Apollo 15 ALSEP ARCSAV Lunar SIDE/CCIG Raw Cleaned ASCII Data Collection (1975-092 to 1975-181)

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 15 site consists of cleaned (corrected) ASCII tabular files of Suprathermal Ion Detector Experiment (SIDE) and Cold Cathode Ion Gage (CCIG) raw data for the period of April 2, 1975 through June 30, 1975. These scientific, housekeeping 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 binary data for all the ALSEP instruments deployed at one of the Apollo landing sites [3]. Data from several instruments were intermeshed into ALSEP 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-00914 consists of daily binary files of raw, intermeshed Apollo 15 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 15 daily binary files for NSSDCA data set PSPG-00918. Corrections were possible because the original ALSEP ARCSAV document is still available [3].
- NSSDCA data set PSFP-00743 consists of 90 daily files of raw binary SIDE/CCIG data extracted from the cleaned ARCSAV data set for Apollo 15, PSPG-00918.
- This present collection is a transformation of 90 daily SIDE/CCIG raw binary files in NSSDCA data set PSFP-00743 into ASCII format. The Fortran programs used by the data provider for transformation are included, for documentation purposes only, in the same document collection as this data description file.

Required Reading

The user should read several publications before using this collection.

Required: [3] provides a detailed description of the contents of the ALSEP ARCSAV tapes. Relevant sections in [3] are 1.0, 2.0, 6.4, 6.6, and Appendix C including pages C-36 through C-70 that explain the SIDE and CCIG measurements. [6] provides detailed engineering and operations information about the Apollo 15 ALSEP station (also known as Array A2) and the SIDE and CCIG experiments. The most relevant chapters in [6] are 6 - ALSEP Telemetry Subsystem and 11 – SIDE/CCIG Operations.

Strongly Recommended: [2] provides a very detailed operational history of each individual ALSEP experiment, including operational status, anomalies, and failures by date. [10] describes the SIDE experiment and reports initial results. [12] provides a detailed description of each SIDE and CCIG science, engineering, and housekeeping measurement, while [13] presents only SIDE measurements but includes an explanation of the SIDE instrument and how it worked. [11] provides the SIDE and CCIG final engineering report that covers electrical, thermal, and mechanical descriptions of the instrument.

Additional detailed engineering and operations information on the Apollo 15 ALSEP and the SIDE and CCIG experiments, see [7] and [8]. 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 [9].

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 SIDE/CCIG scientific measurements with filenames a15_side_1975DDD_l1_arcsav.tab/.xml, where DDD is the day of year,
- Raw Housekeeping: One product of raw analog SIDE Housekeeping (Engineering) data with filename a15_side_1975_l1_arcsav_hk.tab/.xml, and
- Command Verification: One product containing a log of SIDE/CCIG Command Verifications with filename a15_side_1975_l1_arcsav_cv.tab/.xml.

Raw Science Data Products

These products contain raw, unreduced measurements of the differential energy spectrum of positive ions having energies from 0.2 to 48.6 eV per unit charge and from 10 to 3500 eV per unit charge as acquired, respectively, by the low-energy mass analyzer detector and the high-energy total ion detector of SIDE [6]. These products also contain raw, unreduced density and temperature measurements for pressures ranging from 10^{-6} to 10^{-12} torr as acquired by the CCIG experiment [6] that was connected by a cable to SIDE. The raw SIDE/CCIG data are identified by Measurement Numbers "DI-n", "DJ-n" and "DF-n" [3, 6] and were converted within the experiments to digital data numbers (DN) and stored in the designated ALSEP Main Frame Words 15, 31, 47, 56, and 63 [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 (a15_side_1975DDD_l1_arcsav.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 an ALSEP frame duration time of 603.75 milliseconds per frame, or 9.4336 milliseconds per ALSEP data word.
3. RawData Table: A multi-record fixed-width ASCII table containing raw SIDE and CCIG scientific and engineering data where each record contains one SIDE frame that consists of 10 SIDE Data Words WD-1 to WD-10 (subcommutated in ALSEP Words 15, 31, 47, 56, and 63) which provide SIDE/CCIG measurements numbered "DI-n", "DJ-n" and "DF-n" [3]. There are 128 SIDE frames, numbered from 0 to 127, in one SIDE "ground plane" cycle before repeating. There are 24 SIDE "ground plane" cycles in one SIDE field [6, pages 11-1 to 11-3; 3, page C-36], where the ground plane voltage is stepped through 24 values [6, page 11-3], one for each SIDE cycle, before repeating for a new SIDE field. Each record begins with the earth-received time in UTC for the set of data in that record followed by eight columns containing 10 SIDE Data Words measurements:

   - Column WD-1 is SIDE Word 1 that contains SIDE measurement DI-1, which is the 7-bit SIDE frame counter ranging from decimal integer value 0 to 127),
   - Column WD-2 is SIDE Word 2 which contains one of SIDE/CCIG measurements DI-2 to DI-30 or DF-29 as identified in the preceding 'Meas' column, where DI-3 contains CCIG output science data; DI-4 contains a CCIG temperature measured at the gage head sitting on the lunar surface; DI-8 contains CCIG science measurement range; and DI-5, DI-6, DI-9, DI-10, and DI-19 contain SIDE electronics temperatures, which may be useful when interpreting scientific data from SIDE and CCIG; All SIDE Word 2 measurements are 8 bits and range from integer value 0 to +255 DN,
   - Column WD-3 is SIDE Word 3 which contains one of SIDE measurements DI-40 to DI-60 (high-energy curved plate analyzer step voltages from the Total Ion Detector) as identified in the preceding 'Meas' column; All SIDE Word 3 measurements are 8 bits and range from decimal integer value 0 to +255 DN,
   - Column WD-4-5 provides the high-energy data value from the Total Ion Detector resulting from combining SIDE Words 4 and 5 that contain SIDE measurements DI-61 (most significant 10 binary digits – 0 to 999 decimal – of a 20-bit count) and DI-62 (least significant 10 binary digits – 0 to 999 decimal – of a 20-bit count), respectively, into a decimal integer value ranging from 0 to +999999 DN,
   - Column WD-6 is SIDE Word 6 which contains one of SIDE measurements DI-63 to DI-71 (experiment status readings command and mode registers data and ground plane step

numbers) identified in the preceding 'Meas' column; All SIDE Word 6 measurements are 7 bits and range from decimal integer value 0 to +127 DN,

- Column WD-7 is SIDE Word 7 which contains one of SIDE measurements DI-72 to DI-99 and DJ-0 to DJ-97 (velocity filter voltages) as identified in the preceding 'Meas' column; All SIDE Word 7 measurements are 8 bits and range from decimal integer value 0 to +255 DN,
- Column WD-8 is SIDE Word 8 which contains one of SIDE measurements DJ-98, DJ-99, and DF-0 to DF-4 (high-energy curve plate analyzer step voltages from the Mass Analyzer) as identified in the preceding 'Meas' column; All SIDE Word 8 measurements are 8 bits and range from decimal integer value 0 to +255 DN, and
- Column WD-9-10 provides the low-energy data value from the Mass Analyzer resulting from combining SIDE Words 9 and 10 that contain SIDE measurements DI-5 (most significant 10 binary digits– 0 to 999 decimal – of a 20-bit count) and DI-6 (least significant 10 binary digits– 0 to 999 decimal – of a 20-bit count), respectively, into a decimal integer value ranging from 0 to +999999 DN.
- As noted above, these raw measurements are provided 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 provides a more detailed description of each column. Additional explanation of the contents is provided here:

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

  This earth-received time is the UTC time when the first word of the ALSEP frame containing the SIDE Word 1 (WD-1) measurement 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.
- A WD data value of integer -9 (negative nine) indicates a missing value.
- Each WD 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 could still contain an error.
- Appendix B provides a cross reference of SIDE/CCIG measurement numbers “DI-n”, “DJ-n” and “DF-n” to their location/name and the SIDE frame numbers in which they appear. Additional information includes sensor ranges, nominal values, or decimal count

ranges. To better understand the raw measurements, the user should also refer to the required reading sections in [3] and [6].

