

Controller.....Chapter 1....Introduction
RC2000B Az/El Tracking Antenna Controller.....Chapter
1....Introduction
Chapter 1 INTRODUCTION.c.Chapter 1 INTRODUCTION;

The RC2000B AZ/EL tracking antenna controller is designed to control an elevation over azimuth antenna with 36 volt actuators and pulse type position sense feedback. Another member of the RC2000 family, the RC2000B Polar, is available to provide tracking for a modified polar mount antenna. Henceforth, in this manual the term RC2000B is used to refer to the RC2000B AZ/EL controller.

The RC2000B was designed with the requirements of the commercial user of satellite downlink services in mind. Here is a brief listing of the capabilities of the RC2000B.

1. The controller utilizes a solid state drive system capable of providing 8 amps to the antenna actuators. The drive system has built-in over-current sensing with mechanical relay backup to disconnect the drive from the actuators in the event of a fault.
2. The controller can control polarization via a polarotor type interface. In addition, an AUTO_POL feature allows the polarization to be controlled via a digital input or contact closure supplied by a receiver to the RC2000B.
3. Position sensing feedback can be supplied by any pulse based sensor - reed switch, Hall effect, or electro-optical. There is no need for special sensors or actuators. The RC2000B keeps track of both rising and falling pulse edges from the pulse sensor for increased accuracy.
4. The non-volatile memory can hold position and polarization data for 50 geostationary and 5 inclined orbit satellites.
5. The Adapti-Drive variable speed control system allows the user to specify the desired slow speed for each axis. The Adapti-Drive system will then adjust the actuator voltage (via a pulse width modulation scheme) to maintain the speed selected by the user. This alleviates the problem of poor speed regulation with varying direction along a given axis associated with constant voltage slow speed systems.
6. The tracking scheme used in the RC2000B employs a step track algorithm to build up a track table which logs the satellite position versus time (a real time clock powered by a lithium battery is present in the RC2000B). If the current time corresponds to a time interval for which there are valid entries in the track table, the controller switches over to a program track algorithm. In this mode the antenna smoothly tracks the satellite based on position data stored in the track table.

If the satellite transponder goes down while the controller is step tracking, the controller enters a search mode. The RC2000B has a unique algorithm, denoted Intelli-Search, which determines the boundaries of a parallelogram shaped region where the controller has determined that the satellite will be found. This algorithm ensures that the region searched is large enough to include the motion of the desired satellite and is centered and oriented

properly so that satellites adjacent to the desired satellite are not 'found' during the search.

7. The data which has to be specified by the user to configure the tracking system is straightforward. The user must specify the time and date, the latitude and longitude of the antenna, the longitude of each satellite (both geostationary and inclined orbit) programmed into the RC2000B, the maximum antenna tracking error (in dB), and the antenna size.

1.1 Organization of this Manual.c.:1.1 Organization of this Manual;

This manual is divided into two broad parts, Installation and Reference. The Installation part of this manual is designed to familiarize the user with the controller and guide him or her through the installation and configuration of the controller. The Reference portion of the manual gives a detailed description of all of the features and capabilities of the controller.

The Installation portion of the manual is comprised of Chapters 2 through 4. Chapter 2 explains the user interface and the basic operation of the unit. Chapter 3 guides the user through the physical installation and wiring of the unit as well as the initial software configuration. Chapter 4 covers all aspects of tracking inclined orbit satellites. It begins with a brief discussion of some of the theoretical aspects of the inclined orbit, and continues with a description of the algorithms used by the RC2000B for tracking inclined orbit satellites. Chapter 4 concludes with a step by step procedure which guides the user through the entry of track parameters and the initialization of a track on an inclined orbit satellite.

The Reference portion of this manual is comprised of chapters 5, 6, and 7 as well as the appendices which follow. These chapters of the manual describe the fields on the screens which the user will encounter, as well as the data which can be entered at any prompt. After the initial installation, when the user has become familiar with the operation of the controller, these chapters will probably be the only ones consulted by the user to handle the routine chores of adding new satellites and deleting old ones.

1.2 Before You Begin.c.:1.2 Before You Begin;

Please read and understand the manual. Time invested in understanding the installation and operation of the controller will insure satisfactory results. The unit has been tested thoroughly and will work accurately and reliably if it is installed and configured properly. There is an old saying in the controller business - "Garbage in, garbage out". Be very careful when entering data into the controller. For example, if the longitude data for a geostationary satellite is entered incorrectly, the controller will accurately position itself on that satellite. If however, at a later time, a track is initiated on an inclined orbit satellite in the vicinity of that geostationary satellite, the incorrect longitude may be used to calculate incorrect step track angles and unsatisfactory results will occur.

