BRADSHAW COMMUNICATION SYSTEMS

MODEL ACU1
ANTENNA CONTROL UNIT
OPERATION
INSTRUCTION
MANUAL

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INTRODUCTION

A.   MANUAL PURPOSE

This manual contains operating instructions for the Bradshaw Communication Systems ACU1 Antenna Control Unit.   The instructions herein are provided for personnel responsible for monitoring and controlling an Earth Station Antenna using the ACU1. A nameplate label located on the rear panel of the ACU1 identifies the units' model number, part number, revision, and serial number.   The serial number is used by Bradshaw Communication Systems (BCS) to identify the units' particular firmware and hardware configuration.

This manual does <u>not</u> provide information pertaining to installation, troubleshooting, and/or maintenance of the ACU1. Information pertaining to these subjects is found only in the ACU1 Installation & Maintenance Manual, which, is intended only for qualified service personnel. The ACU1 contains no operator serviceable parts and all maintenance and/or repairs should be referred to qualified service personnel.

B.   MANUAL ORGANIZATION

This manual is organized into the following four sections:

"Introduction" – This section provides manual purpose, manual organization, unit specifications, and customer support information.

"General Description" – This section provides safety precautions, typical system configuration, and a description of the operator controls and indicators found on the ACU1 front panel.

"Modes of Operation" – This section provides a detailed description of each of the ACU1 operational modes, fault & status display modes, and parameter setup modes.

"Monitor & Control Port" – This section provides both a description of and the protocol used when accessing the ACU1 RS232 Serial M&C Port (J8).

C.   UNIT SPECIFICATIONS

Dimensions:	Rack Mount ANSI/EIA 2 Rack Height Chassis
	3.5" (88.9mm) high x 19.0" (482.6mm) wide x 13.5" (342.9mm) deep
Weight:	13.5 LBS (6.12 Kg)
Power Requirements:	Universal Input 90-264VAC / 47-63Hz / 0.75 Amps Max
Environmental:	0° to 50°Celsius (32° to 122° Fahrenheit) Operational
	-40° to 85°Celsius (-40° to 185°Fahrenheit) Storage
	0 – 90% Relative Humidity (Non-Condensing)
Tracking:	Typical Accuracy 10% of received 3dB beamwidth (RMS) or better for beamwidths $\geq 0.20°$ and up to 2° target inclinations. Memory Track option adds execution of interpolated trajectory data from stored data while in Steptrack mode.
Position Measurement:	4:1 Synchro Position Encoders providing absolute angular position with typical accuracy of 0.03° RMS and 0.01° position display resolution.
	Optional 1:1 Synchro Transmitter for polarization axis w/ 0.1° resolution.
Receiver Interface:	D.C. Output Proportional to Signal Strength
	($\pm$10 V Analog 0.01 to 1.0V/dB Gradient)

D.   CUSTOMER SUPPORT

Customer support, replacement parts, and repair are available 8AM – 5PM CST M-F by contacting Bradshaw Communication Systems at 770-844-9704 or by fax at 770-886-0205.

GENERAL DESCRIPTION

A. SAFETY PRECAUTIONS

	Lethal voltages are present inside the ACU1. Emergency Stop switches and other interlocks will disable the system, but do not disconnect the ACU1 from primary power. Refer all troubleshooting and repair to qualified service personnel. The ACU1 contains no operator serviceable parts.

B. INTRODUCTION

The ACU1 is designed to allow manual or automatic positioning of an earth station antenna from a remote location away from the antenna. Operators may select from various modes of operation providing antenna control, displaying fault and/or status information, and to adjust setup parameters. The ACU1 is only a part of the antenna control system. A typical antenna control system configuration using the ACU1 is depicted in Figure 1.
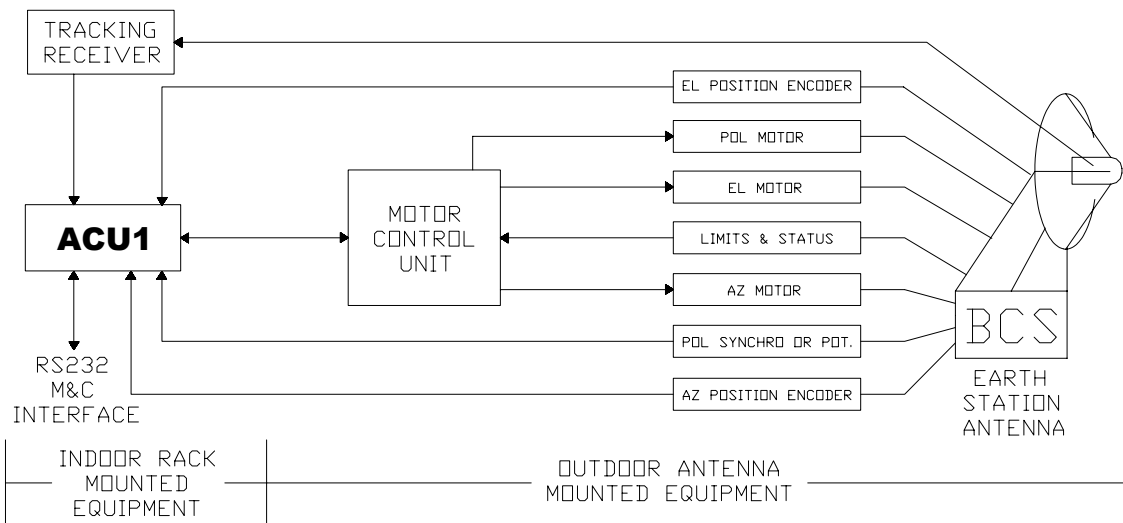
TYPICAL SYSTEM CONFIGURATION
FIGURE 1

The ACU1 is the main system component and contains the control logic electronics to generate motor drive commands. The motor control commands are produced in response to inputs from the position encoders, limit and status switches, front panel controls, and R.F. signal receiving equipment. Control may also be accomplished via the RS-232 monitor & control port.

The angular position of each axis is reported by synchro based position encoders that are mounted on their corresponding axes of the earth station antenna. The signal from these position encoders is converted in the ACU1 to provide an angular display on the front panel display as well as being used for automatic positioning modes.

For automatic satellite tracking operation (Steptrack), a D.C. signal proportional to signal strength is connected to the ACU1. This signal is then used by the ACU1 to optimize the antenna position when in Steptrack mode.

The ACU1 is connected to a motor control unit, which produces the high voltage required to start and stop the earth station antennas' motors. Each axis has a motor (or possibly two depending upon configuration) which allow electrical control of the mechanical movement of each antenna axis. In some system configurations two motors (or dual speed) motors are employed allowing two-speed control of each antenna axis. In these two-speed configurations either a single motor control unit or two separate motor control units (the second for high-speed motor control) are typically used.

If the earth station antenna being controlled by the ACU1 has a linearly polarized feed, the ACU1 polarization option is employed. This option allows the ACU1 to receive a signal from an additional position encoder (either a synchro transmitter or potentiometer depending upon configuration) and to control an additional motor. By adding the additional position encoder and motor the ACU1 can remotely control the rotation of the earth station antenna polarization feed horn.

The ACU1 is generally rack mounted and located in the control room area, while the position encoders, limit switches, motor controller/s, and motors are generally located on the earth station antenna structure. The R.F. tracking equipment is generally located in the control room area as well.

C.   **FRONT PANEL CONTROLS & INDICATORS**
       The following front panel view of the ACU1 should be referred to for the following discussion of each of the ACU1 controls and indicators.
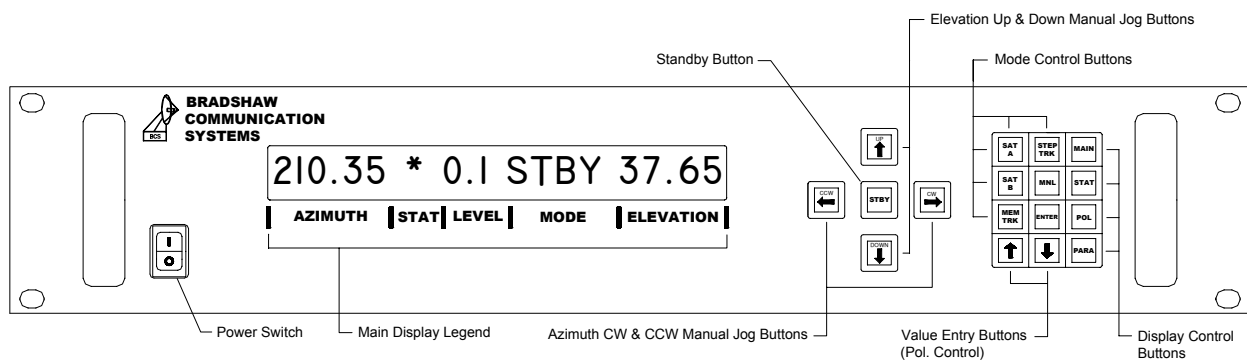
ACU1 Front Panel
Figure 2

1.   **Power Switch**
       The front panel power switch turns the ACU1 internal power supplies on and off. The switch is a rocker style with an international compliant legend. When the switch is rocked to the " **I** " depressed condition, the ACU1 is ON. Conversely, when the switch is rocked to the " **O** " depressed condition, the ACU1 is OFF.

2.   **Standby Button (STBY)**
       The Standby (STBY) button, when depressed, places the ACU1 in the Standby mode. When the ACU1 is in the Standby mode, all active automatic modes are cancelled, all motor movement is stopped, and the axis brakes are set (if the antenna is equipped with brakes). The Standby button also serves as a front panel Emergency Stop switch, thus the labeling of the STBY button in a red legend.