- To compute the time for a specific data measurement, add the milliseconds time offset, which is found in the single-record table TimeOffsets for the data measurement column of interest, to the time stamp (earth-received time) in the first column of the RawData record containing the data measurement of interest.
- 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 Housekeeping Data Product

This product contains raw, unreduced SIDE Housekeeping (HK) measurements, identified by Measurement Numbers AI-n, from analog sensors that indicate the condition of the SIDE experiment. Housekeeping measurements are stored in ALSEP Word 33 [3] for relay to Earth.

The ASCII HK file (a15_side_1975_l1_arcsav_hk.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 RawHK 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 RawHK Table record.

   The sampling-rate-adjusted delay times (offsets) were calculated using the same ALSEP frame duration time as the Raw Science Data Product: 603.75 milliseconds per frame, or 9.4336 milliseconds per ALSEP data word.
3. RawHK Table: A multi-record fixed-width ASCII table containing raw analog SIDE Housekeeping data, where one record contains the housekeeping measurements from two ALSEP frames. Each record begins with the earth-received time in UTC for the set of data in that record followed by two raw analog measurements identified by their SIDE Measurement Number, AI-n: AI-1 contains the low-energy detector (Mass Analyzer) count rate and AI-2 contains the high-energy detector (Total Ion Detector) count rate. Both HK measurements comprise 8-bits and are provided in this table as decimal integers ranging from 0 to +255 DN. The user should refer to the required reading sections in [3] and [6] to understand the raw HK measurements. Also Table 6-XV of [6], shown in Appendix B, specifies the operating ranges in physical units, not DN, for the analog sensors for the HK measurements. Table 6-IX of [6], shown in Appendix C, specifies the operating limits for both HK sensors

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.

  This earth-received time is the UTC time when the first word of the ALSEP frame number 83 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 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

- A HK data value of integer -9 (negative nine) indicates a missing value.

- Each HK data value 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 could still contain an error.

- To compute the start time for a specific HK measurement, add the milliseconds time offset, which is found in the single-record table TimeOffsets for the HK measurement column of interest, to the time stamp (earth-received time) in the first column of the RawHK record containing the HK measurement of interest.

Command Verification Data Product

This product provides a time-ordered log of commands specific to SIDE and CCIG operations that were received by Apollo 15 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 (a15_side_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 SIDE and CCIG 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 C-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 SIDE/CCIG operations are listed in Appendix D of this document.

- 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 (+57 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 the same type of four 1-byte flags as the status column defined for and used in Housekeeping Data Product.

- 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), when the moon was visible, 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). Information for transforming the raw DN to physical values for both SIDE and CCIG is not readily available, and providing this along with calibration information and transfer function of the instrument is beyond the scope our restoration effort.

However SIDE scientist Howard K. Hills, formerly at the NSSDCA, provided a calibration data sheet that contains information such as detector efficiency, geometric factor and directional flux; some of these data only apply to Apollo 12 or 14 SIDE. The sheet also contains a plot of the Apollo 12, 14, and 15 SIDE mass analyzer calibration for mass number versus mass analyzer channel number

Constant Data Values

When analyzing these data, the user should be aware that temperature parameters in the Raw Science Data Products can remain at a mostly constant data value for the duration of each lunar night.

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 collection. Correcting and flagging of all possible errors were beyond the scope of this restoration. However, the user needs to be aware of these errors and know that these could be corrected, if necessary, 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 for day of year. 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.

- The binary to ASCII translation process skipped all ALSEP frames for which the sync bit pattern in the binary source data indicated that the data are out of sync. This is because for those frames, the frame count which directly follows the sync bit string is quite likely to be incorrect, and with the frame count in error, the data for the measurements could not be located. The translation process also skipped ALSEP frames where bad time stamps were coupled with bad frame counts in the binary source data.

- 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 "*").

- The quality flag that follows the earth-received time in the data products is not perfect, and there are cases where the flag is not turned on (not set to an asterisk "*") although the time stamp appears to be incorrect. The goal for this restoration was to recover as much of the original data from tape as possible without overinterpreting those values.

References

[1] Davies, M. E., and T. R. Colvin, Lunar coordinates in the regions of the Apollo landers, Journal of Geophysical Research, Volume 105, Issue E8, pages 20,227-20,280, 2000. (doi:10.1029/1999JE001165)

[2] Bates, J. R., et al., ALSEP Termination Report, NASA Reference Publication 1036, April 1979. (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19790014808.pdf)

[3] Apollo Lunar Surface Experiments Package Archive Tape Description Document, JSC-09652, NASA Johnson Space Center, Houston, Texas, May 1975. (https://repository.hou.usra.edu/handle/20.500.11753/42)

[4] Nagihara, S., Y. Nakamura, L. R. Lewis, D. R. Williams, P. T. Taylor, E. J. Grayzeck, P. Chi, and G. K. Schmidt, Search and Recovery Efforts for the ALSEP Data Tapes, 42nd Lunar and Planetary Science Conference, held March 7-11, 2011 at The Woodlands, Texas, Lunar and Planetary Institute Contribution No. 1608, Abstract 1103, 2011. (https://www.lpi.usra.edu/meetings/lpsc2011/pdf/1103.pdf)

[5] Nagihara, S., Y. Nakamura, D. R. Williams, P. T. Taylor, W. S. Kiefer, M. A. Hager, and H. K. Hills, Availability Of Previously Unprocessed ALSEP Raw Instrument Data and Derivative Data and Metadata Products, 47th Lunar and Planetary Science Conference, held March 21-25, 2016 at The Woodlands, Texas, Lunar and Planetary Institute Contribution No. 1903, Abstract 1194, 2016. (https://www.hou.usra.edu/meetings/lpsc2016/pdf/1194.pdf)

[6] Apollo Lunar Surface Experiments Package Systems Handbook: ALSEP A2, PCN-1, unnumbered, NASA Manned Spacecraft Center, Houston, Texas, 24 March 1971, revised 15 April 1971. (https://www.lpi.usra.edu/lunar/ALSEP/pdf/31111000675122.pdf)

[7] Apollo Lunar Surface Experiments Package, ALSEP Flight System Familiarization Manual, Revision B, ALSEP-MT-03, NASA CR-99604, The Bendix Corporation for NASA Manned Spacecraft Center, published 1 August 1967, revised 15 April 1969. (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19710014816.pdf or https://repository.hou.usra.edu/handle/20.500.11753/238)