RC2000B Az/El Tracking Antenna Controller.....Chapter
2....Basic Function
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2....Basic Function

This chapter describes the controller's front panel layout, user interface and basic operation. When the user has completed this chapter, he or she should have a basic understanding of the various operating modes of the unit and be able to use the keyboard and liquid crystal display (LCD) to navigate through those modes.

2.1 Front Panel.c.:2.1 Front Panel;

The front panel (figure 2.1) of the RC2000B contains an ON/OFF switch, a 2 row by 40 column backlit LCD, and a 4 by 4 matrix keypad with tactile feedback. On the rack mount version of the controller, an AC line circuit breaker is built into the ON/OFF switch. For the desktop version of the controller, the AC line circuit breaker is the 4 amp breaker located on the back panel. For both versions, a 12 amp circuit breaker (located on the back of the unit) protects the controller's 36 volt actuator drive circuits. When a circuit breaker of this type trips, it will protrude from its mounting bezel. To reset a circuit breaker, turn the power switch off, wait a few minutes for the circuit breaker to cool down, then depress the breaker so that it latches and is even with the bezel.

Figure 2.1

The field in the upper right hand corner of the LCD is reserved for the display of the current mode of the controller. The various modes are introduced in the following section. If an error condition is active, an error message will periodically flash across the bottom row of the display. Error messages are

discussed in chapter 7. Chapter 5 explains the contents of every field on the display for all of the various controller modes.

An examination of the keyboard in figure 2.2 reveals that many of the keys have 2 or more labels. The function of each key is determined by the current operational mode of the controller. The various modes are discussed in the following section.

Figure 2.2

MODE

This key is used to select the current mode of the controller. See the description of the various modes in the next section. This key is always active. Depressing this key will always cause a mode change to occur. This key is acted on when it is released. If the key is briefly depressed and released the controller mode will change to the next sequential mode of the mode group which is currently active. If the key is depressed for at least five seconds and then released, the current mode will change to the first mode of the mode group which is not currently active.

SCROLL UP/SCROLL DOWN

These keys are used to scroll up or down through a list of items. These keys are used when selecting a satellite from a list of satellites, selecting a data item to either view or modify, and when selecting alphanumeric characters for a user specified satellite name in SETUP mode.

YES/NO

These keys are used to supply an answer to a yes or no question.

ENTER

This key is used to select an entry from a list, terminate a prompt for some action by the user, or to complete the entry of numeric data.

0-9/DECIMAL POINT (with the stop key)/BKSP

These keys are used for numeric entry. The BKSP key causes the cursor to move one column to the left writing over the character which was there. In some modes, the BKSP key is used to prompt the user to confirm that a critical parameter is about to be changed.

SPEED

This key toggles the speed from fast to slow and vice versa.

ARROW KEYS - 2/4/6/8

These keys are used to manually jog the antenna in some modes. The left and right arrow keys jog the antenna east and west in azimuth, respectively, while the up and down arrow keys jog the antenna up or down in elevation.

E/W/N/S

These direction keys, E east, W west, N north, and S south are used to specify a direction when the user is entering latitude or longitude data.

CCW/CW/H/V

These keys control the Polarization. The CCW and CW keys skew the polarotor counterclockwise and clockwise. The H and V keys are used to either select or specify the polarization position associated with a given satellite.

Note that all of these keys are not active simultaneously. The function of each key is dependent on the current mode of the controller. In some modes certain keys are ignored.

2.2 Operating Modes.c.:2.2 Operating Modes;

The mode system on the RC2000B antenna controller resembles the menu system used with many personal computer (PC) programs. On a PC program a menu system allows the user to perform operations or to enter in data. The user must navigate through the menu structure to the particular menu which allows access to the function or data that the user wishes to manipulate.

On the RC2000B the mode which is currently active is always displayed in the upper right hand corner of the LCD. The MODE key is used to switch between modes. User access to all operations performed by the controller and all data maintained by the controller is governed by the mode system. Here is a summary of the modes implemented on the RC2000B.

MANUAL

```
AZ:175.6 EL: 43.8 PL: 15 H SS:635 MANUAL
SBS 2          97.0 W    SPEED:FAST
```

This mode allows the user to jog the antenna in elevation and azimuth using the ARROW KEYS, toggle the speed from fast to slow (and vice versa) with the SPEED key, jog the polarization with the CCW/CW keys, and use the H/V keys to toggle between the preset H and V polarizations of the satellite located closest to the antenna's present position. When MANUAL mode is active the following information is displayed on the top row of the LCD - azimuth position (AZ), elevation position (EL), polarization position (PL), and the current signal strength (SS). The signal strength is derived from a receiver automatic gain control (AGC) output (which will be described in the chapter on tracking). The bottom row of the LCD displays the name and longitude of the satellite on which the antenna is currently aligned and either the FAST or SLOW banner to indicate the speed which will be used for jogging the antenna.