       Each time the Standby button is depressed, the ACU1 microprocessor is reset and upon restart will perform a system self-test. During the self-test "BCS" and the software release date will be displayed. If any errors are encountered, the ACU1 microprocessor will be halted while displaying the hardware/firmware fault encountered. This self-test is also performed anytime the ACU1 is powered on after being off.

3.   **Azimuth Clockwise (CW) & Counter-Clockwise (CCW) Buttons**
       When the ACU1 is placed in the Manual Jog mode, the CW button will move the antenna azimuth axis in the clockwise direction and the CCW button will move the antenna azimuth axis in the counter-clockwise direction. The direction of clocking clockwise and counter-clockwise is viewed as looking down on the antenna from the top. Refer to the

Modes of Operation section "B" for information on placing the ACU1 into the Manual Jog mode.

4.   **Elevation Up (UP) & Down (DOWN) Buttons**
     When the ACU1 is placed in the Manual Jog mode, the UP button will move the antenna elevation axis in the UP direction and the DOWN button will move the antenna elevation axis in the DOWN direction. Refer to the Modes of Operation section "B" for information on placing the ACU1 into the Manual Jog mode.

5.   **Move To Satellite A (SAT A) & Satellite B (SAT B) Buttons**
     By depressing the SAT A button followed by the ENTER button, the ACU1 will <u>move</u> the azimuth, elevation, and polarization (if equipped with the polarization option) antenna axes <u>to</u> a pre-programmed azimuth, elevation, and polarization position stored in the setup parameters for Position A (parameters PAA, PAE, & PAP).

     By depressing the SAT B button followed by the ENTER button, the ACU1 will <u>move</u> the azimuth, elevation, and polarization (if equipped with the polarization option) antenna axes <u>to</u> a pre-programmed azimuth, elevation, and polarization position stored in the setup parameters for Position B (parameters PBA, PBE, & PBP).

6.   **Option Mode Button (40 SAT), (MEM TRK), (PGM TRK), or (SAT C)**
     By depressing the Option mode button followed by the ENTER button, the selected Option mode will be initiated. The Option mode button will be labeled as one of the following four ACU1 options depending upon firmware configuration.

     40 SAT   Forty Satellite Mode
     MEM TRK   Memory Track Mode
     PGM TRK   Program Track Mode
     SAT C   Move To Satellite C Mode (same as SAT A / SAT B mode above except the earth station antenna will move to the stored positions for Position C (parameters PCA, PCE, & PCP)

     Refer to the appropriate section in the Modes of Operation chapter for a complete description of each mode listed.

     It is possible that more than one Option mode is available depending upon ACU1 firmware configuration. If more than one mode is available, depressing the Option mode button more than once will scroll through the available flashing option modes. Pressing the ENTER button while the desired mode is being displayed will initiate the displayed mode. When the ACU1 is configured with only one Option mode, depressing the Option mode button more than once will exhibit no change in the choice of the Option mode displayed.

7.   **Steptrack Button (TRK)**
     By depressing the TRK button followed by the ENTER button, the Steptrack mode is initiated. The Steptrack mode automatically moves the antennas' azimuth and elevation axes to the position of strongest received signal strength (if the system is equipped with a tracking receiver).

8.   **Manual Jog Button (MNL)**
     By depressing the MNL button followed by the ENTER button, the Manual Jog mode is enabled allowing the CW, CCW, UP, & DOWN Manual Jog buttons to become active. Simultaneous movement of both the azimuth and elevation axes is allowed (polarization axis also, if so equipped).

Depressing the POL button while in the Manual Jog mode will enable the " ⇑ " and " ⇓ " value entry buttons to rotate the polarization axis (if the ACU1 is configured for linear polarization control). The " ⇑ " value entry button will rotate the polarization axis clockwise as viewed from the rear of the antenna hub. Likewise, depressing the " ⇓ " value entry button will rotate the polarization axis counter-clockwise as viewed from the rear of the antenna hub.

By depressing the MNL button without depressing the ENTER button, and selecting the " ⇑ " or " ⇓ " value entry buttons, the ACU1 may be switched from low speed (MNL) to high speed (MNL2). This two-speed functionality is only present on systems with two-speed configuration in firmware and equipped with two-speed motorization capability.

9.   **Enter Button (ENTER)**
The ENTER button, when depressed, actively enters a selected mode of operation.

When a mode of operation (i.e. Steptrack, Manual Jog, etc…) is selected, the MODE portion of the main display will indicate the abbreviated mode pneumonic in a flashing condition without actually entering the selected mode. By depressing the ENTER button within 20 seconds of depressing the mode button, the selected mode will be initiated. If more than 20 seconds elapse before the ENTER button is depressed, the ACU1 will revert to it's former display condition prior to the mode button being depressed without initiating the selected mode. Prior to pressing the ENTER button and within the 20 seconds any other mode may be selected. This two-step functionality prevents inadvertent entry of any mode of operation.

10.   **Value Entry Buttons (⇑) & (⇓)**
The value entry buttons are used for three primary functions as follows:

- Altering and setting the values of stored setup parameters.
- Rotating the polarization feed when the Manual mode is initiated and the POL display is selected (only on systems equipped with polarization control).
- Changing from low-speed (MNL) to high-speed (MNL2) when the Manual mode is initiated (only on 2-speed equipped systems).

11.   **Main Display Button (MAIN)**
By depressing the MAIN button at any time, the ACU1 display will be returned to the main display. The main display is indicated by the silk-screened legend on the ACU1 front panel below the display window. The main display is always displayed at ACU1 power-up. The main display provides the following information:

- Azimuth Angle in Degrees
- Fault/Status Indicator
- Signal Strength in Decibels
- Mode of Operation (Pneumonic)
- Elevation Angle in Degrees

12.   **Fault & Status Display Button (STAT)**
By depressing the STAT button at any time, the ACU1 display will be switched to the fault & status display mode. When depressed, all fault and status information is provided (in abbreviated form) in the MODE & LEVEL portions of the display.

When a blinking asterisk appears in the STATUS section of the display, depressing the STAT button will show which fault and/or status conditions have occurred. Depressing the STAT button a second time will acknowledge the fault and/or status condition and cause the asterisk to stop blinking and become solid if the fault and/or status condition/s are still present. Once the fault and/or status condition is cleared, the asterisk will extinguish completely.

Refer to the Fault & Status Display Mode section of the Modes of Operation chapter for a listing of the Fault & Status messages and their displayed abbreviations.

NOTE: Pressing the STAT button a second time will also acknowledge the ACU1 Summary Alarm contacts provided for remote monitoring purposes.

13. **Polarization Display Button (POL)**
By depressing the POL button at any time, the ACU1 display will be switched to the polarization angle display (only when equipped with the polarization option firmware and polarization motorization). When depressed, the polarization angle is displayed in the MODE & LEVEL portions of the display. Polarization angle is displayed with a resolution of 0.1 degrees.

Additionally, if in the Manual Jog Mode (MNL or MNL2) and the POL display button is depressed, the Value Entry buttons (⇑) & (⇓) will allow the polarization feed to be rotated.

14. **Setup Parameters Display Button (PARA)**
By depressing the PARA button at any time, the ACU1 display will be switched to the parameter setup display. When depressed, the parameters (in pneumonic form) and their associated stored values are displayed one at a time in the MODE & LEVEL portions of the display. Each time the PARA display button is depressed the next parameter in sequence is displayed, repeating at the end of the sequence. Depressing a Value Entry button (⇑) or (⇓) while in the Parameter Setup Display mode will allow the displayed value to be modified.

Refer to the Parameter Setup Display Mode section of the Modes of Operation chapter for a listing of the ACU1 parameters, their descriptions, displayed pneumonic, associated stored value, and nominal values.

MODES OF OPERATION

A. **Standby Mode**
The ACU1 is in the Standby mode anytime the Standby (STBY) button is depressed. When the ACU1 is in the Standby mode, all active automatic modes are cancelled, all motor movement is stopped, and the axis brakes are set (if the antenna is equipped with brakes). The Standby button also serves as a front panel Emergency Stop switch, thus the labeling of the STBY button in a red legend. The Standby mode may be selected at any time and in any mode. It does not effect the operation of the display select or value entry buttons.

When the ACU1 is in the Standby mode, " STBY " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the Standby mode.

Each time the Standby mode is entered, the ACU1 microprocessor is reset and upon restart will perform a system self-test. During the self-test "BCS" and the software release date will be displayed. If any errors are encountered, the ACU1 microprocessor will be halted while displaying the hardware/firmware fault encountered. This self-test is also performed anytime the ACU1 is powered on after being off. The ACU1 will always power up in the Standby mode.

B. **Manual Jog Mode**
The ACU1 is in the Manual Jog mode any time the MNL button is depressed followed by the ENTER button. The Manual Jog mode allows the CW, CCW, UP, & DOWN Manual Jog buttons to become active. Simultaneous movement of both the azimuth and elevation axes is allowed (polarization axis also, if so equipped).

When the ACU1 is in the Manual Jog mode, " MNL or MNL2 " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the Manual Jog mode.

Depressing the POL button while in the Manual Jog mode will enable the " ⇑ " and " ⇓ " value entry buttons to rotate the polarization axis (if the ACU1 is configured for linear polarization control). The " ⇑ " value entry button will rotate the polarization axis clockwise as viewed from the rear of the antenna hub. Likewise, depressing the " ⇓ " value entry button will rotate the polarization axis counter-clockwise as viewed from the rear of the antenna hub.

By depressing the MNL button without depressing the ENTER button, and selecting the " ⇑ " or " ⇓ " value entry buttons, the ACU1 may be switched from low speed (MNL) to high speed (MNL2). This two-speed functionality is only present on systems with two-speed configuration in firmware and equipped with two-speed motorization capability.