[8] Apollo Lunar Surface Experiments Package, ALSEP Flight System Familiarization Manual, Revision B / Change 1, ALSEP-MT-03, NASA CR-99604, The Bendix Corporation for NASA Manned Spacecraft Center, Houston, Texas, 18 March 1970. (https://repository.hou.usra.edu/handle/20.500.11753/45)

[9] Lauderdale, W. W., and W. F. Eichelman, Apollo Scientific Experiments Data Handbook, NASA, TM-X-58131, Houston, Texas, August 1974, updated August 1976. (https://repository.hou.usra.edu/handle/20.500.11753/17 or https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19760007062.pdf)

[10] Apollo 15 Preliminary Science Report, NASA SP-289, NASA, Washington, D.C., January 1972. (https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19720015164.pdf)

[11] Rivas, R. A. and S. Pollack, Final Engineering Report for ALSEP/SIDE/CCGE (Apollo Lunar Surface Experiments Package / Suprathermal Ion Detector Experiment / Cold Cathode Gauge Experiment), Volume 1, NASA CR-102046, Rice University, Houston, Texas, 1 January

1969. (https://www.lpi.usra.edu/lunar/ALSEP/pdf/Final Rep_ALSEP_SIDE_CCGE_Vol 1.pdf or https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19700004894.pdf)

[12] Hills, H. K. and J. W. Freeman, ALSEP SIDE Data Handbook (includes CCGE), Unpublished, Unnumbered, Nov. 1969. (Available from NSSDCA at Goddard Space Flight Center as publication number B56520-000A)

[13] Hills, H. K. and J. W. Freeman, ALSEP SIDE data user's information package, Unpublished, Unnumbered, Feb. 1974. (Available from NSSDCA at Goddard Space Flight Center as publication number B32229-000A)

Appendix A

The Apollo 15 ALSEP main frame word assignments from page 6-7 of [6].

ALSEP A2
BASIC

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 HF
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
28	X = Passive seismic – short period
12	– = Passive seismic – long period
2	● = Passive seismic – long period tidal and one temperature
7	o = Magnetometer experiment
4	S = Solar wind spectrometer experiment
5	I = Suprathermal ion detector experiment
1	HF = Heat flow experiment
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

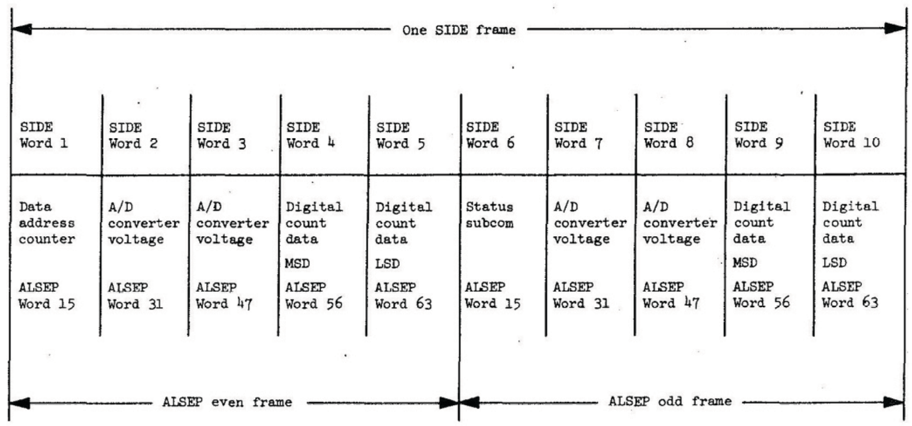
Figure 6-2.– Main frame format.

6-7

Appendix B

A cross reference of SIDE/CCIG measurement numbers “DI-n”, “DJ-n” and “DF-n” to their location/name and the SIDE frame numbers in which they appear, excerpted from pages 6-24 to 6-30 in [6]. Additional information includes sensor ranges and nominal values in physical units s.

ALSEP A2
BASIC



SIDE Word 1 - Provides identification of selected step in measurement program (SIDE frame count), a parity check of SIDE data in previous ALSEP frame, and even frame identification

Word 2 - CCGE data and housekeeping data, subcommutated

Word 3 - Voltage on high-energy curved-plate analyzer

Word 4 and Word 5 - Count data from high-energy curved-plate analyzer

Word 6 - Various data subcommutated, such as command mode, command waiting for execution, range of electrometer, and ground plane grid voltage step; also, parity check of SIDE data in previous ALSEP frame and odd frame identification

Word 7 - Velocity filter voltage

Word 8 - Voltage on low-energy curved-plate analyzer

Word 9 and Word 10 - Count data from low-energy curved-plate analyzer

Figure 6-5.- SIDE word format.

6-24

TABLE 6-XV.- SIDE/CCGE MEASUREMENTS

Symbol	Location/Name	SIDE Frames	Sensor Range
Following measurements carried in ALSEP Word 15 even, SIDE Word 1 and in indicated SIDE Frames.			
DI-1	*SIDE Frame Counter	All	0-127 *7 bits 4 to 10 inclusive
Following measurements carried in ALSEP Word 31 even, SIDE Word 2 and in indicated SIDE Frames.			
DI-2	+5 volts analog	0,32,64,96	5 V ± 0.15 V
DI-3	CCGE Science Data	1,3,5,7,9,41,73,105,121-127	
DI-4	Temp 1 (CCIG)	2,34,66,98	100 to 400°K
DI-5	Temp 2 (200 Blivet)	4,36,68,100	-90 to +125°C
DI-6	Temp 3 (500 Blivet)	6,38,70,102	-90 to +125°C
DI-7	4.5 kV	8,40,72,104	3.72 to 5.45 kV
DI-8	CCGE Range	10,24,42,56,74,88,106,120	Range 1 6.9 to 9.0 V Range 2 4.2 to 5.7 V Range 3 2.2 to 3.2 V
DI-9	Temp 4 (100 Blivet)	11,43,75,107	-50 to +90°C
DI-10	Temp 5 (300 Blivet)	12,44,76,108	-50 to +90°C
DI-11	GND Plane voltage	13,15,29,31,45,47,61,63,69 77,79,93,95,109,111	
DI-12	Solar Cell	14,78	15 mV to 600 mV
DI-13	+60 volts	16,48,80,112	.15 to 150 V
DI-14	+30 volts	17,49,81,113	.15 to 150 V
DI-15	+5 volts digital	18,50,82,114	15 mV to 15 V
DI-16	Ground	19,51,83,115	0 to 18 mV
DI-17	-5 volts	20,52,84,116	-15 mV to -15 V
DI-18	-30 volts	21,53,85,117	-.15 to -150 V
DI-19	Temp 6 (800 Blivet)	22,54,86,118	-50 to +90°C
DI-20	-3.5 kV	23,55,87,119	-2.9 to -4.25 kV
DI-21	+1.0 volt cal.	27,59,91	15 mV to 15 V
DI-22	+30 mV cal.	25,57,89	15 mV to 15 V
DI-23	+A/D Ref. voltage	26,58,90	15 mV to 15 V
DI-24	Dust Cover and Seal	67,71	Preset 3.125 to 5.5 V Seal Only 1.875 to 3.125 Dust Cover Only .625 to 1.875 Cover and Seal 0 to .625
DI-25	-A/D Ref. volt	30,62,94	-15 mV to -15 V
DI-26	-1.0 volt cal.	37,101	-15 mV to -15 V
DI-27	-12 volt cal.	39,103	-15 mV to -15 V
DI-28	+12 volt cal.	28,60,92	15 mV to 15 V
DI-29	Pre Reg Duty Factor	65	68% to 100%
DI-30	-30 mV cal.	46,110	-15 mV to -15 V
DF-29	One Time Command Register Status	33,35,97,99	Preset 0 to .625V Seal Only .625 to 1.875V Dust Cover 1.875 to 3.125V Dust Cover and Seal 3.125 to 5.5V

*See note on Page 6-27 for measurement content.