AUTO

```
SELECT A SATELLITE: PANAMSAT-1    AUTO
USE SCROLL UP/DOWN, ENTER TO SELECT
```

This mode allows the user to select a satellite which has previously been stored in memory and automatically position the antenna on that satellite. In this

mode the SCROLL UP/DOWN keys are used to scroll through the list of satellites which have been programmed in by the user (via SETUP mode). When the name of the desired satellite appears the ENTER key is hit to initiate the automatic move. While movement is in progress the STOP key can be hit to terminate the move. For a geostationary satellite, at the conclusion of the automatic move the mode is switched to MANUAL. For an inclined orbit satellite, the automatic move will position the antenna at the satellite's nominal position and the mode is switched to TRACK. The nominal position is where the controller estimates that the satellite would be located if it were a geostationary satellite.

SETUP

POSITION ANTENNA, SELECT SETUP
SATELLITE USING SCROLL UP/DOWN,HIT ENTER

This mode allows the user to store satellite azimuth and elevation positions and horizontal/vertical polarization values into the controller's non-volatile memory. Once stored in memory, the satellite is available for recall by AUTO mode. When SETUP mode is invoked the user peaks the antenna up on the desired satellite using the azimuth jog, elevation jog, polarization jog, H/V, and SPEED keys as described for MANUAL mode above. The SCROLL UP/DOWN and ENTER keys are also active at this time. The SCROLL keys are used to scroll through a list of satellite names stored in the controller's EPROM memory. This is the name which will be assigned to the azimuth and elevation positions and the polarization values stored in the non-volatile memory. The ENTER key is used to select a value from the list of satellite names.

When the ENTER key is hit the user is prompted to specify the satellite longitude, whether or not the satellite is in an inclined orbit (and if so, the current inclination of the satellite's orbit to the earth's equatorial plane - more on this in the chapter on tracking), and the H and V polarization values for the satellite. If the user wishes to assign a name which is not stored in the satellite's EPROM memory, the USER entry in the satellite name list may be selected and the operator will be prompted to enter in an alphanumeric string using the SCROLL UP/DOWN and ENTER keys. When the user has entered in all of the requested data, control will switch to the TRACK mode if the satellite just entered was an inclined orbit satellite. Otherwise, SETUP mode will retain control and the user can jog the antenna to another satellite and repeat the procedure.

RESET

AZ: OK 0 EL: OK 0 RESET
1 - RESET AZ, 2 - RESET EL, MODE - EXIT

This mode allows the user to examine the error status of the motor drive circuits and reset them if a fault has occurred. The drive systems of each axis are independent. There are 3 types of faults which can occur. A DRIVE error indicates that the drive circuits detected an over current fault and shut down. A JAMMED error indicates that the antenna actuators were commanded to move but no movement was detected. A RUNAWAY error indicates that antenna movement was detected when the actuators were not energized. Errors are covered in chapter 7.

DELETE

SELECT A SATELLITE: PANAMSAT-1 DELETE
USE SCROLL UP/DOWN, ENTER TO SELECT

This mode allows the user to delete satellites from non-volatile memory. The SCROLL UP/DOWN and ENTER keys are active.

RE-SYNC

```
SELECT A SATELLITE: PANAMSAT-1 RE-SYNC
USE SCROLL UP/DOWN, ENTER TO SELECT
```

The antenna azimuth and/or elevation position can be corrupted by any number of causes (sensor failure, lightning strike, faulty shield connection, etc). If there is an error in the position counts, the controller cannot properly position itself on the satellites stored in non-volatile memory, and the limits are not valid. In this situation, it is necessary to re-synchronize the controller's internal position counts. To do this, the operator positions the antenna on a known satellite which has previously been stored in the controller's non-volatile memory. The user then activates RE-SYNC mode and selects the satellite with which the antenna is currently aligned using the SCROLL UP/DOWN and ENTER keys. When the ENTER key is hit, the controller's internal position counts are initialized to the positions which were assigned to the satellite name when that satellite was stored in non-volatile memory. This restores the count to the value stored prior to the event which caused the data corruption, and applies to all satellites stored in non-volatile memory.