C. **Move To SAT A / SAT B Mode**
The ACU1 may be preprogrammed with two different satellite azimuth, elevation, and polarization (if so equipped with polarization) stored positions. One called SAT A, the other called SAT B. The SAT A or SAT B modes may be entered at any time and from any mode including the Standby mode.

By depressing the SAT A button followed by the ENTER button, the ACU1 will <u>move</u> the azimuth, elevation, and polarization (if equipped with the polarization option) antenna axes <u>to</u> a pre-programmed azimuth, elevation, and polarization position stored in the setup parameters for Position A (parameters PAA, PAE, & PAP). When the SAT A mode is selected, " POS A " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the SAT A mode. After the earth station antenna has moved to the designated SAT A position, it will stop movement and hold position until another mode or Standby mode is initiated.

Likewise, by depressing the SAT B button followed by the ENTER button, the ACU1 will <u>move</u> the azimuth, elevation, and polarization (if equipped with the polarization option) antenna axes <u>to</u> a pre-programmed azimuth, elevation, and polarization position stored in the setup parameters for Position B (parameters PBA, PBE, & PBP). When the SAT B mode is selected, " POS B " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the SAT B mode. After the earth station antenna has moved to the designated SAT B position, it will stop movement and hold position until another mode or Standby mode is initiated.

For a description of how to alter the stored angle values for SAT A and SAT B, refer to the Parameter Setup Display Mode section of this chapter.

D. **Steptrack Mode**
Basic Steptrack Functionality
The Steptrack mode automatically moves the earth station antenna to the position where the received signal from the satellite is strongest. While in this mode, the antenna moves in pre-defined series of sequential steps until the received signal strength is at maximum as defined by various alterable parameters. When maximum signal strength is acquired the earth station antenna stops moving. When the received signal level drops below a stored parameter preset threshold, or a stored parameter preset amount of time elapses, the earth station antenna will again be commanded to move in order to maximize the received signal strength. This automatic process continues until another mode or the Standby mode is initiated.

When the ACU1 is in the Steptrack mode, " TRK or STTK " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the Steptrack mode. Anytime the earth station antenna is actively moving, searching for maximum received signal strength, " TRK " is displayed. Anytime the antenna is not moving (parked), waiting for pre-defined events to occur, " STTK " is displayed.

Detailed Steptrack Functionality
The Steptrack algorithm commands a series of box-like movements in azimuth and elevation of the earth station antenna while monitoring the received satellite signal level. Once maximum (peak) signal is acquired the earth station antenna stops moving (parks) and waits until the time value stored in the Scan Cycle Time (SCT) parameter elapses or the received signal level drops below the value stored for the Decibel Threshold (DBT) parameter. While actively moving the earth station antenna and searching for maximum received signal strength, " TRK " is displayed in the MODE portion of the display. While the antenna is not moving (parked), monitoring the

received signal level, and waiting for SCT to elapse and/or DBT to be violated, " STTK " is displayed in the MODE portion of the display.

Use of the Scan Cycle Timer (SCT) functionality of the Steptrack algorithm allows intermittent tracking operation when the wind is low and satellite motion is small. This helps limit unnecessary earth station antenna movement when conditions are favorable. Scan cycle timing starts from the beginning of Steptrack motion and ends upon elapsing the time set by the SCT parameter starting another series of Steptrack motions.

If the system is between scan cycles, and the signal level drops below the stored value for the Decibel Threshold (DBT) parameter, Steptrack motion is immediately re-initiated, despite any remaining time in the Scan Cycle Timer. The Scan Cycle Timer is then immediately reset. Use of this functionality of the Steptrack algorithm provides for automatic shortening of the cycle time in the event winds, or satellite movement, cause a received signal change.

Further, if the received signal level drops below the stored value for the Signal Range Control (SRC) parameter, Steptrack will stop scanning, hold antenna position, and a "LOW SIGNAL" fault will be displayed in the Fault & Status Display.

If the Tracking Signal (TRS) parameter is set to " 0 ", and a "LOW SIGNAL" fault condition is encountered, the Steptrack algorithm will initiate a search for other received signal inputs. If a source sufficient for tracking purposes is found (i.e. a signal level greater than the stored SRC parameter value), the algorithm will use the new source to continue the Steptrack peaking process. The Tracking Signal (TRS) parameter may be set to any one of five pre-defined receive signal level inputs (TRS = 1–5), or to zero (TRS = 0) which allows the Steptrack algorithm to search all five inputs in the event of a "LOW SIGNAL" fault condition.

When the ACU1 is equipped with either Memory Track Mode or Program Track Mode and a "LOW SIGNAL" fault condition is encountered, the Steptrack algorithm can initiate either Memory Track Mode or Program Track Mode accordingly. This backup of the Steptrack process is controlled by a backup parameter ("MTB" for Memory Track or "PTB" for Program Track). When either parameter is set to " 1 ", backup of the Steptrack process by that mode is enabled. If a signal greater than set by the stored SRC parameter is restored by the backup mode, the ACU1 will automatically revert back to the Steptrack process for peaking the received signal. These modes, if enabled, help protect from losing the satellite if a loss of the received signal level occurs.

If excessive variation of the received signal occurs during the Steptrack signal integration process, the antenna is halted and held in position until the condition clears. The level of variation of the received signal sufficient to halt the Steptrack process is alterable via the stored parameter value Signal Rate Threshold (SRT). Safety checking of the receive signal variation is performed by the Steptrack algorithm in order to prevent bad sampling data during the Steptrack process leading to erroneous antenna peaking movements.

In detail, when Steptrack is actively moving the antenna, each axis moves in sequential discrete steps. The steps are made alternately in azimuth and elevation. This motion initially causes the antenna to move in a square about the line-of-sight established by the previous position as seen in Figure 3.

ELEVATION AXIS

B   A

AZIMUTH AXIS

C   D
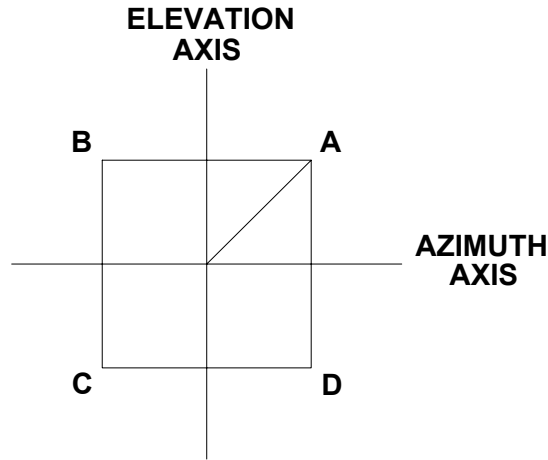
STEPTRACK PROCESS EXAMPLE
FIGURE 3

In Figure 3, the origin represents the previous command position. While scanning, the antenna stops at each point (A, B. C, & D) in turn. The azimuth data is obtained by digitally integrating the inverse of the received signal level voltage while the antenna is at B and C. If the correct line-of-sight was anywhere along the vertical axis, the integral of the received signal level voltage while at D and A is equal to and opposite the integral of the negative received signal level voltage. The resultant output would, therefore, be zero. If the correct line-of-sight was not found on the vertical axis, the difference between the two integrals would not be zero, and the output would be proportional to the error. The sign of the output would indicate the direction of the error. Similar results for elevation are obtained by integrating the signal at A and B and the inverse at C and D.

Since the integrator residuals are proportional to the position error, they are used to update the present position command. This process repeats until the measured error in each axis is below an acceptable threshold controlled by the Tracking Gain (TRG) parameter.

E.   **40 Satellite Mode (OPTIONAL)**
The optional 40 Satellite mode allows the user to store up to 40 satellite azimuth, elevation, and polarization angle positions in non-volatile memory. Each satellite position is stored by number (1–40). Upon selection of one of the desired 40 stored satellite positions, the ACU1 will command the earth station antenna to move to the nominal look angles as stored for the selected satellite position.

To select on of the possible 40 stored satellites, first select the **MAIN** display button. Next, depress the **40 SAT** button (Note: if 40 SAT option is not included, the 40 SAT button will not be found). The "MODE" portion of the display will show "S-XX" blinking with "XX" representing the last commanded satellite. Using the ⇑ or ⇓ value entry buttons select the number for the desired satellite. Once the desired satellite number is displayed (still blinking), depress the **ENTER** button to command the earth station antenna to move to the selected satellite nominal look angles.

To store look angles for each of the possible 40 positions, depress the **PARA** button to select the parameter setup mode. Next, depress the **40 SAT** button. The "MODE" portion of the display will show "S-XX" blinking with "XX" representing the last commanded satellite. Using the ⇑ or ⇓ value entry buttons select the number of the satellite to be edited. By depressing the **ENTER** button, the azimuth stored angle (for the selected 40 SAT position) is displayed. By using the ⇑ or ⇓ value entry buttons the stored azimuth angle (for the selected 40 SAT position) may be edited. By depressing the **ENTER** button once more, the altered azimuth angle is stored, and the elevation angle is displayed for editing in the same manner as azimuth. If the ACU1 is equipped with the polarization option, depressing **ENTER** again, will store the altered elevation angle, and display the polarization angle for editing. Once the polarization angle is edited (or if the ACU1 does not employ the polarization option), depressing the ENTER button again will store the altered polarization angle and/or return the display to the 40 SAT selection list. By using the ⇑ or

⇓ value entry buttons any of the 40 stored satellite position angles may be altered as previously described. When finished with 40 Satellite position editing, the **MAIN** display button may be pressed to exit the parameter setup mode.