TABLE XV.- SIDE/CCGE MEASUREMENTS - Continued

Symbol	Location/Name	SIDE Frame	Nominal Value
Following measurements carried in ALSEP Word 47 even, SIDE Word 3 and in indicated SIDE Frames.			
			Voltage
DI-40	HECPA Stepper Voltage	1,21,41,61,81,101	+437.5V
DI-41	HECPA Stepper Voltage	2,22,42,62,82,102	406.25V
DI-42	HECPA Stepper Voltage	3,23,43,63,83,103	375.0V
DI-43	HECPA Stepper Voltage	4,24,44,64,84,104	343.75V
DI-44	HECPA Stepper Voltage	5,25,45,65,85,105	312.5V
DI-45	HECPA Stepper Voltage	6,26,46,66,86,106	281.25V
DI-46	HECPA Stepper Voltage	7,27,47,67,87,107	250.0V
DI-47	HECPA Stepper Voltage	8,28,48,68,88,108	218.75V
DI-48	HECPA Stepper Voltage	9,29,49,69,89,109	187.5V
DI-49	HECPA Stepper Voltage	10,30,50,70,90,110	156.25V
DI-50	HECPA Stepper Voltage	11,31,51,71,91,111	125.0V
DI-51	HECPA Stepper Voltage	12,32,52,72,92,112	93.75V
DI-52	HECPA Stepper Voltage	13,33,53,73,93,113	62.5V
DI-53	HECPA Stepper Voltage	14,34,54,74,94,114	31.25V
DI-54	HECPA Stepper Voltage	15,35,55,75,95,115	12.5V
DI-55	HECPA Stepper Voltage	16,36,56,76,96,116	8.75V
DI-56	HECPA Stepper Voltage	17,37,57,77,97,117	6.25V
DI-57	HECPA Stepper Voltage	18,38,58,78,98,118	3.75V
DI-58	HECPA Stepper Voltage	19,39,59,79,99,119	2.5V
DI-59	HECPA Stepper Voltage	20,40,60,80,100,120	1.25V
DI-60	HECPA Stepper Voltage	0,121,122,123,124,125 126,127	0 V
Following measurements carried in ALSEP Word 56 even, SIDE Word 4 and in indicated SIDE Frames.			
DI-61	HE Data - MSD*	All	0 to 999 decimal
*MSD - Most significant data.			
Following measurements carried in ALSEP Word 63 even, SIDE Word 5 and in indicated SIDE Frames.			
DI-62	HE Data - LSD**	All	0 to 999 decimal
**LSD - Least significant data.			

Calibration counts are downlinked in the following SIDE frames:			
SIDE Frame	Calibration Rate Number	SIDE Word 4 5 (DI-61) (DI-62)	SIDE Word 9 10 (DF-5) (DF-6)
120	1	Science data	000 002 ±2
121	2	000 002 ±2	000 154 ±4
122	3	000 154 ±4	019 775 ±400
123	4	019 775 ±400	632 800 ±1400
124	1	632 800 ±1400	000 002 ±2
125	2	000 002 ±2	000 154 ±4
126	3	000 154 ±4	019 775 ±400
127	4	019 775 ±400	632 800 ±1400
000		632 800 ±1400	Science data

TABLE 6-XV.- SIDE/CCGE MEASUREMENTS - Continued

Symbol	Location/Name	SIDE Frame	Decimal Count
Following measurements carried in ALSEP Word 15 odd, SIDE Word 6, and in indicated SIDE Frames, bits 4 to 10 inclusive.*			
DI-63	Ground Plane Step	0,2,4,6,8,10,12,14,16 18,20,22,24,26,28,30 32,34,36,38,40,42,44,46,48 50,52,54,56,58,60,62,64, 66,68,70,72,74,76,78,80 82,84,86,88,90,92,94,96, 98,100,102,104,106,108,110 112,114,116,118	24 steps 0 - 11 16 - 27
DI-64	Command Register	1,5,13,17,21,29,33,37,45,49 53,61,65,69,77,81,85,93,97 101,109,113,117,125	0 to 15
DI-65	Mode Register	3,11,15,19,23,27,31,35,43,47 51,55,59,63,67,75,79,83,87 91,95,99,107,111,115,119	0 to 14
DI-66	Dust Cover and Seal	7,39,71,103	Dust Cover and Seal Blown -0 Seal Only -1 Dust Cover Only -2 Reset -3
DI-67	CCGE Electrometer Range	9,25,41,57,73,89,105	Range #1 - 0 Range #2 - 2 Range #3 - 3
DI-68	Cal Rate #1	120,124	0
DI-69	Cal Rate #2	121	1
DI-70	Cal Rate #3	122,126	2
DI-71	Cal Rate #4	123,127	3

*SIDE Words 1 and 6 measurement content shown below

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
P	F_1	F_2	A_1	A_2	A_3	A_4	A_5	A_6	A_7

P Parity
F Frame ID
A Data (LSB in A_7)

DF-7	SIDE Parity	In SIDE Word 1 and 6, all frames	"1" odd number of ones in previous ALSEP frame. "0" even number of ones in previous ALSEP frame.
DF-8	SIDE Frame ID	In SIDE Word 1 and 6, all frames.	00 even ALSEP frame. 11 odd ALSEP frame.