CONFIG

```
AUTOPOL ENABLE:* CONFIG
0-DISABLE, 1-ENABLE ENT,BKSP,SCROLL ^v
```

This mode allows the user to view and enter configuration data into the controller. This data is stored in non-volatile memory and is used to set certain parameters and enable or disable certain controller options. The following parameters and options are controlled or configured via data entered into the controller from CONFIG mode: AUTOPOL (described below), simultaneous azimuth/elevation movement, the time and date, inclined orbit satellite tracking setup and control parameters, azimuth and elevation slow speed control parameters, and a controller reset function.

In CONFIG mode, the SCROLL UP/DOWN and ENTER keys as well as the numeric keypad are active. The SCROLL UP/DOWN keys are used to select the parameter to be viewed or modified. If asterisks are displayed in the parameter field it means that the present value for the parameter is invalid. The parameter can be modified using the numeric keypad to key in a new value. For the modification to take affect the numeric entry must be terminated with the ENTER key. A message in the lower left hand corner of the display gives the user data entry instructions.

LIMITS

```
AZ: 5000 EL: 5000 SS1,2: 2, 1 LIMITS
7 - SET EAST LIMIT 9 - SET DOWN LIMIT
```

This mode allows the user to jog the antenna to any azimuth or elevation position without regard to any existing limits, and initialize the east and west and/or down and up limits. Once the limits are set the antenna cannot be moved (except in LIMITS mode) to a position that is not within the region defined by the down, up, east and west limits.

To set the azimuth limits, the user would first move the antenna to the desired east limit, set the limit, then move the antenna to the desired west limit and set that limit. When the limits for a particular axis are initialized the position count for that axis is also reset. Whenever the azimuth (or elevation) limits are reset the east (or down) limit is assigned a position count of 30.

TRACK

AZ: 1344 EL: -46 PL: 73 V SS:621 TRAK K
GSTAR 3 PROGRAM IDLE 15.56.0-MENU

TRACK mode is activated to track an inclined orbit satellite. TRACK mode is slightly different than the other modes described above in that TRACK mode cannot be reached directly through the use of the MODE key. TRACK mode can be entered only via the SETUP or AUTO modes. TRACK mode is described in Chapter 4.

More detailed information is available concerning each the modes described above in Chapter 5 of this manual.

2.3 Changing Modes with the MODE Key.c.:2.3 Changing Modes with the MODE Key;

The user can switch the current controller mode by use of the MODE key. The MODE key is always active - when the MODE key is depressed, the controller's current mode will change. The various modes are divided into two groups. The Operational mode group consists of the MANUAL and AUTO modes. The Programming mode group consists of the SETUP, RESET, DELETE, RE-SYNC, CONFIG and LIMITS modes. The Programming modes are typically only used during system installation and configuration. The Operational modes are the ones used in everyday operation of the controller.

The modes are divided into two groups, referred to as mode groups, as part of a scheme to keep the user out of the Programming modes in the course of the normal everyday operation of the controller after the unit has been installed. This scheme is based on the use of the MODE key.

If the MODE key is depressed for 5 seconds and released, the current controller mode will switch to the first mode of the mode group which was NOT active when the MODE key was depressed.

If the MODE key is rapidly depressed and released, the controller mode will switch to the next mode in the mode group that was active when the MODE key was depressed.

For example, if AUTO mode is active (the active mode is always displayed in the upper right hand corner of the LCD) and the user depresses the MODE key for at least 5 seconds and releases it, SETUP mode will become the active mode. As another example, if AUTO mode is active and the user rapidly depresses and releases the MODE key, MANUAL mode will become the active mode.

TRACK mode is a special case. As mentioned above TRACK mode can only be entered via the AUTO or SETUP modes, it cannot be entered directly by depressing the MODE key. Otherwise, the TRACK mode is treated as if it were part of the Operational mode group. If TRACK mode is active and the user rapidly depresses and releases the MODE key, MANUAL mode will become the active mode. If TRACK mode is active and the user depresses the MODE key for at least 5 seconds, SETUP mode will become the active mode.

2.4 Autopol.c.:2.4 Autopol;

The Autopol feature slaves the RC2000B polarization control to an output derived from a satellite receiver. The RC2000B has an Autopol input accessible via one of the connectors on the back of the unit. When the controller is operating in MANUAL or TRACK modes, this input is monitored and the polarotor is controlled according to a digital level present at this input.

To configure the controller for Autopol operation, the user must have a suitable output available on the satellite receiver which is connected properly to the Autopol input of the RC2000B, the polarity of the Autopol input must be specified (from CONFIG mode), and the Autopol feature must be enabled (also from CONFIG mode). When the polarity of the Autopol input is specified, the user is informing the controller that a given Autopol input level (high or low) corresponds to vertical polarization. Configuring the Autopol system during installation is covered in more detail in Chapter 3 and the CONFIG mode prompts which enable and specify the polarity of the Autopol input are described in Chapter 5 in the CONFIG mode section.