F.   **Memory Track Mode (OPTIONAL)**
Memory Track mode allows the ACU1 to command the antenna azimuth and elevation axes to move along a path described by data points spaced ten minutes apart. Data points are stored in the Memory Track table at intervals of ten minutes when in the Steptrack mode and no Low Signal condition exists. Data points may also be entered by the user using the front panel keyboard or through the M&C Port.   The data points contain time of day, an azimuth angle and an elevation angle.   When in the Memory Track mode, a position is commanded based on a straight-line interpolation of the data points.

Sidereal and Solar Time Discussion
Time, as we measure it, is based on the earth's rotation around the sun. A sidereal day is based on the time required for the earth to make a complete rotation with respect to the vernal equinox. The satellite orbit trajectory (ephemeris) is based on sidereal time. It thus becomes necessary to compensate for the difference in sidereal time and solar time. The sidereal day is approximately 23 hours, 56 minutes measured in solar units.

Therefore, the following statements regarding the data points in the Memory Track table are made:
> 1.   The point immediately proceeding the present time is for today.
>
> 2.   Points previous to that have been corrected for when they will next occur.

Thus, a point 20 minutes earlier than the present time will have been corrected for sidereal time for the following day. The Steptrack algorithm compensates for sidereal time by reading the azimuth and elevation angles that are to be stored in the table 4 minutes before the ten minute time interval and then storing those values at the ten minute time frame for use tomorrow. To avoid writing over values that still might be used for Memory Track interpolation today, there is a delay of 16 minutes before actually storing these values.

If not in Steptrack mode, the ACU will calculate the value to be used tomorrow by a straight-line interpolation between points. The value is based on calculations using the value for the next ten-minute time frame minus 4 minutes. Again, to avoid writing over values that still might be used for Memory Track interpolation today, there is a delay before actually storing these values.

If values in the Memory Track table are altered (either through the front panel controls or M&C Port) and they are immediately preceding or succeeding the present time, the altered values are assumed to be corrected for sidereal time. These altered values will not be corrected for sidereal time by the ACU1 until 24 hours later.

Memory Track Operation
To activate Memory Track mode, depress the **MEM TRK** button. The display will then show a flashing "MTRK" in the "MODE" portion of the display. To begin Memory Track execution, depress **ENTER**. The display will then stop flashing. If no errors are found in the data table, Memory Track will become the active mode and the antenna will be commanded to the appropriate point.   If errors are found, then the ACU1 will remain inactive until the errors are corrected. During Memory Track execution the antenna will be commanded to a point using straight-line interpolation between data points corresponding to the time of day updated at a once per second rate. If the Memory Track backup parameter is set to a "1", then the mode may change to Steptrack if the following conditions are met:

> 1.   No Excess Signal (fade) condition faults have occurred for three tracking signal integration periods (approximately 12 seconds).
>
> 2.   The present signal level exceeds the low signal threshold by 0.7 dB.

Likewise while in Steptrack mode, if the Memory Track backup parameter is set to a "1" then the mode may change to Memory Track if the following conditions are met:

1.	Three successive Excess Signal (fade) condition faults have occurred.

2.	A Low Signal fault condition exists, and, all beacon signal sources have been searched and found to be below threshold of the SRC parameter (signal search occurs only when the Tracking Signal Select (TRS) parameter is set to "0").

Memory Track Stored Table Examine and Change
To edit or examine the data points contained in the Memory Track table, the **PARA** button is depressed followed by the **MEM TRK** button. Each data field has three data points associated with it.

The first data field displayed is the time. Depressing the **ENTER** button will change the display to the stored azimuth angle. Depressing **ENTER** again will change the display to the elevation angle. Again, depressing **ENTER** will return to the time display. To select a new data field use the " ⇑ " or " ⇓ " value entry buttons to alter the time display. To change any data value use the " ⇑ " or " ⇓ " value entry buttons. NOTE: The maximum value for Elevation is 99.99 degrees.

Setup Parameters Associated with Memory Track Mode
Parameters associated the optional Memory Track mode are summarized as follows:

Azimuth Difference (AZD) and Elevation Difference (ELD)
Azimuth Difference (AZD) and Elevation Difference (ELD) are displayed in angles. Data points are checked for validity using these parameters. These values are the maximum differences that can exist between two successive data points. If this difference is exceeded, then an error message will be displayed with the appropriate time of day (i.e. 00:50 ERR.). This error means the azimuth or elevation angle associated with the time displayed when compared with the next time period, has exceeded the difference parameter value.

Time of Day
Time of Day is displayed as "hours : minutes : seconds". To change the time, depress either the " ⇑ " or " ⇓ " value entry buttons.   To zero the seconds, depress the **ENTER** button.

Time Offset (TOS)
Time offset is displayed as "TOS XXX" where "XXX" is the offset in seconds. The offset has a range of -30 seconds to +30 seconds. This offset is used to correct for inaccuracies inherent in the crystal that drives the clock. Every 24 hours (at time 00:00:00), the time is corrected using the time offset.

Memory Track Backup (MTB)
The mnemonic for Memory Track backup", is "MTB". The associated value is either a "1" or "0". If set to "1" then Memory Track and Steptrack can alternate modes as described above.

Azimuth Position Offset (APO) and Elevation Position Offset (EPO)
The Azimuth offset is added to the stored azimuth angle as the elevation offset to the stored elevation angle. These two parameters are displayed in degrees. The mnemonics for these parameters is "APO" and "EPO".

**G.	Program Track Mode (OPTIONAL)**
The Program Track mode allows the ACU1 to command the antenna along a path that is described by 170 user defined data points for one week. Each data point is associated with a specific day of the week and time of day in hours and minutes. The data points contain the azimuth, elevation and polarization angles (if equipped with polarization control) that the earth station antenna will be driven to at that point in time. The operation is similar to a position designate mode in that the program consists of a time sequence of position designate commands.

Program Track Operation
To activate the Program Track mode, select the Program Track mode by depressing the **PROG TRK** button.   (Note: some firmware options have multiple modes on a single button, it may be required to press the 40 SAT or MEM TRK button more than once to locate the PROG TRK

mode). The display will respond with a flashing "PTRK" in the "MODE" portion of the display. To begin Program Track execution press the **ENTER** button. If no errors are found in the data point table, the display will stop flashing and display "PTRK". If errors are found, the Program Track mode will remain inactive and the appropriate fault message will be activated. All fault conditions must be corrected before Program Track execution will begin. Upon execution of the Program Track mode, the ACU will command the antenna to the angular position described by the point that corresponds to the current day and time equal to that of the real time of day clock. If a table error occurs during Program Track the ACU will hold the last position and activate the appropriate fault message.   When the fault condition is removed the ACU will resume active Program Tracking.

Program Track Mode Stored Table Examine or Change
To edit or examine the stored data points contained in the Program Track table, depress the **PARA** button to enter the parameter setup mode. Next, depress the **PROG TRK** button (again, depending upon firmware configuration this may be the **40 SAT** or **MEM TRK** button) to allow display/editing of the Program Track table. Each data point has six data fields associated with it and they will be displayed as shown:

Mnemonic	Range	Field	Description
P	1 - 170	Data Point No.	Data Point Currently Displayed
D	0, 1 - 7	Day	Day of Week
T	00:00 – 23:59	Time	Time of Day (hours : minutes)
AZ	0.00 – 359.99	Azimuth	Azimuth Angle
EL	0.00 – 99.99	Elevation	Elevation Angle
POL	0.00 – 359.9	Polarization	Polarization Angle

The first field to be displayed will be P or the point number. To step to the next field press the **ENTER** button. The display will show the next parameter without any change to the previous parameter. To edit a value at the displayed field, depress either the " ⇑ " or " ⇓ " value entry buttons to increment or decrement the displayed field. After selecting the desired value, depress the **ENTER** button; the data field will be changed to the displayed value and the display will rotate to the next data field. If the day field of a point is set to zero, that point is treated as a "null" point in the Program Track table. Null points allow the user to have less than 170 data points in the Program Track table. Unused data points should be set to null points if they are not already set to null points. The Program Track table points may be examined at any time. However, editing of the Program Track table is not allowed in the active Program Track mode. If a table error is present (indicated by a fault message) the Program Track mode is not active, therefore, a point may be corrected at this time while in the Program Track mode. Once an error point has been edited or examined the fault message is cleared until another error is found by the checking routine.

Each data point (excluding null points) is checked for validity using the following rules:

1.   The day and time of day for each point must be in chronological order.

2.   Each data point must be within 1 day of the previous data point.

3.   The difference in azimuth between two consecutive data points is less than the parameter AZD (Azimuth Difference).

4.   The difference in elevation between two consecutive data points is less than the parameter ELD (Elevation Difference).

5.   The difference in polarization between two consecutive data points is less than the parameter POD (Polarization Difference) if equipped with the polarization option.

6.   There must be at least one data point per day; therefore, a minimum of seven data points is required.

7.   Null days will not be checked for validity.

8.   Only one week of data may be entered at any one time.

If any of the above rules are violated, the error message "P XXX ERR" is displayed on the front panel with "XXX" representing the number of the data point where the first error occurred. If there are two or less valid data points, the error message "P 171 ERR" will be displayed upon entering the Program Track mode. This validity check is continuously executed by a routine which checks three adjacent non-null data points. Due to the nature of this validity check the point displayed as an error could be any of the three points checked. Therefore, when examining an error point the operator should always examine the previous and the next non-null data table points as well as the error point to determine the cause of the error.

Setup Parameters Associated with Program Track Mode
Setup parameters associated with the optional Program Track mode are as follows:

Time of Day
Time of day is displayed as "td hh:mm:ss" where d is day of week (1-7), hh is hour of day (00-23), mm is minutes of day (00-59), and ss is seconds of the day (00-59). While the time of day is being displayed in the Setup Parameters mode the Time of Day may be changed. To change the hours, minutes, and the day of the week, depress the " ⇑ " or " ⇓ " value entry buttons. Once the desired value is displayed, press the **ENTER** button and the seconds will be reset to zero to start the clock at the exact value of hours, minutes, and seconds.