TABLE 6-XV.- SIDE/CCGE MEASUREMENTS - Continued

Symbol	Location/Name	SIDE Frame		Nominal Value
Following measurements carried in ALSEP Word 31 odd, SIDE Word 7 and in indicated SIDE Frames.				
		Normal Mode	Reset @9	Voltage
DI-72	Velocity Filter Voltage	0	0,60	14.5 V
DI-73	Velocity Filter Voltage	1	1,61	13.2
DI-74	Velocity Filter Voltage	2	2,62	11.9
DI-75	Velocity Filter Voltage	3	3,63	10.7
DI-76	Velocity Filter Voltage	4	4,64	9.6
DI-77	Velocity Filter Voltage	5	5,65	8.5
DI-78	Velocity Filter Voltage	6	6,66	7.25
DI-79	Velocity Filter Voltage	7	7,67	6.65
DI-80	Velocity Filter Voltage	8	8,68	5.8
DI-81	Velocity Filter Voltage	9	9,69	5.0
DI-82	Velocity Filter Voltage	10		4.3
DI-83	Velocity Filter Voltage	11		3.65
DI-84	Velocity Filter Voltage	12		3.2
DI-85	Velocity Filter Voltage	13		2.57
DI-86	Velocity Filter Voltage	14		2.12
DI-87	Velocity Filter Voltage	15		1.75
DI-88	Velocity Filter Voltage	16		1.45
DI-89	Velocity Filter Voltage	17		1.20
DI-90	Velocity Filter Voltage	18		1.04
DI-91	Velocity Filter Voltage	19		0.94
DI-92	Velocity Filter Voltage	20	10,70	8.35
DI-93	Velocity Filter Voltage	21	11,71	7.6
DI-94	Velocity Filter Voltage	22	12,72	6.85
DI-95	Velocity Filter Voltage	23	13,73	6.2
DI-96	Velocity Filter Voltage	24	14,74	5.5
DI-97	Velocity Filter Voltage	25	15,75	4.93
DI-98	Velocity Filter Voltage	26	16,76	4.18
DI-99	Velocity Filter Voltage	27	17,77	3.83
DJ-0	Velocity Filter Voltage	28	18,78	3.34
DJ-1	Velocity Filter Voltage	29	19,79	2.8
DJ-2	Velocity Filter Voltage	30		2.48
DJ-3	Velocity Filter Voltage	31		2.10
DJ-4	Velocity Filter Voltage	32		1.85
DJ-5	Velocity Filter Voltage	33		1.48
DJ-6	Velocity Filter Voltage	34		1.23
DJ-7	Velocity Filter Voltage	35		1.01
DJ-8	Velocity Filter Voltage	36		0.84
DJ-9	Velocity Filter Voltage	37		0.695
DJ-10	Velocity Filter Voltage	38		0.60
DJ-11	Velocity Filter Voltage	39		0.54
DJ-12	Velocity Filter Voltage	40	20,80	4.82
DJ-13	Velocity Filter Voltage	41	21,81	4.39
DJ-14	Velocity Filter Voltage	42	22,82	3.97
DJ-15	Velocity Filter Voltage	43	23,83	3.57
DJ-16	Velocity Filter Voltage	44	24,84	3.19
DJ-17	Velocity Filter Voltage	45	25,85	2.85
DJ-18	Velocity Filter Voltage	46	26,86	2.44

TABLE 6-XV.- SIDE/CCGE MEASUREMENTS - Continued

Symbol	Location/Name	SIDE Frame		Nominal Value
		Normal Mode	Reset @9	Voltage
DJ-19	Velocity Filter Voltage	47	27,87	2.21 V
DJ-20	Velocity Filter Voltage	48	28,88	1.93
DJ-21	Velocity Filter Voltage	49	29,89	1.67
DJ-22	Velocity Filter Voltage	50		1.43
DJ-23	Velocity Filter Voltage	51		1.22
DJ-24	Velocity Filter Voltage	52		1.07
DJ-25	Velocity Filter Voltage	53		0.85
DJ-26	Velocity Filter Voltage	54		0.71
DJ-27	Velocity Filter Voltage	55		0.59
DJ-28	Velocity Filter Voltage	56		0.484
DJ-29	Velocity Filter Voltage	57		0.402
DJ-30	Velocity Filter Voltage	58		0.345
DJ-31	Velocity Filter Voltage	59		0.312
DJ-32	Velocity Filter Voltage	60	30,90	2.78
DJ-33	Velocity Filter Voltage	61	31,91	2.53
DJ-34	Velocity Filter Voltage	62	32,92	2.29
DJ-35	Velocity Filter Voltage	63	33,93	2.06
DJ-36	Velocity Filter Voltage	64	34,94	1.85
DJ-37	Velocity Filter Voltage	65	35,95	1.65
DJ-38	Velocity Filter Voltage	66	36,96	1.40
DJ-39	Velocity Filter Voltage	67	37,97	1.78
DJ-40	Velocity Filter Voltage	68	38,98	1.12
DJ-41	Velocity Filter Voltage	69	39,99	0.965
DJ-42	Velocity Filter Voltage	70		0.825
DJ-43	Velocity Filter Voltage	71		0.70
DJ-44	Velocity Filter Voltage	72		0.615
DJ-45	Velocity Filter Voltage	73		0.494
DJ-46	Velocity Filter Voltage	74		0.409
DJ-47	Velocity Filter Voltage	75		0.337
DJ-48	Velocity Filter Voltage	76		0.278
DJ-49	Velocity Filter Voltage	77		0.232
DJ-50	Velocity Filter Voltage	78		0.20
DJ-51	Velocity Filter Voltage	79		0.180
DJ-52	Velocity Filter Voltage	80	40,100	1.61
DJ-53	Velocity Filter Voltage	81	41,101	1.46
DJ-54	Velocity Filter Voltage	82	42,102	1.32
DJ-55	Velocity Filter Voltage	83	43,103	1.19
DJ-56	Velocity Filter Voltage	84	44,104	1.07
DJ-57	Velocity Filter Voltage	85	45,105	0.95
DJ-58	Velocity Filter Voltage	86	46,106	0.81
DJ-59	Velocity Filter Voltage	87	47,107	0.74
DJ-60	Velocity Filter Voltage	88	48,108	0.65
DJ-61	Velocity Filter Voltage	89	49,109	0.55
DJ-62	Velocity Filter Voltage	90		0.477
DJ-63	Velocity Filter Voltage	91		0.405
DJ-64	Velocity Filter Voltage	92		0.355
DJ-65	Velocity Filter Voltage	93		0.285
DJ-66	Velotity Filter Voltage	94		0.236

TABLE 6-XV.- SIDE/CCGE MEASUREMENTS - Continued

Symbol	Location/Name	SIDE Frame		Nominal Value
		Normal Mode	Reset @9	Voltage
DJ-67	Velocity Filter Voltage	95		0.195
DJ-68	Velocity Filter Voltage	96		0.160
DJ-69	Velocity Filter Voltage	97		0.134
DJ-70	Velocity Filter Voltage	98		0.115
DJ-71	Velocity Filter Voltage	99		0.104
DJ-72	Velocity Filter Voltage	100	50,110	0.93
DJ-73	Velocity Filter Voltage	101	51,111	0.85
DJ-74	Velocity Filter Voltage	102	52,112	0.765
DJ-75	Velocity Filter Voltage	103	53,113	0.685
DJ-76	Velocity Filter Voltage	104	54,114	0.615
DJ-77	Velocity Filter Voltage	105	55,115	0.55
DJ-78	Velocity Filter Voltage	106	56,116	0.465
DJ-79	Velocity Filter Voltage	107	57,117	0.425
DJ-80	Velocity Filter Voltage	108	58,118	0.372
DJ-81	Velocity Filter Voltage	109	59,119	0.321
DJ-82	Velocity Filter Voltage	110		0.275
DJ-83	Velocity Filter Voltage	111		0.234
DJ-84	Velocity Filter Voltage	112		0.205
DJ-85	Velocity Filter Voltage	113		0.165
DJ-86	Velocity Filter Voltage	114		0.136
DJ-87	Velocity Filter Voltage	115		0.112
DJ-88	Velocity Filter Voltage	116		0.093
DJ-89	Velocity Filter Voltage	117		0.077
DJ-90	Velocity Filter Voltage	118		0.067
DJ-91	Velocity Filter Voltage	119		0.060
DJ-92	Velocity Filter Voltage	120	120	14.5
DJ-93	Velocity Filter Voltage	121	121	13.2
DJ-94	Velocity Filter Voltage	122	122	11.9
DJ-95	Velocity Filter Voltage	123	123	10.7
DJ-96	Velocity Filter Voltage	124	124	9.6
DJ-97	Velocity Filter Voltage	125,126,127	125,126,127	>16.1
Following measurements carried in ALSEP Word 47 odd, SIDE Word 8 and in indicated SIDE Frames.				
		Normal Mode	Reset Vel Filter @9	Voltage
DJ-98	LECPA Stepper Voltage	0-19	0-9,60-69	12.15 V
DJ-99	LECPA Stepper Voltage	20-39	10-19,70-79	4.050
DF-0	LECPA Stepper Voltage	40-59	20-29,80-89	1.35
DF-1	LECPA Stepper Voltage	60-79	30-39,90-99	0.450
DF-2	LECPA Stepper Voltage	80-99	40-49,100-109	0.150
DF-3	LECPA Stepper Voltage	100-119	50-59,110-119	0.050
DF-4	LECPA Stepper Voltage	120-127	120-127	0 V
Following measurements carried in ALSEP Word 56 odd, SIDE Word 9 and in indicated SIDE Frames.				
DF-5	LE Data - MSD	All		0 to 999 decimal
Following measurements carried in ALSEP Word 63 odd, SIDE Word 10 and in indicated SIDE Frames.				
DF-6	LE Data - LSD	All		0 to 999 decimal
Two SIDE measurements are included in ALSEP Housekeeping Word 33				
		Channel		
AI-1	LE Count Rate	70		0 to 1.4×10^6 counts/sec
AI-2	HE Count Rate	85		0 to 1.4×10^6 counts/sec