RC2000B Az/El Tracking Antenna Controller.....Chapter
3....Installation/Setup
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3....Installation/Setup

This chapter guides the user through the installation and the initial software setup. The procedures outlined in this chapter cover the mechanical and electrical installation of the unit, setting the azimuth and elevation limits, determining the azimuth and elevation slow speed parameters, and programming the geostationary satellites.

3.1 Before You Begin.c.:3.1 Before You Begin;

Before installing the unit the installer must ensure that the line voltage is correct, the controller's memory has been cleared, and that he or she is familiar enough with the mode system described in Chapter 2 to place the controller in any desired mode. All units are shipped from the factory with memory cleared, a line cord appropriate for the line voltage selected, and a sticker placed over the AC power entry module labeled either 115 or 230 volts.

If the line cord received with the unit is not appropriate for the power available at the installation site, or if the sticker over the AC power entry module is missing the installer should check the controller to ensure that the proper line voltage has been selected.

To check the line voltage setting of the RC2000B:

1. Make sure that the unit is disconnected from the AC power source.
2. Remove the top cover of the unit.
3. Check the line voltage switch mounted on the circuit board attached to the AC power entry module. The slide switch can be positioned either at 115 or 230 volts.
4. Replace the top cover of the unit.

When the AC line voltage has been verified, and before any of the antenna wiring has been connected, the installer should become familiar with the controller's user interface. It is not necessary to understand every aspect of the controller's operation to install the unit, but the installer should be familiar with the mode structure of the RC2000B and be able to use the MODE key to place the controller in any of the modes described in Chapter 2.

When the unit is powered up, it should be verified that the controller goes to LIMITS mode ('LIMITS' displayed in the upper right hand corner of the LCD). Before the controller is shipped from the factory, the memory is cleared and the azimuth and elevation limits are invalidated. Whenever the unit is powered up and the limits are invalid, the controller automatically places itself in LIMITS mode. If the unit does not power up in LIMITS mode the installer should perform a system reset to place the controller into a known state before proceeding with the installation.

To perform a system reset:

1. Use the MODE key to place the controller into CONFIG mode ('CONFIG' displayed in the upper right hand corner of the LCD).
2. Use the SCROLL DOWN and SCROLL UP keys to bring up the 'RESET SYSTEM DATA:' screen.

3. At the 'RESET SYSTEM DATA:' screen enter '41758' followed by the ENTER key.

Figure 3.1 RC2000B Interface Diagram

Figure 3.2 Reed Sensor Diagram

Figure 3.3 Hall Effect Diagram

3.2 Mechanical and Electrical Installation.c.:3.2 Mechanical and Electrical Installation;

This section covers the mechanical and electrical installation of the unit. For rack mount models, use 4 #10-32 mounting screws to secure the unit to a standard 19" rack. Please refer to figures 3.1, 3.2, and 3.3 for diagrams of the controller back panel and electrical connections.

The following electrical connections must be made:

Azimuth and Elevation Motor Drive - 4 wires (2 for each axis)

These cables connect the controller to the antenna actuators. Since these conductors carry up to 40 volts DC, the motor drive cables should be protected in conduit for the entire run to the antenna to minimize the electrical shock hazard.

The conductors must be sized appropriately for the current required by the actuators. See the following table which gives the appropriate wire size as a function of the distance between the controller and the antenna and the current required by each actuator.

Maximum Cable Run (in feet) for 15% Voltage Drop

Motor Current	Wire Gauge			
	16	14	12	10
2 amps	350	550	885	1400
4 amps	160	260	410	650
6 amps	100	160	225	405
8 amps	70	110	175	280

Notes:

- for 20% voltage drop multiply each distance by 1.33
- for 25% voltage drop multiply each distance by 1.67
- 1 foot equals 0.3 meters

Polarotor™ - 3 wires in a shielded cable.

Connect the polarotor as shown in figures 3.2 or 3.3. Shielded cable is required to minimize noise pickup.

NOTE: A SHIELDED CABLE IS REQUIRED FOR THE POLAROTORTM. THE SHIELD MUST BE CONNECTED TO J1-9 ON THE BACK OF THE CONTROLLER AND MUST NOT BE CONNECTED AT THE ANTENNA.

Azimuth and Elevation Position Sense

If reed switch sensors are used, each axis requires 2 wires in a shielded cable. If Hall effect sensors are used, each axis requires 3 wires in a shielded cable. Shielded cables are required to minimize noise pickup which can result in antenna positioning errors. Please refer to figure 3.2 for reed sensor connections and figure 3.3 for Hall Effect sensor connections.