Time Offset (TOS)
Time Offset is displayed as "TOS XX" where "XX" is the offset in seconds. The offset value has a range of -30 to +30 seconds. This offset is used to correct for inaccuracies in the crystal that drives the real-time clock. Every 24 hours, the time offset is added to the time of day.

Program Track Backup (PTB)
The Program Track Backup parameter is displayed as "PTB X" where "X" is "1" or "0". If PTB is set to "1" with the ACU1 in Steptrack mode and a Low Signal fault appears the ACU will automatically revert to Program Track mode if no Program Track errors are present. The "MODE" portion of the display will then show "BTRK". If the Low Signal fault is removed the ACU will then revert to back Steptrack.

Azimuth Difference (AZD)
Azimuth Difference is displayed as "AZDXXX.XX" where "XXX.XX" is the maximum allowed azimuth difference between two valid contiguous data points in the Program Track data table. The limit has a range of 0.00-359.99 degrees.

Elevation Difference (EZD)
Elevation Difference is displayed as "ELD XX.XX" where "XX.XX" is the maximum allowed elevation difference between two valid contiguous data points in the Program Track data table. The limit has a range of 0.00-99.99 degrees.

Polarization Difference (POD)
Polarization Difference is displayed as "POD XXX.X" where "XXX.X" is the maximum allowed polarization angle difference between two valid contiguous data points in the Program Track data table. The limit has a range of 0.0 - 359.9 degrees.

H.   **Move To SAT C Mode (OPTIONAL)**
The ACU1 may be preprogrammed with azimuth, elevation, and polarization (if so equipped with polarization) stored positions for a third satellite SAT C. The operation of this mode is identical to that of SAT A and SAT B modes supplied standard on the ACU1. The SAT C mode may be entered at any time and from any mode including the Standby mode.

By depressing the **SAT C** button followed by the **ENTER** button, the ACU1 will move the azimuth, elevation, and polarization (if equipped with the polarization option) antenna axes to a pre-programmed azimuth, elevation, and polarization position stored in the setup parameters for Position C (parameters PCA, PCE, & PCP). When the SAT C mode is selected, " POS C " will be displayed in the MODE portion of the MAIN display indicating the ACU1 is actively in the SAT C mode. After the earth station antenna has moved to the designated SAT C position, it will stop movement and hold position until another mode or Standby mode is initiated. For a description of

how to alter the stored angle values for SAT C, refer to the Parameter Setup Display Mode section of this chapter.

I.   Box Limits Protection Feature (OPTIONAL)
In addition to the normal travel limits, software limits called box limits may be provided. The box limit, when enabled, prevents the antenna ACU1 from commanding the earth station antenna axes more than a user programmable amount in degrees from a memorized position in any mode. The ± limit may be a value between 0.00 and 5.00 degrees with a resolution of 0.01 degrees. The center position is memorized when the box limit is enabled. The system enable will be removed whenever movement reaches the limit value in either azimuth or elevation. The parameter "BX" displays the value of the box. To change the value, depress the " ⇑ " or " ⇓ " value entry buttons while in the Setup Parameters Mode.

To arm the box limit, depress the **ENTER** button with the "BX" parameter displayed in setup mode. This causes the display to change to "BXA" and the memorized position is flashed in the AZ/EL display. The status message "LIMIT ARMED" is present whenever the box limit has been enabled. When a limit is exceeded, the fault message "EL BX LMT" or "AZ BX LMT" is displayed. To disable the box limit, depress the **ENTER** button when the "BXA" parameter is displayed in setup mode.

J.   Emergency Override Manual Jog Mode
In the unlikely event a microprocessor failure occurs, an emergency method of controlling the Motor Control Unit has been built into the ACU1. The earth station antenna may be moved in the Emergency Override Manual Jog mode even with a failed microprocessor. The antenna may be driven manually by pressing (and holding) the Standby button while depressing an azimuth CW or CCW Manual Jog button to move the azimuth axis and/or an elevation UP or DOWN Manual Jog button to move the elevation axis.

K.   Fault & Status Display Mode
A blinking asterisk present in the "STAT" portion of the display indicates a monitored fault or status has been activated. Under this condition the Summary Alarm (Form C) monitor contacts on the station alarm output at the back of the ACU1 are released to indicate an alarm condition has occurred. Pressing the **STAT** button will cause the ACU1 to show the appropriate fault or status message in the center of the display, leaving only the azimuth and elevation angular positions still showing. If more than one fault or status message is present, the ACU1 will rotate through each message, repeating at the end of the list.

By depressing the **STAT** button again while still viewing the fault and status message/s, the blinking asterisk will stop blinking and the Summary Alarm contact will reset indicating an acknowledged fault or status condition. It is possible to acknowledge the fault or status condition, with the actual fault or status condition and associated message still being present. If a second fault or status message is activated after acknowledgement of the first, the asterisk will again start blinking and the Summary Alarm will again be issued. Depressing the **STAT** button again will again acknowledge the new fault or status condition. This process can continue up to the limit of all available fault and status messages.

The following table details the fault and status messages reported by the ACU1. The table is comprehensive and not all ACU1 units will contain every message due to optional firmware configurations.

ACU1 Fault and Status Message Table

Message	Fault or Status	Cause	Solution
LOW SGNL	Fault	Tracking signal below the threshold set by the SRC parameter	Check tracking receiver, satellite signal, and ACU1 signal calibration
EXC SGNL	Fault	Excessive signal strength variation, threshold set by the SRT parameter	Possible rain fade and/or verify proper setup of the SRT parameter
AZ SDC	Fault	AZ Synchro to Digital Conversion Failure	Check AZ position encoder & wiring, check reference voltage
EL SDC	Fault	EL Synchro to Digital Conversion Failure	Check EL position encoder & wiring, check reference voltage
POL SDC	Fault	POL Synchro to Digital Conversion Failure	Check POL synchro/pot & wiring, check reference voltage
LOC CNTRL	Status	Control taken at Motor Controller Unit	Check Local/Remote at MCU
SYS INTLK	Fault	Emergency Stop Switch activated or loss of Motor Controller Unit power	Reset Emergency Stop Switch and/or check for correct MCU power
AZ INTLK	Fault	AZ Interlock Switch Activated or MCU AZ motor circuit breaker tripped	Check AZ Interlock Switch and/or MCU AZ motor circuit breaker
AZ CW LIM	Fault	AZ Clockwise Limit Switch activated	Jog CCW out of limit and/or check AZ CW limit switch & wiring
AZ CCW LM	Fault	AZ Counter-Clockwise Limit Switch activated	Jog CW out of limit and/or check AZ CCW limit switch & wiring
EL INTLK	Fault	EL Interlock Switch Activated or MCU EL motor circuit breaker tripped	Check EL Interlock Switch and/or MCU EL motor circuit breaker
EL UP LIM	Fault	EL Up Limit Switch activated	Jog Down out of limit and/or check EL Up limit switch & wiring
EL DN LIM	Fault	EL Down Limit Switch activated	Jog Up out of limit and/or check EL Down limit switch & wiring
POL INTLK	Fault	POL Interlock Switch Activated or MCU POL motor circuit breaker tripped	Check POL Interlock Switch and/or MCU POL motor circuit breaker
PO CW LIM	Fault	POL Clockwise Limit Switch activated	Jog CCW out of limit and/or check POL CW limit switch & wiring
PO CCW LM	Fault	POL Counter-Clockwise Limit Switch activated	Jog CW out of limit and/or check POL CCW limit switch & wiring
AZ BX LMT	Fault	Defined AZ Box Limit Value exceeded	Jog antenna back into defined box
EL BX LMT	Fault	Defined EL Box Limit Value exceeded	Jog antenna back into defined box
LMT ARMED	Status	Box Limits armed	Status Message only
P 171 ERR	Fault	Two or less data points valid in Program Track table	Correct table errors
P XXX ERR	Fault	Program Track data point at, before, or after "XXX" not valid	Correct Program Track table error at or near position "XXX"
XX:XX ERR	Fault	Memory Track table error at time location "XX:XX"	Correct Memory Track table error at or near time location "XX:XX"
CHK PARM	Status	Parameters Changed	Check/Reload Parameters then depress **STBY** button
RAM ERROR	Fault	RAM Memory Failure	Contact BCS
ROM ERROR	Fault	ROM Memory Failure	Contact BCS
ERAM EROR	Fault	Extended RAM Memory Failure	Contact BCS
BRAM EROR	Fault	Base RAM Memory Failure	Contact BCS
SDC ERROR	Fault	SDC Conversion Circuit Failure	Contact BCS

L.   Parameter Setup Display Mode

The ACU1 stores setup parameters in non-volatile memory. The parameters are then safely stored even in the event of power loss. The parameters may be altered by use of the " ⇑ " or " ⇓ " value entry buttons after depressing the **PARA** button. Depressing the **PARA** button will cause the ACU1 to enter the parameter setup mode. By repeatedly depressing the **PARA** button, all of the available ACU1 parameters available for the particular unit's firmware version may be scrolled through. While stopped at any given parameter value display, the parameter value may be adjusted by using the " ⇑ " or " ⇓ " value entry buttons. The parameter list repeats at the end.

Each parameter is labeled with a three-letter mnemonic and is shown with a corresponding value in the center portion of the ACU1 display upon depressing the **PARA** button. Only the azimuth and elevation angular position show on the displays when in parameter setup mode.