Appendix C

Operating limits, in physical units, for the analog sensors for Housekeeping measurements AI-1 and AI-2, excerpted from page 6-14 in [6].

ALSEP A2
BASIC

TABLE 6-IX.- ANALOG CHANNEL USAGE - Concluded

Symbol	Location/Name	Channel	Nominal Operating Limits Low	Nominal Operating Limits High	Nom Oper Value	Redline Limits Low	Redline Limits High
RTG Temperatures (Fahrenheit)							
AR-1	Hot Frame 1 Temp	6	1060°	1150°	1107°	980°	1160°
AR-2	Hot Frame 2 Temp	37	1060°	1150°	1107°	980°	1160°
AR-3	Hot Frame 3 Temp	52	1060°	1150°	1107°	980°	1160°
AR-4	Cold Frame 1 Temp	7	415°	500°	450°	401°	500°
AR-5	Cold Frame 2 Temp	67	400°	470°	430°	401°	500°
AR-6	Cold Frame 3 Temp	82	415°	500°	450°	401°	500°
DTREM							
AX-1	DTREM Inner Temp (Centigrade)	83	N/A	N/A	N/A	-150	135
AX-2	DTREM Cell Temp (Centigrade)	30	37	125	110	37	125
AX-3	DTREM Outer Temp (Centigrade)	56	N/A	N/A	N/A	-150	135
AX-4	DTREM Cell 1 Output (No Filter)	84	0 mV	75 mV	65 mV	0 mV	75 mV
AX-5	DTREM Cell 2 Output (Irradiated/Filter)	26	0 mV	75 mV	65 mV	0 mV	75 mV
AX-6	DTREM Cell 3 Output (Filter)	41	0 mV	75 mV	65 mV	0 mV	75 mV

Symbol	Location/Name	Channel	Value in Decimal PCM
Central Station Discretes			
AB-1	Command Demodulator 1 kHz Present	9	No modulation 0 to 76, no carrier 128 to 255 Modulation 77 to 127
AB-4	Power Distribution Experiment 1 and 2 Standby Status	12	Exper 1 / Exper 2: Standby-off / Standby-off: 1 ± 1 Standby-on / Standby-off: 72 ± 10 Standby-off / Standby-on: 131 ± 10 Standby-on / Standby-on: 192 ± 12
AB-5	Power Distribution Experiment 3, 4, 5 Standby Status	14	Exper 3 / Exper 4 / Exper 5: Standby-off / Standby-off / Standby-off: 1 ± 1 Standby-off / Standby-off / Standby-on: 35 ± 10 Standby-off / Standby-on / Standby-off: 69 ± 10 Standby-off / Standby-on / Standby-on: 100 ± 10 Standby-on / Standby-off / Standby-off: 131 ± 10 Standby-on / Standby-off / Standby-on: 160 ± 10 Standby-on / Standby-on / Standby-off: 188 ± 10 Standby-on / Standby-on / Standby-on: 214 ± 10
AB-6	Data Processor X On/Off Status	25	X processor on PCM > 128 X processor off PCM < 32
AZ-1	Timer 18 Hr Status	10	0 to 18 hrs PCM < 32 18 to 36 hrs PCM >128 } Alternates every 18 hours
AZ-2	Timer Counter 1 Status	11	0 to 1-1/2 months PCM < 32 1-1/2 to 3 months PCM > 128 } Alternates every 1-1/2 months
AZ-3	Timer Counter 2 Status	86	0 to 1-1/2 months PCM < 32 1-1/2 to 3 months PCM > 128 } Alternates every 1-1/2 months

EXPERIMENTS:

Symbol	Location/Name	Channel	Nominal Operating Limits
Passive Seismic			
AL-1	LP Amplifier Gain (X and Y)	23	Discrete
AL-2	LP Amplifier Gain (Z)	38	Discrete
AD-3	Level Direction and Speed	53	Discrete
AL-4	SP Amplifier Gain (Z)	68	Discrete
AL-5	Leveling Mode and Coarse Sensor Mode	24	Discrete
AL-6	Thermal Control Status	39	Discrete
AL-7	Calibration Status LP and SP	54	Discrete
AL-8	Uncage Status	69	Discrete
			See Table 6-X (PSE) Page 6-15
SIDE/CCGE			
AI-1	LE Count Rate	70	0 to 1.4 x 10^6 counts/second
AI-2	HE Count Rate	85	0 to 1.4 x 10^6 counts/second
Heat Flow			
AH-1	Supply Voltage 1 (5 V)	29	4.9 to 5.1 Vdc
AH-2	Supply Voltage 2 (-5 V)	45	-4.9 to -5.1 Vdc
AH-3	Supply Voltage 3 (15 V)	55	14.7 to 15.3 Vdc
AH-4	Supply Voltage 4 (-15 V)	74	-14.7 to -15.3 Vdc
AH-5	Not Assigned		
AH-6	Low Cond Heater Power Status	57	Discrete
AH-7	High Cond Heater Power Status	75	Discrete

6-14

Appendix D

Command Verification values and their actions for the SIDE and CCIG instruments, excerpted from pages 5-14 to 5-15, 5-17, 5-24 to 5-30 and 5-37 in [6]. The SIDE/CCIG commands used during the time span of this data collection are octal integers 33, 53-54, 104-110, and 153.

031 DUST CELLS OFF — POWER DISTRIBUTION UNIT

Command 031 is a one-state command that deactivates the DTREM photo cell amplifiers.

032 TIMER OUTPUT ACCPT — COMMAND DECODER

Command 032 enables the 18-hour and the 1-minute timer output pulses, thus allowing automatic commands to be generated by the timer and the delayed-command sequencer. This command cancels the effect of Command 033. Central station activation or power reset initializes the TIMER OUTPUT ACCPT.