NOTE: SHIELDED CABLES ARE REQUIRED FOR THE POSITION SENSORS. THE SHIELDS BE MUST CONNECTED TO PINS J1-4 OR J1-6 ON THE BACK OF THE CONTROLLER AND MUST NOT BE CONNECTED AT THE ANTENNA.

Position count errors due to improper use of the shield on the position sense lines is one of the most frequent problems encountered during the installation of the RC2000B. Here are the problems that are encountered.

1. A shielded cable was not used for the position sense wires.
2. The shield is not connected at the connector on the rear panel of the RC2000B.
3. The shield is connected to earth ground at the antenna. This results in ground currents flowing in the shield. The shield must not be connected to anything at the antenna.
4. The insulator on the sensor cable is broken and the shield is grounded to something. As in #3, this results in ground currents.
5. The sensor cable is spliced but the shield has not been spliced or the shield is spliced but is also shorted to earth ground.

3.3 Setting Azimuth and Elevation Limits.c.:3.3 Setting Azimuth and Elevation Limits;

Once the electrical connections are made, the next steps in the installation procedure are to ensure that the polarity of the motor drive wiring is correct, the position sensors and polarotor function properly, and then to set the azimuth and elevation limits. All of the operations outlined in this section can be carried out with the controller in LIMITS mode.

In LIMITS mode the user has unrestricted movement of the antenna, there are no software azimuth or elevation limits, and antenna jammed sensing does not take place. When moving the antenna in LIMITS mode an assistant should be stationed at the antenna to ensure that the antenna does not move past a physical limit. Note also that the CW and CCW polarization adjustment keys are active, even though the polarization position is not displayed.

3.3.1 Motor Drive Polarity.c.:3.3.1 Motor Drive Polarity;

The polarity of the azimuth motor drive is checked by depressing the LEFT (RIGHT) ARROW key and verifying that the antenna moves east (west). If the antenna does not move in the proper direction, connector J2 pins 4 and 6 need to be reversed. The polarity of the elevation motor drive is checked in a similar fashion. The UP ARROW key corresponds to up elevation movement.

The azimuth and elevation position sensor operation can be checked by jogging the antenna about the appropriate axis and verifying that the position count changes for that axis. Note that the position count will always decrease for east and down movement, and will always increase for west and up movement. Also the count will not decrement lower than 1 or increment higher than 65535.

Polarotor operation is checked by using the CW and CCW keys to skew the polarization.

3.3.2 Setting Limits.c.:3.3.2 Setting Limits;

The east and/or down limits are set first. The bottom row of the display prompts the user to set the limits for each axis. To set a limit, position the antenna at the desired limit, and hit either the 7 key to set an azimuth limit or the 9 key to set an elevation limit. When the east azimuth limit or down elevation limit is set, the position count for the axis is reset to 30. The limits should be specified so that there is adequate clearance between the antenna and any obstacles when the antenna is positioned at any azimuth/elevation combination within the limits.

3.4 Slow Speed Adjustment.c.:3.4 Slow Speed Adjustment;

The Adapti-Drive slow speed control system allows the user to specify a desired slow speed. When the antenna is moving at slow speed the controller will vary the voltage to the drive to maintain the actual antenna slow speed at the value specified by the user. Other slow speed drive systems in use reduce the voltage to the drive to a constant value whenever slow speed movements occur. This results in poor speed regulation as the load on the motor varies or as friction in the drive system changes with temperature.

For the RC2000B the user sets the slow speed for each axis independently by entering a slow speed code via the appropriate CONFIG mode prompt. This section outlines the procedure for selecting the appropriate slow speed code. When the system memory is reset the azimuth and elevation slow speed codes are initialized to 254. This code value effectively disables the slow speed system by making slow speed equal to the maximum possible speed.

When slow speed movement occurs, the RC2000B determines the speed at which the actuator is moving by measuring the rate at which position feedback pulses are received for the axis which is being moved. The controller adjusts the voltage to the drive by using a Pulse Width Modulation (PWM) scheme, which essentially turns the 36 volt drive voltage off and on very rapidly. Whenever the antenna is manually jogged at slow speed (in MANUAL or SETUP mode) an indication of the voltage delivered to the drive is displayed to the right of the 'SLOW' banner. This quantity, referred to as a 'voltage code', varies from 1 to 24. The drive voltage associated with a voltage code of 1 is the minimum voltage which can be delivered to the actuators. A voltage code of 24 is associated with the maximum voltage which can be delivered to the drive.

To determine the slow speed code which is appropriate for the azimuth axis, use the following procedure.