The following table details a comprehensive list of all ACU1 parameters. Not all parameters are available in every ACU1. The parameters for use with any given ACU1 may vary depending upon firmware configuration for options. It is strongly suggested that the operator be completely familiar with the function and effect of the parameters before attempt is made to alter them.

ACU1 Parameter Table

Mnemonic	Range	Name	Nominal	Function
T	d=1 – 7 hh=00-23 mm=00-59 ss=00-59	Time of Day		Used to set the real-time clock to the proper day, hours, minutes, and seconds
TOS	-30 to +30	Time Offset (Seconds)	0	Offset Inaccuracies in Real Time Clock
TRS	0 to 7	Tracking Signal		Determines which tracking signal is to be used for Steptrack. Setting TRS to "0-1" or "0-7" places ACU1 in auto signal search mode. ACU1 searches until a signal greater than SRC is found. Set unused channels to –9.9
SG1	-9.9 to +9.9	Tracking Signal #1		Tracking Signal #1 Gain & Offset Entry Refer to Install & Maintenance Manual
SG2	-9.9 to +9.9	Tracking Signal #2		Tracking Signal #2 Gain & Offset Entry Refer to Install & Maintenance Manual
SG3	-9.9 to +9.9	Tracking Signal #3		Tracking Signal #3 Gain & Offset Entry Refer to Install & Maintenance Manual
SG4	-9.9 to +9.9	Tracking Signal #4		Tracking Signal #4 Gain & Offset Entry Refer to Install & Maintenance Manual
SG5	-9.9 to +9.9	Tracking Signal #5		Tracking Signal #5 Gain & Offset Entry Refer to Install & Maintenance Manual
CC6	-9.9 to +9.9	Comm. Channel #6		Tracking Signal #6 Gain & Offset Entry Refer to Install & Maintenance Manual
CC7	-9.9 to +9.9	Comm. Channel #7		Tracking Signal #7 Gain & Offset Entry Refer to Install & Maintenance Manual
SDP	0 to 359.99	Slew Decision Point (degrees) (2speed systems only)	0.20	Distance in degrees away from commanded position where motors will be switched from high speed to low speed. (359.99 for 1 speed systems)
DBT	0 to 80	dB Threshold	5	Signal level in ±10ths of a dB away from signal level at "park" which will initiate a Steptrack cycle
SRC	0 to 80	Signal Range Control	30	Signal level in 10ths of a dB below 0.0 at which the Low Signal alarm occurs
TRG	0 to 80	Tracking Gain	12	Sets the gain of the corrective step / Tracking gain adjust parameter
RNT	0 to 255	Run Time (0.1 sec. increments)		Sets the Steptrack nominal step size. EL receive -3dB BW (degrees) Velocity (degrees/second)

SRT	0 to 255	Signal Rate Threshold (100th of dB/second)	11	Net rate of change in signal level during a Steptrack integration period that is acceptable. Greater signal rate changes will inhibit corrective steps.
SCT	0 to 255	Scan Cycle Time (minutes)	30	Sets time between Steptrack cycles.
DBD	0 to 255	AZ & EL Deadband (0.01° units)	4	Deadband about a commanded position where motors are turned off.
PDB	0 to 255	POL Deadband (0.1° units)	50	Deadband about a commanded position where POL motor is turned off.
PAA	0 to 359.99	SAT A AZ Position		Stores SAT A AZ Command Position
PAE	0 to 359.99	SAT A EL Position		Stores SAT A EL Command Position
PAP	0 to 359.9	SAT A POL Position		Stores SAT A POL Command Position
PBA	0 to 359.99	SAT B AZ Position		Stores SAT B AZ Command Position
PBE	0 to 359.99	SAT B EL Position		Stores SAT B EL Command Position
PBP	0 to 359.9	SAT B POL Position		Stores SAT B POL Command Position
PCA	0 to 359.99	SAT C AZ Position		Stores SAT C AZ Command Position
PCE	0 to 359.99	SAT C EL Position		Stores SAT C EL Command Position
PCP	0 to 359.9	SAT C POL Position		Stores SAT C POL Command Position
AOS	0 to 359.99	Azimuth Offset		Used to align AZ Position Encoder
EOS	0 to 359.99	Elevation Offset		Used to align EL Position Encoder
POS	0 to 359.9	Polarization Offset		Used to align POL Position Encoder
AZD	0 to 359.99	Azimuth Difference (Program Track & Memory Track)		Used to set acceptable limit of AZ angular distance between two contiguous valid table data points.
ELD	0 to 359.99	Elevation Difference (Program Track & Memory Track)		Used to set acceptable limit of EL angular distance between two contiguous valid table data points.
POD	0 to 359.9	Polarization Difference (Program Track & Memory Track)		Used to set acceptable limit of POL angular distance between two contiguous valid table data points.
PTB	0 or 1	Program Track Backup	0	When set to "1" enables Program Track to backup Steptrack
MTB	0 or 1	Memory Track Backup	0	When set to "1" enables Memory Track to backup Steptrack
APO	0 to 359.99	Azimuth Position Offset		Allows offset of the stored AZ angle in the Memory Track table
EPO	0 to 359.99	Elevation Position Offset		Allows offset of the stored EL angle in the Memory Track table
BX	0 to 5.00	Box Limit		Stores Box Limit size value (disabled)
BXA	0 to 5.00	Box Limit Armed		Stored Box Limit size value (enabled)

MONITOR & CONTROL PORT

A. Introduction

The Monitor & Control (M&C) Port section describes the protocol and hardware interface required for use of the ACU1 M&C Port (J8 at the ACU1 rear panel). A terminal or remote Host processor connected to the M&C Port may exercise a set of operational mode commands and obtain complete operational status information from the ACU1 at any time. Any mode command issued by the Host (and accepted by the ACU1) will be observed on the ACU1 front panel display "MODE" portion in brackets (i.e. "(STBY)"). Also, all ASCII command letters must be upper case.

Optional Features

The M&C Port is designed to support the full range ACU1 options. As a result, it is possible that not all commands, fault, and status functions will apply to a particular version ACU1. In this case, the following extensions to the remainder of the protocol specification will apply.

1. The ACU1 will properly acknowledge all command sequences included in this document. Attempts to use commands that are not implemented will be acknowledged but not executed.

2. When the Polarization Option is <u>not</u> implemented, the ACU1 will indicate a Polarization Angle of 0.0 at all times. When using the position designate command with an ACU1 without polarization control, the inclusion of the Polarization Angle is optional; if included, it will be ignored.

3. Azimuth and elevation angles are always indicated by the ACU1 with two decimal places. For the position designate command tthe least significant digit is optional.

B. Communication Protocol

The M&C Port communication protocol is configured in a master-slave arrangement, that is, the ACU1 will transmit only in response to a command by the Host. A list of the available commands and the corresponding ACU1 responses is, shown in the following table. Any communications from the M&C Port, which does not conform to this table, will be acknowledged by the ACU with an ASCII <u>BEL</u> on a character by character basis. Framing errors, buffer over-run errors, and parity errors will be acknowledged by the ACU with an ASCII <u>BEL</u>.

The communication protocol is based on the command line. In the case of operational mode commands, a command line consists of the command character or character sequence followed by the EXECUTE command. In the case of reporting commands, the command line consists of the command character only. Command lines are executed by the ACU1 after completion of the response sequence.

Prior to completion of a command line, the Host may edit the command line. The Host may transmit an ASCII " <u>/</u> " prior to the completion of a command line to cause the current command line to be ignored. Transmission of an ASCII " <u>/</u> " is acknowledged by the ACU1 with the ASCII character sequence " <u>/</u> <u>CR</u> <u>LF</u> ". The Host may delete the last character in the command line by transmitting a ASCII <u>BS</u>. Characters, which have been acknowledged by the ACU1 with an ASCII <u>BEL</u>, are not considered part of the command line. Transmission of an ASCII <u>BS</u> is acknowledged by the ACU1 with the ASCII character sequence " <u>BS</u> <u>SP</u> <u>BS</u> " unless there are no characters in the current command line; in this case the ACU1 will respond with an ASCII <u>BEL</u>. The ACU1 response to a report command may be aborted at any time by transmission of an ASCII " <u>!</u> "; this transmission will be acknowledged by the ASCII character sequence " <u>!</u> <u>BEL</u> <u>CR</u> <u>LF</u> ".

The communication protocol is based on a full duplex communication channel. The ACU1 will allow the Host to transmit a new command line prior completion of the current acknowledgement sequence. All commands, except for ASCII " <u>!</u> " are executed serially, that is, a command is not executed until the previous acknowledgement sequence has been completed.

ACU1 M&C Port Host Command / ACU1 Response Table

Host Command	ACU1 Response	Description
A	ECHO	Move To SAT A Stored Position (POS A)
B	ECHO	Move To SAT B Stored Position (POS B)
C	ECHO	Move To SAT C Stored Position (POS C)
D	ECHO	Standby Mode (STBY)
E	E CR LF	EXECUTE Command (must follow initial Host command)
F	ECHO	Report Fault and Interlock Status
G	ECHO	Program Track Mode (PTRK)
H	See Binary Status	Report Complete Status in Binary
I	ECHO	Memory Track Mode (MTRK)
J	ECHO	Display Memory Track Table
K	ECHO	Disarm Box Limits
L	ECHO	Arm Box Limits
M	ECHO	Recall ACU1 Real-time Clock (Program Track Only)
N	ECHO	Set ACU1 Real-time Clock (Program Track Only)
P	ECHO	Position Designate Mode (POSD)
R	ECHO	Report Operational Status
S	ECHO	Recall or Change the Current Tracking Signal
T	ECHO	Steptrack Mode (TRK / STTK)
U	ECHO	Update Program Track Table
V	ECHO	Recall Program Track Table
W	ECHO	Recall or Set ACU1 Real-time Clock (Memory Track Only)
X	ECHO	40 SAT Designate Mode (SPXX)
Y	ECHO	Recall or Update the Memory Track Table
Z	ECHO	Recall or Change Memory Track Backup Parameter
/	/ CR LF	Cancel Current Command Line
BS	BS CR BS or BEL	Backspace on current command line
!	! BEL CR LF	Cancel Report

Control Modes

This section provides detailed discussion and examples of the ACU1 control modes available to the Host as listed in the above table.   On all control modes, transmission of the control characters to the ACU1 will be echoed to the terminal. Transmission of the character "E" will cause the selected mode to be executed. If it is desired to change a transmitted control mode before execution (transmission of " E "), a " / " or BS must first be transmitted. Incorrect reception of an " E " following a control mode transmission will cause the ACU to transmit a BEL.