033 TIMER OUTPUT INHIB — COMMAND DECODER

Command 033 inhibits the 18-hour and the 1-minute timer output pulses which in turn will disable the following automatic commands generated in the delayed-command sequencer:

One-time commands	Normal time of execution after command sequencer reset
SET CCIG SEAL BREAK and ARM PSE UNCAGE CIRCUIT	Eight 18-hr pulses + 2 min
EXECUTE CCIG SEAL BREAK	Eight 18-hr pulses + 3 min
REMOVE SWS DUST COVER and SET SIDE REMOVE DUST COVER	Eight 18-hr pulses + 4 min
EXECUTE SIDE REMOVE DUST COVER	Eight 18-hr pulses + 5 min
Repetitive command	
MAGNETOMETER FLIP CALIBRATE	Nine 18-hr pulses + 1 min and every 18 hours

Command 033 will also disable the following automatic commands generated by the timer. These are repetitive (every 18-hour pulse commands):

A. COMMAND RECEIVER RESET

B. SHORT PERIOD CALIBRAGE PSE

C. UNCAGE PSE

1. ARM UNCAGE PSE (first 18-hour pulse)
2. EXECUTE UNCAGE PSE (second 18-hour pulse)

NOTE

SINCE THIS COMMAND INHIBITS THE RECEIVER RESET, IT IS CONSIDERED HIGHLY CRITICAL.

This command will input level changes to the hours and minutes counters of the delayed-command sequencer and advance the counters by 18 hours and 1 minute. This may change the execution times of the automatic commands from the delayed-command sequencer and the timer.

This command does not inhibit or affect the 3-month transmitter turnoff command generated by the timer.

034 DSS/PROC X SEL POWER DISTRIBUTION UNIT

Command 034 actuates relays K-02 and K-03, in the PDU, to the position that applies operational power to the X digital data processor, X 90-channel analog multiplexer, and X A/D converter. The digital data processor will initialize in the normal bit rate. Command 034 simultaneously deselects the Y system. DSS/PROC X SEL is the lunar surface initial condition.

035 DSS/PROC Y SEL POWER DISTRIBUTION UNIT

Command 035 activates relays K-02 and K-03, in the PDU, to the position that applies operational power to the Y digital data processor, Y 90-channel analog multiplexer, and Y A/D converter. The digital data processor will initialize in the normal bit rate. Command 035 simultaneously deselscts the X system. Activation of astronaut switch 2 provides the same function as Command 035.

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.

153 EXP 4 OPER SEL (SIDE/CCGE) POWER DISTRIBUTION UNIT

Command 153 actuates relay K-12, in the PDU, applying +29 Vdc to the SIDE instrument and the SIDE heater.

053 EXP 4 STBY SEL (SIDE/CCGE) POWER DISTRIBUTION UNIT

Command 053 actuates relays K-12 and K-13, in the PDU, applying +29 Vdc to the SIDE heater. It simultaneously deactivates the SIDE by removing +29 Vdc from the instrument. EXP 4 STBY SEL (SIDE) is the lunar surface initial condition.

054 EXP 4 STBY OFF (SIDE/CCGE) POWER DISTRIBUTION UNIT

Command 054 actuates relay K-13, in the PDU, to the position that removes +29 Vdc from the SIDE heater. If the SIDE operating power is on, transmission of this command will have no effect.

055 EXP 5 OPER SEL (HFE) POWER DISTRIBUTION UNIT

Command 055 actuates relay K-14, in the PDU, applying automatic leveling mode. PSE activation initializes the coarse level sensor to OUT.

103 PSE LVL MDE A/F EXP 1 (PSE)

Command 103 is a two-state command (AUTOMATIC/FORCED) which controls the leveling mode of LPX, LPY, and LPZ axes. PSE activation initializes the leveling mode to AUTOMATIC.

NOTE

Only one axis motor is to be on at a time.

SIDE/CCGE COMMANDS EXP 4 (SIDE/CCGE)

The following commands are encoded by the SIDE into two one-time commands and 15 operational commands:

104 SIDE LOAD 1
105 SIDE LOAD 2
106 SIDE LOAD 3
107 SIDE LOAD 4*
110 SIDE EXECUTE*

Encoding is as follows:

	Function	SIDE command register encoding 104	105	106	107	110
One Time Commands	BREAK CCIG SEAL		X			X
One Time Commands	REMOVE DUST COVER				X	X
	1. GND PLANE STEP PROGRAMER ON/OFF	X				X
	2. RESET SIDE FRAME COUNTER AT 10		X			X
	3. RESET SIDE FRAME COUNTER AT 39	X	X			X
	4. RESET VELOCITY FILTER AT 9			X		X
	5. RESET SIDE FRAME COUNTER AT 79	X		X		X

*Refer to Note 1, Figure 11-1.

Function		SIDE command register encoding 104	105	106	107	110
6.	RESET SIDE FRAME COUNTER AT 79 AND VELOCITY FILTER AT 9		X	X		X
7.	X10 ACCUMULATION INTERVAL ON/OFF	X	X	X		X
8.	MASTER RESET				X	X
9.	VELOCITY FILTER VOLTAGE ON/OFF	X			X	X
10.	LECPA HIVOLTAGE ON/OFF		X		X	X
11.	HECPA HIVOLTAGE ON/OFF	X	X		X	X
12.	FORCE CONTINUOUS CALIBRATION (RESET TO 120)			X	X	X
13.	CCIG HIVOLTAGE ON/OFF	X		X	X	X
14.	CHANNELTRON HIVOLTAGE ON/OFF		X	X	X	X
15.	RESET COMMAND REGISTER	X	X	X	X	X

NOTE

Commands to break CCIG seal and reset SIDE frame counter at 10 are identical. The first transmission of Commands 105 and 110 causes both functions to occur but not thereafter. Commands to remove dust cover and master reset are also identical. The first transmission of Commands 107 and 110 causes both functions to occur but not thereafter.

The SIDE/CCIG commands are functionally divided into two types: on/off commands and mode commands. Initiation of a mode command changes the operational data format characteristics.

Operationally executing any mode or on/off command will eliminate the existing operational mode. Operationally executing any of on/off commands 1, 7, 9, 10, 11, 13, or 14 will reset the SIDE frame counter (DI-1) to zero if any of the mode commands 2, 3, 4, 5, 6, or 12 is present in the mode register, whereas execution of mode commands will not affect the status of any on/off commanded functions.

A brief description of SIDE commands follows:

A. One-time commands:

BREAK CCIG SEAL

Command 105 followed by 110 causes the one-time function of CCIG seal break. It simultaneously resets the SIDE FRAME COUNTER AT 10 (described later). This command is an irreversible function and is necessary to obtain CCGE scientific data. This command is also generated by the delayed-command sequencer (see Command 033).

REMOVE DUST COVER

Command 107 followed by 110 causes the one-time function of blowing the SIDE dust cover. It simultaneously resets the SIDE MASTER RESET (described later). This command is an irreversible function and is necessary to obtain SIDE scientific data. This command is also generated by the delayed-command sequencer (see Command 033). REMOVE DUST COVER command may cause a heater interrupt. (Refer to Figure 11-1.)

