTION UNIT

Command 050 actuates relay K-11, in the PDU, to the position that removes +29 Vdc from the SWS standby heater. If the SWS operating power is on, transmission of this command will have no effect.

122 SWS CVR GO EXP 3 (SWS)

Command 122 causes the one-time function of removing the SWS dust covers. This command is an irreversible function and is necessary to obtain SWS scientific data.

122 SWS CVR GO (Three times $\leq$10 seconds) EXP 3 (SWS)

Command 122, when sent three times within 10 seconds, places the high voltage amplifiers in the high gain mode. SWS activation presets the amplifiers to be low gain mode. The low gain mode of operation causes the 21 voltage steps applied to the Faraday cup sensors during proton and electron measurements to be scaled such that the highest level will be 6 kilovolts. The high gain mode increases the gain of the amplifiers by a factor of 1.68, with the highest level going to 10 kilovolts. STBY SEL command (046) followed by an OPER SEL command (045) presets the amplifiers to the low gain mode.

Appendix D

Position and width of SWS energy steps in terms of positive ion (proton) velocity for normal incidence, excerpted from [14].

TABLE 1

Position and Width of SWS Energy Steps in Terms of Proton Velocity for Normal Incidence (Velocities expressed in km/sec).

SWS APOLLO 12					
	LOW GAIN			HIGH GAIN	
STEP	MEAN	WIDTH	MEAN	WIDTH	STEP
1	62	20	112	21	1
2	91	18	143	25	2
3	120	22	175	30	3
4	156	28	216	37	4
5	191	32	259	43	5
6	235	40	314	53	6
7	285	48	377	62	7
8	337	57	446	74	8
9	400	67	527	87	9
10	480	79	629	104	10
11	569	92	744	122	11
12	682	114	893	149	12
13	807	132	1055	172	13
14	968	157	1266	206	14

SWS APOLLO 15					
	LOW GAIN			HIGH GAIN	
STEP	MEAN	WIDTH	MEAN	WIDTH	STEP
1	66	13	105	20	1
2	90	17	135	25	2
3	120	20	169	28	3
4	151	26	208	35	4
5	188	31	252	42	5
6	230	38	305	51	6
7	280	46	370	60	7
8	333	55	439	71	8
9	395	64	519	83	9
10	469	77	616	103	10
11	557	91	730	119	11
12	666	109	874	144	12
13	791	130	1039	170	13
14	946	154	1235	218	14