Position Designate Mode

Position Designate requires the character "P" followed by the desired azimuth, elevation, and polarization angles per the following format example. The range of angles in azimuth is from 0.00 degrees to 359.99 degrees. The range of angles in polarization is 0.0 degrees to 359.9 degrees. The range of angles in elevation is from 0.00 degrees to 99.99 degrees. A space before "E" is mandatory. Leading and trailing zeros are optional, however, the digit preceding the decimal point and the decimal point are mandatory. If it is desired to change the transmitted position designate command before execution (transmission of "E"), a " / " or BS must first be transmitted. Incorrect transmission of an "E" following position designate transmission will cause the ACU1 to transmit a BEL. After execution of the position designate command, the "MODE" portion of the display will contain the characters "(POSD)".

Host Command Example for Position Designate Mode

Host Command	Azimuth Angle	Elevation Angle	Polarization Angle	Execute Command
P	SP XXX.XX	SP XX.XX	SP XXX.X	SP E
1 ASCII Character	7 ASCII Characters	6 ASCII Characters	6 ASCII Characters	2 ASCII Characters

Standby Mode

Standby Mode is activated by the transmission of a "D" followed by an "E", and will remove the drive enable, causing the earth station antenna to stop all motion. After execution of the Standby command, the "MODE" portion of the display will contain the characters "(STBY)". Transmission of any other mode command will again enable the earth station antenna.

<u>40 Satellite Designate Mode (OPTIONAL)</u>

The 40 Satellite Designate Mode command requires the transmission of the character "X" followed by a satellite number per the following format example. The range of satellite numbers is from 1 to 40. A space before the "E" is required. If it is desired to change the satellite designate command before execution (transmission of "E"), a " / " or BS must first be transmitted. Leading zeros may be omitted.

Host Command Example For 40 Satellite Position Designate Mode

Host Command Sat. No.	Execute Command
X SP XX	SP E
3 ASCII Characters	2 ASCII Characters

<u>Program Track Mode (OPTIONAL)</u>

Program Track Mode requires a "G" followed by an "E". The Program Track Table may be loaded, updated or examined one point at a time in any mode except the Program Track mode. A "U" followed by the desired point, day, time, azimuth, elevation and polarization data per the following format example allows loading of the program track table. A "V" followed by the desired point per the following format example recalls the point, day, time, azimuth, elevation and polarization data for the selected point. The range of table points is 1 to 170. The range of days is 0 to 7 with 0 being a null entry indicating no action will be taken for this point. The time is a mandatory 5-byte entry with a range of 00:00 to 23:59. The range of angles in azimuth is 0.00 degrees to 359.99 degrees. The range of angles in elevation is 0.00 degrees to 99.99 degrees, the range of angles in polarization is 0.0 degrees to 359.9 degrees. A space before "E" is mandatory. A minimum of seven data points are required with at least one point for each day of the week (1-7) in the Program Track Table. In time data entry, 5-bytes are required with the third byte being a colon. In angular data entry, leading and trailing zeros are optional, however, the digit preceding the decimal point and the decimal point are mandatory. If it is desired to change the transmitted program track data before entry (transmission of "E"), a " / " or BS must first be transmitted. Incorrect transmission of an "E" following a "G", "U" or "V" will cause the ACU1 to transmit a BEL. After execution of the Program Track command "G" (and acceptance of the ACU1), the "MODE" portion of the display will contain the characters "(PTRK)".

Host Command Example for Program Track Mode

Host Command	Execute Command
G	SP E
1 ASCII Character	2 ASCII Characters

Host Command Example for Loading Program Track Table Data

Host Command	Table Point	Day	Time	Azimuth Angle	Elevation Angle	Polarization Angle	Execute Command
U	SP XXX	SP X	SP XX:XX	SP XXX.XX	SP XX.XX	SP XXX.X	SP E
1 ASCII Character	4 ASCII Characters	2 ASCII	6 ASCII Characters	7 ASCII Characters	6 ASCII Characters	6 ASCII Characters	2 ASCII Characters

Host Command Example for Recall of Program Track Table Data

Host Command	Table Point	Execute Command
V	SP XXX	SP E
1 ASCII Character	4 ASCII Characters	2 ASCII Characters

ACU1 Example Response to the " V " Host Command

Table Point	Day	Time	AZ Angle	EL Angle	POL Angle	Suffix
XXX	SP X	SP XX:XX	SP XXX.XX	SP XX.XX	SP XXX.X	CR LF
3 ASCII Characters	2 ASCII Characters	6 ASCII Characters	7 ASCII Characters	6 ASCII Characters	6 ASCII Characters	2 ASCII Characters

The Program Track Clock may be set by the transmission of an ASCII "N". The clock may be recalled by transmission of an ASCII "M". An example of each clock related function is detailed below.

Host Command Example for Setting the Program Track Clock

Host Command	Day	Time	Execute Command
N	SP X	SP XX:XX:XX	SP E
1 ASCII Character	2 ASCII Characters	9 ASCII Characters	2 ASCII Characters

Host Command Example for Recalling the Program Track Clock

Host Command	Execute Command
M	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Example Response to the "N" Host Command

Day	Time	Suffix
X	SP XX:XX:XX	SP CR LF
1 ASCII Character	9 ASCII Characters	2 ASCII Characters

Memory Track Mode (OPTIONAL)

Hours, minutes and seconds are all 2-digit numbers. Azimuth angles range from 0.0 to 359.99. Elevation angles range from 0.0 to 99.99. The digit before the decimal point and the decimal point are required.

To recall the Memory Track time of day the format is as follows:

Host Command Example for Recalling the Memory Track Time of Day

Host Command	Execute Command
W	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Example Response to the "W" Host Command

Prefix	Hours	Minutes	Seconds	Suffix
CR LF SP	XX:	XX:	XX	CR LF
3 ASCII Characters	3 ASCII Characters	3 ASCII Characters	2 ASCII Characters	2 ASCII Characters

To set the Memory Track time of day the format is as follows:

Host Command Example for Setting the Memory Track Time of Day

Host Command	Hours	Minutes	Seconds	Suffix
W	XX:	XX:	XX	SP E
1 ASCII Character	3 ASCII Characters	3 ASCII Characters	2 ASCII Characters	2 ASCII Characters

ACU1 Response to the Set Memory Track Time of Day is: " CR LF "

To recall a Memory Track Table data point the format is as follows:

Host Command Example for Recalling a Memory Table Data Point

Host Command	Hours	Minutes	Execute Command
Y SP	XX:	XX	SP E
1 ASCII Characters	3 ASCII Characters	2 ASCII Characters	2 ASCII Characters

ACU1 Example Response to the "Y" Host Command

Prefix	Hours	Minutes	Azimuth Angle	Elevation Angle	Suffix
CR LF	XX:	XX	SP XXX.XX	SP XX.XX	SP CR LF
2 ASCII Characters	3 ASCII Characters	2 ASCII Characters	7 ASCII Characters	6 ASCII Characters	3 ASCII Characters

To set a Memory Track Table data point the format is as follows:

Host Command Example for Setting a Memory Track Table Data Point

Host Command	Hours	Minutes	Azimuth Angle	Elevation Angle	Execute Command
Y SP	XX:	XX	SP XXX.XX	SP XX.XX	SP E
2 ASCII Characters	3 ASCII Characters	2 ASCII Characters	7 ASCII Characters	6 ASCII Characters	2 ASCII Characters

ACU1 Response to a Set Memory Track Table Data Point is: " CR LF "

To recall the entire Memory Track Table in a single listing the format is as follows:

Host Command Example for Memory Track Table Recall List

Host Command	Execute Command
J	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Response to the "J" Command is "CR LF" then the table listing as follows:

00:00	SP XXX.XX	SP XX.XX	CR LF
00:10	SP XXX.XX	SP XX.XX	CR LF
00:20	SP XXX.XX	SP XX.XX	CR LF
↑	↑	↑	↑
↓	↓	↓	↓
23:50	SP XXX.XX	SP XX.XX	CR LF

To set the Memory Track Backup parameter to active, the format is as follows:

Host Command Example to Set Memory Track Parameter to Active

Host Command	Backup Parameter Value	Execute Command
Z	SP 1	SP E
1 ASCII Character	2 ASCII Characters	2 ASCII Characters

ACU1 Response to the "Z" Set Backup parameter to active is: "CR LF"

To set the Memory Track Backup parameter to NOT active, the format is as follows:

Host Command Example to Set Memory Track Parameter to NOT Active

Host Command	Backup Parameter Value	Execute Command
Z	SP 0	SP E
1 ASCII Character	2 ASCII Characters	2 ASCII Characters

ACU1 Response to the "Z" Set Backup parameter to NOT active is: "CR LF"

To recall the Memory Track Backup parameter current stored value, the format is as follows:

Host Command Example for Memory Track Backup Parameter Recall

Host Command	Execute Command
Z	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Response Example for the "Z" Host Command if Memory Track Backup is Active

Prefix	Backup Parameter Stored Value	Suffix
CR LF	1	CR LF
2 ASCII Characters	1 ASCII Character	2 ASCII Characters

ACU1 Example Response to "Z" Host Command if Memory Track Backup is NOT Active

Prefix	Backup Parameter Stored Value	Suffix
CR LF	0	CR LF
2 ASCII Characters	1 ASCII Character	2 ASCII Characters

Tracking Signal Recall / Change
The Tracking Signal may be recalled or changed by the M&C Port. Changing the Tracking Signal requires the transmission of the character "S" followed by the desired signal number per the following format example. The allowable value range for the Tracking Signal is 0 to 7.