B. On/off commands and mode commands:

1. GROUND PLANE STEP PROGRAMER ON/OFF EXP 4 (SIDE/CCGE)

Command 104 followed by 110 is a two-state command (ON/OFF) that controls the operation of the ground plane step programer. SIDE activation initializes the programer to ON. The ground plane voltage is then stepped through 24 levels (one level/SIDE cycle). Transmission of this command will cause the step programer to stop. Retransmission will start step programer and does not reset voltage level to zero but continues to step from level where last stopped.

2. RESET SIDE FRAME COUNTER AT 10 EXP 4 (SIDE/CCGE)
Command 105 followed by 110 is a mode command. (Initiation of a mode command changes the operational data format characteristics.) Upon receipt of the command, the experiment resets to SIDE frame zero and then steps to SIDE frame 10 before resetting again to zero. The velocity filter and the high- and low-energy curved-late analyzers step through the values obtained for these SIDE frames in the normal mode of operation. The ground plane voltage steps through the normal 24-step sequence, one step per 11-frame cycle. (See Figure 11-3.)

3. RESET SIDE FRAME COUNTER AT 39 EXP 4 (SIDE/CCGE)
Commands 104 and 105, followed by 110, is a mode command. Upon receipt of the command, the experiment operates in a similar fashion to the reset at 10 mode except that it resets at SIDE frame 39. (See Figure 11-4.)

4. RESET VELOCITY FILTER COUNTER AT 9 EXP 4 (SIDE/CCGE)
Command 106 followed by 110 is a mode command. The experiment, in this mode, executes the normal 128 SIDE frame cycle. The velocity filter voltage only executes the first 10 of it normal 20-step program. That is, at SIDE frame 10, instead of completing the 20 steps, the velocity filter assumes the value of SIDE frame 20 in the normal mode. Similarly at SIDE frame 20, the filter adopts the normal mode value of SIDE frame 40. This operation continues for the complete 128 SIDE frames. The low-energy curved-plate analyzer, instead of maintaining its value for 20 SIDE frames,

steps to the next value every 10 SIDE frames. This means that the six values are repeated from SIDE frame 60. (See Figure 11-5.)

5. RESET SIDE FRAME COUNTER AT 79 EXP 4 (SIDE/CCGE)
Commands 104 and 106, followed by 110, is a mode command. Upon receipt of the command, the experiment operates in a similar fashion to the reset at 10 mode except that it resets at SIDE frame 79. (See Figure 11-4.)

6. RESET SIDE FRAME COUNTER AT 79
AND VELOCITY FILTER COUNTER AT 9 EXP 4 (SIDE/CCGE)
Commands 105 and 106, followed by 110, is a mode command. Upon receipt of the command, the experiment performs the functions of command RESET VELOCITY FILTER COUNTER AT 9, but the sequence stops at SIDE frame 79 and repeats. All other functions are unchanged from the normal operational mode.

7. X10 ACCUMULATION INTERVAL ON/OFF EXP 4 (SIDE/CCGE)
Commands 104, 105, and 106, followed by 110, is a two-state command (ON/OFF). The accumulation time period is increased from a normal 1.2 seconds (X1) to 12 seconds (X10). Each SIDE frame is downlinked 10 times before advancing to the next SIDE frame. The X10 mode can be used with any counter reset mode.

8. MASTER RESET EXP 4 (SIDE/CCGE)
Command 107 followed by 110 is a mode command. Upon receipt of the command, the experiment will return to the normal operational mode. The master reset performs the following:
   a. Defeats all short cycles
   b. Resets SIDE frame counter, velocity counter, HECPA and LECPA counters
   c. Does not disturb any on/off commands or the X10 accumulation interval

9. VELOCITY FILTER VOLTAGE ON/OFF EXP 4 (SIDE/CCGE)
Commands 104 and 107, followed by 110, is a two-state command (ON/OFF). Transmission of this command removes velocity filter voltage (i.e., filter voltage equals 0 Vdc). However, the velocity filter programer is not inhibited, and upon retransmission of this command, the velocity filter assumes the appropriate voltage level of that SIDE frame in process.

10. LOW ENERGY CPA HIGH VOLTAGE ON/OFF EXP 4 (SIDE/CCGE)
Commands 105 and 107, followed by 110, is a two-state command (ON/OFF). Transmission of this command removes LECPA voltage (i.e., LECPA equals 0 Vdc). However, the LECPA programer is not inhibited, and upon retransmission of this command, the LECPA assumes the appropriate voltage level of that SIDE frame in process. With zero voltage, no low-energy data is transmitted.

11. HIGH ENERGY CPA HIGH VOLTAGE ON/OFF EXP 4 (SIDE/CCGE)
Commands 104, 105, and 107, followed by 110, is a two-state command (ON/OFF). Transmission of this command removes HECPA voltage (i.e., HECPA equals 0 Vdc). However, the HECPA programer is not inhibited, and upon retransmission of this command, the HECPA assumes the appropriate voltage level of that SIDE frame in process. With zero voltage, no high-energy data is transmitted.

12. FORCE CONTINUOUS CALIBRATION (RESET TO 120) EXP 4 (SIDE/CCGE)
Commands 106 and 107, followed by 110, is a mode command. Upon receipt of the command, the experiment resets to SIDE frame 120 and then steps through SIDE frame 127 before resetting again to SIDE frame 120.

13. COLD CATHODE ION GAGE HIGH VOLTAGE ON/OFF — EXP 4 (SIDE/CCGE)

Commands 104, 106, and 107, followed by 110, is a two-state command (ON/OFF). Transmission of this command turns off high voltage to the CCIG sensor, thereby disabling all CCGE scientific data.

14. CHANNELTRON HIGH VOLTAGE ON/OFF — EXP 4 (SIDE/CCGE)

Commands 105, 106, and 107, followed by 110, is a two-state command (ON/OFF). Transmission of this command removes high voltage from the Channeltron multipliers, thus disabling SIDE scientific data.

15. RESET COMMAND REGISTER — EXP 4 (SIDE/CCGE)

Commands 104, 105, 106, and 107, followed by 110, are commands used to clear the command register of any command awaiting execution. Note that SIDE power on will cause the following:

a. A power reset will force the instrument into the normal mode, which does the following:
   (1) Removes all short cycles
   (2) Resets SIDE frame counter, velocity counter, HECPA and LECPA counter
   (3) Resets ground plane counter
b. Resets all command flip-flops
c. Turns on all the internal voltages of the system (velocity filter, HECPA, LECPA, Channeltron high voltage, CCIG high voltage)

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.

152 HFE HTR STEPS EXP 5 (HFE)

This command (C10) is a 16-state command which advances the heater excitation programer ($H_4H_3H_2H_1$) each time the command is executed. In MODE/G the programer advances but there is no other effect since the probe heater current supply is off. In MODE/LK the execution of Command 152 alternates the heater status between on and off, simultaneously stepping through the eight heaters (current supply in on full time, and heater elements are switched in and out of circuit). In MODE/HK the heater excitation programer (advanced by Command 152) also selects the data to be sampled.

NOTE

HFE commands are executed at the ALSEP 90 frame mark; therefore, there must be 54 seconds delta time between transmission of commands to the HFE.

153 EXP 4 OPER SEL (SIDE/CCGE) POWER DISTRIBUTION UNIT

Command 153 actuates relay K-12, in the PDU, applying +29 Vdc to the SIDE instrument and the SIDE heater.

NOTE

Command 153 is also listed out of numeric sequence following Command 050.