1. In MANUAL mode jog the antenna in azimuth at FAST speed for exactly 10 seconds and record the number of counts which occur. Make sure that the antenna does not reach a limit during the move.

2. Use the following table to determine an initial setting for the speed code.

counts	speed	counts	speed
	code		code
60	80	300	165
70	90	350	170
80	100	415	175
95	110	525	180
120	120	715	185
145	130	1100	190
170	140	1325	195
200	150	1450	200
250	160		

3. Go to CONFIG mode and use the SCROLL DOWN and SCROLL UP keys to bring up the 'AZIM SLOW SPEED' item. Key in the new speed code followed by the ENTER key.

4. Go to MANUAL mode, toggle the speed to SLOW, and jog the antenna in azimuth. Continue jogging the antenna until the voltage code displayed to the right of the SLOW banner settles to a steady state range of values. This may take 5 to 10 seconds. If a limit is reached, jog the antenna in the opposite direction. After the voltage code settles to a steady state range of values, check the rate of movement to make sure that it is slow enough to be useful but not so slow that the motor stalls or moves in a jerky fashion. If the movement is not satisfactory increase or decrease the speed code by 3 to 5 counts. Increasing the speed code results in a faster rate of slow speed movement. Repeat steps 3 and 4 until satisfactory slow speed movement is attained.

A similar procedure is used to adjust the elevation slow speed. The elevation slow speed code is entered at the CONFIG mode 'ELEV SLOW SPEED' prompt and the user jogs the antenna about the elevation axis to check the rate of slow speed movement.

3.5 Programming Geostationary Satellites.c.:3.5 Programming Geostationary Satellites;

After the limits have been set and the slow speed codes determined, the geostationary satellites can be programmed into the controller's memory. The user should review this section along with the following section (3.6) before programming in any satellites. Section 3.6 discusses the display of azimuth and elevation position data in an angle format and explains the use of the IBM PC programs found on the disk in the back of this manual.

All satellites are programmed into memory via SETUP mode. In SETUP mode the user can jog the antenna in azimuth and elevation to peak up on a satellite, specify the satellite name and jog the polarization to assign H and V polarization values. This information is retained in the controller's non-volatile memory. The user can automatically position the antenna on a satellite which has previously been programmed into memory by invoking the AUTO mode and using the SCROLL UP and SCROLL DOWN keys followed by the ENTER key to select the satellite.

SETUP mode is straightforward. If the user wishes to assign a satellite name which is not in the list, the USER entry in the satellite name list may be selected. The user is then prompted to enter an alphanumeric string using the SCROLL UP, SCROLL DOWN, and ENTER keys.

After the satellite name has been selected, the user is prompted to enter in the satellite's longitude position. If the satellite name came from the controller's internal list, the user is presented with a longitude value from that same list. The user should consult a CURRENT satellite guide to ensure that the controller's longitudinal position for a given satellite is correct. It is possible for the position of an orbiting satellite to be changed. If the longitudinal position of a geostationary satellite is incorrectly specified, the inclined orbit tracking algorithms may not function properly. BE SURE TO VERIFY THE LONGITUDINAL POSITION OF ALL GEOSTATIONARY SATELLITES PROGRAMMED INTO THE CONTROLLER VIA SETUP MODE.

The range of longitude values accepted by the controller ranges from 0 to 179 West and 0 to 180 East. Satellites located over North America have West longitude values. Satellites located over Asia have East longitude values. Some Intelsat literature gives satellite longitude values in a range of 0 to 359. In this scheme, values from 0 to 180 correspond to East longitudes, and values from 180 to 359 correspond to West longitudes. To convert from the Intelsat scheme to the scheme used by the controller, a simple example is presented. If the satellite longitude is specified as 325 degrees in the Intelsat scheme, to convert to the value needed for entry into the controller, calculate $360 - 325 (= 35)$. The value entered into the controller would then be 35.0 West.

The user also has an option in specifying the H/V polarization data. After at least one satellite has been programmed into non-volatile memory, the user can specify that the horizontal and vertical position data for a satellite which is about to be entered into non-volatile memory can be copied from the satellite in non-volatile memory closest to the antenna's present position. With an elevation over azimuth type mount, however, it is recommended that the user always manually peak up the H and V polarization values for each satellite.

It is recommended that the user first program in a pair of geostationary satellites and then use the AUTO mode to repeatedly position the antenna on one satellite and then the other. This will exercise the controller, actuators, mount, and position sensors. If the antenna does not return to the peak for each satellite, make sure that the position sensors are properly wired. After the operation of the system has been verified by testing with two geostationary satellites, the rest of the geostationary satellites may be programmed in.