Host Command Example for Changing the Tracking Signal

Host Command	Tracking Signal Value	Execute Command
S	SP X	SP E
1 ASCII Character	2 ASCII Characters	2 ASCII Characters

ACU1 response to the "S" Host Tracking Signal Change Command: "CR LF"

Host Command Example for Recalling the Current Tracking Signal Stored Value

Host Command	Execute Command
S	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Response to the "S" Host Tracking Signal Recall Command

Prefix	Tracking Signal Stored Value	Suffix
CR LF	X	CR LF
2 ASCII Characters	1 ASCII Character	2 ASCII Characters

<u>Box Limit Mode (OPTIONAL)</u>
The box limits command requires an "L" followed by the box size in degrees per the following format example. The parameter must be between 0.00 and 5.00 degrees, inclusive. Otherwise, the protocol is identical to the position designate command. Upon execution of the box limits command (transmission of "E"), the current azimuth and elevation positions are memorized and the box limit function is armed. This data may be determined by the status reporting function (transmissions of "R"). Transmission of a "K" followed by an "E" will disarm the box limit function.

Host Command Example to Set and Arm Box Limits

Host Command	Desired Box Limit Angular Value	Execute Command
L	SP X.XX	SP E
1 ASCII Character	2 ASCII Characters	2 ASCII Characters

ACU1 Response to the "L" Box Limits Set and Arm command: "<u>CR</u> <u>LF</u>"

Host Command Example to Disarm Box Limits

Host Command	Execute Command
K	SP E
1 ASCII Character	2 ASCII Characters

ACU1 Response to the "K" Box Limits Disarm command: "<u>CR</u> <u>LF</u>"

Remote Reporting Functions
This section provides detailed discussion and examples of the ACU1 remote reporting functions available to the Host as listed in the ACU1 M&C Port Host Command / ACU1 Response Table. The Host may request all reporting functions, by transmission of one of three ASCII characters to the ACU1. The monitoring functions with their corresponding ASCII characters are summarized as follows. The ASCII character used to invoke the monitoring function is <u>not</u> echoed.

Monitoring Function	ASCII Character
AZ Angle, EL Angle, POL Angle, Mode, Tracking Signal Strength	R
Fault and Status Information – ASCII Format	F
Mode and Fault/Status – BIT Format	H

<u>Report Function</u>
In response to an "R", the ACU1 provides the following data as shown in the following formatted example.

Example of Data & Format Transmitted by the ACU1 in Response to the "R" Command

Azimuth Angle	Elevation Angle	Polarization Angle	Control Mode	Tracking Signal Strength	Suffix
SP XXX.XX	SP XX.XX	SP XXX.X	SP XXXXXX	SP X X.X	<u>CR</u> <u>LF</u>
7 ASCII Characters	6 ASCII Characters	6 ASCII Characters	7 ASCII Characters	5 ASCII Characters	2 ASCII Characters

<u>Fault / Status Reporting</u>
In response to an "F", the ACU1 will transmit a series of messages describing the current ACU status as shown in the following formatted example. Each status message is a 9 ASCII character string separated by carriage return, line feed, and space. At the end of the last message, an ETX is transmitted. If no faults are present, only CR, LF, ETX is transmitted.

Example of Data & Format Transmitted by the ACU1 in Response to the "F" Command

First Message	Second Message	Last Message
SP XXXXXXXX	<u>CR</u> <u>LF</u> SP XXXXXXXX	<u>CR</u> <u>LF</u> SP XXXXXXXX <u>CR</u> <u>LF</u> ETX
9 ASCII Characters	9 ASCII Characters	9 ASCII Characters

<u>Binary Status Function</u>
System status of the ACU1 may be obtained in binary format by transmission of the ASCII character "H" to the ACU1. The binary status function includes the current mode status and the fault/status report. The binary status transmission consists of 5 consecutive bytes. The first byte (byte 0) contains mode information. Bytes 1 through 3 contain fault/status information. Byte 4 contains a check sum such that the addition without carry of all five bytes of the transmission

equals FF in hexadecimal. On ACU1 units equipped with the Program Track option Byte 4 contains, the binary valve 1-171 for the Program Track Table error point value, also the check sum is contained in Byte 5.

The first byte (byte 0) is encoded into a hexadecimal value per the following list and contains the mode information. A one indicates that the condition is true.

MODE	HEX CODE
SAT A	00
SAT B	01
SAT C	02
Steptrack	04
Manual Jog	05
Program Track	06
Memory Track	07
Standby	0C
Position Designate	0F
Satellite 1 (40 SAT)	80
Satellite 2 (40 SAT)	81
Satellite 3 (40 SAT)	82
Satellite 4 (40 SAT)	83
Satellite 5 (40 SAT)	84
Satellite 6 (40 SAT)	85
Satellite 7 (40 SAT)	86
Satellite 8 (40 SAT)	87
Satellite 9 (40 SAT)	88
Satellite 10 (40 SAT)	89
Satellite 11 (40 SAT)	8A
Satellite 12 (40 SAT)	8B
Satellite 13 (40 SAT)	8C
Satellite 14 (40 SAT)	8D
Satellite 15 (40 SAT)	8E
Satellite 16 (40 SAT)	8F
Satellite 17 (40 SAT)	90
Satellite 18 (40 SAT)	91
Satellite 19 (40 SAT)	92
Satellite 20 (40 SAT)	93
Satellite 21 (40 SAT)	94
Satellite 22 (40 SAT)	95
Satellite 23 (40 SAT)	96
Satellite 24 (40 SAT)	97
Satellite 25 (40 SAT)	98
Satellite 26 (40 SAT)	99
Satellite 27 (40 SAT)	9A
Satellite 28 (40 SAT)	9B
Satellite 29 (40 SAT)	9C
Satellite 30 (40 SAT)	9D
Satellite 31 (40 SAT)	9E
Satellite 32 (40 SAT)	9F
Satellite 33 (40 SAT)	A0
Satellite 34 (40 SAT)	A1
Satellite 35 (40 SAT)	A2
Satellite 36 (40 SAT)	A3
Satellite 37 (40 SAT)	A4
Satellite 38 (40 SAT)	A5
Satellite 39 (40 SAT)	A6
Satellite 40 (40 SAT)	A7

The following chart provides decoding for bytes 1 - 3 containing the system fault and status messages. Again, a one indicates that the condition is true.

Status Message Coding Chart

WORD	BIT 7	BIT 6	BIIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
1	Message 7	Message 6	Message 5	Message 4	Message 3	Message 2	Message 1	Message 0
2	Message 15	Message 14	Message 13	Message 12	Message 11	Message 10	Message 9	Message 8
3	Message 23	Message 22	Message 21	Message 20	Message 19	Message 18	Message 17	Message 16

Data Word Format
Each word is 11 bits long and is organized as below.

BIT 1	START BIT
BIT 2	DATA BIT 0
BIT 3	DATA BIT 1
BIT 4	DATA BIT 2
BIT 5	DATA BIT 3
BIT 6	DATA BIT 4
BIT 7	DATA BIT 5
BIT 8	DATA BIT 6
BIT 9	DATA BIT 7
BIT 10	PARITY (ODD)
BIT 11	STOP BIT

This format is identical for transmission both to and from the ACU1. All numbers and characters are in ASCII code except for the Binary Status Report, which is 8-BIT binary.

The summation of bits 2 through 10 will yield odd parity.

Data Link Organization

The data link is organized in a master-slave arrangement; that is, the ACU1 will not transmit unless requested by the Host. The data link is a full duplex channel; that is, either side may transmit or receive simultaneously. Baud rate is 9600.

All circuit functions and signal levels are per RS-232-C. A "1" is –10V while a "0" is +10V. The ACU1 M&C Port is located at the rear panel and is identified as J8. The J8 connector is a 25 Pin D-Sub Socket (female) type. Pin-out of this connector is as follows:

Circuit	J8 Pin Number
Protective Ground	1
Transmitted Data	2
Received Data	3
Clear To Send	5
Data Set Ready	6
Signal Ground	7
Signal Detect	8
Data Terminal Ready	20

All other pins not shown above have no connection in the ACU1. A description of each of the circuits is given below.

PROTECTIVE GROUND   This line is connected directly to chassis ground.

TRANSMITTEO DATA   This line contains data sent from the computer to the ACU1.

RECEIVED DATA   This line contains data sent from the ACU1 to the computer.

CLEAR TO SEND   This line is held constantly high by the ACU1 to enable transmission from the computer.

DATA SET READY   This line is held constantly high by the ACU1 to enable transmission from the computer.

SIGNAL GROUND   This line establishes ground reference potential for all circuits except PROTECTIVE GROUNO.

SIGNAL DETECT   This line is held constantly high by the ACU1 to enable transmission from the computer.

DATA TERMINAL READY   This line allows control of transmission from the ACU1 by the computer. A high level from the computer will allow ACU1 transmission. A low level will inhibit transmission.