3.6 Angle Display of Az/El Position Data.c.:3.6 Angle Display of Az/El Position Data;

The RC2000B antenna controller is capable of displaying its azimuth and elevation position in an angle format. This section describes a method which makes use of this feature to aid the installer in locating the satellites which will be programmed into the controller's non-volatile memory. The procedure outlined in this section makes use of the programs (designed to run on an IBM compatible PC) found on the floppy disk in the back of this manual.

The controller can display azimuth and elevation position in a degrees format. When this feature is enabled, the azimuth position is displayed as a true heading (in degrees - 0 to 360) and the elevation position is displayed as an angle above the horizon (0 to 90 degrees). This feature is controlled by parameters specified by the user via CONFIG mode. The scale.exe program on the floppy disk can be used to determine these parameters once a pair of satellites has been found.

Another program included on the disk is antenna.exe. This is a general purpose program which aids the user in locating any satellite. This program prompts the user to enter the antenna longitude and latitude, the satellite longitude and the satellite inclination angle, and then calculates the magnetic heading, true heading, and elevation angle above the horizon needed to intercept the satellite. Satellite inclination angle is described in the next chapter. For geo-stationary satellites, the satellite inclination angle is 0.

The following step by step procedure can be used to locate geo-stationary satellites. In the process, the parameters needed to display azimuth and elevation parameters in an angle format will also be determined.

1. Determine the antenna latitude and longitude. Obtain a current satellite guide and identify the pair of satellites which will be located initially and used to calibrate the angle display. A reasonable selection would be a pair of satellites with many readily identifiable active transponders that are located 10 to 15 degrees apart (in longitude) placed somewhere in the middle of the arc.

2. Invoke the antenna.exe program to determine the magnetic heading and elevation angle needed to intercept each satellite. To run the antenna.exe program, simply type ANTENNA followed by the ENTER key at the DOS prompt. Position the antenna on each satellite. A magnetic compass and an inclinometer can be used to help point the antenna in the proper direction. For each satellite, record the longitude and the antenna azimuth and elevation count values where the satellite was located.

3. After the two satellites have been found, invoke the scale.exe program to calculate the AZIMUTH SCALE, AZIMUTH OFFSET, ELEVATION SCALE, and ELEVATION OFFSET parameters which will be entered into the controller via CONFIG mode.

4. With the controller, go to CONFIG mode and enter in the values for those parameters determined in step 3. At the CONFIG mode ANGLE DISPLAY ENABLE item, enter 1 to enable the angle display feature. The antenna longitude and latitude values must also be specified via CONFIG mode. A latitude or longitude entry is performed in two parts. The numerical value is entered first (followed by the ENTER key). Next the direction is specified, either E (East) or W (West) for longitude, and N (North) or S (South) for latitude (followed by the ENTER key).

Be sure to terminate all CONFIG mode numeric entries with the ENTER key. When all of the parameters have been entered, scroll back through the list to make sure that each entry is correct.

5. To locate additional satellites, invoke the antenna.exe program to determine the true heading and the elevation angle required to intercept the satellite. Note that when the controller's angle display feature is enabled, the azimuth position is displayed as a true heading. Simply jog the controller until the displayed azimuth position matches the true heading value predicted by the antenna.exe program, and the displayed elevation position matches the elevation value predicted by the program.

For mounts which employ linear actuators, there will be an error in the controller's displayed values for true heading and elevation. The error will be negligible when the antenna is located near the satellites used to calibrate the angle display (the satellites found in step 2). The error will be greater as the antenna is moved away from those satellites. This occurs because the controller uses a linear mapping of the position counts to display angle. For a mount which uses a linear actuator, the actuator forms one side of a triangle, and as that side gets shorter or longer, the opposite angle changes. For this case the mapping of position counts to antenna pointing angle is described by trigonometry and will be non-linear. To minimize the error, try to choose a pair of satellites in the middle of the arc to perform the calibration with.

.c.:;
3.7 Autopol;

This section covers the installation and software configuration required to use the Autopol feature. The Autopol function allows the antenna polarization to be controlled via a digital input to the controller. The Autopol feature, when enabled, is active whenever the controller is in MANUAL or TRACK mode. Note that the H, V, and SKEW keys do not work when Autopol is enabled. The Autopol input of the RC2000B is driven by a digital output from a satellite receiver. The Autopol input responds to a digital level, with a high level being one polarity and a low level the other polarity. The mapping of a high level on the digital input to either H or V polarization is referred to as the Autopol polarity and is controlled via a CONFIG mode item.

The Autopol input on the controller has an internal pull-up resistor which means that the input will float high when it is not driven by the receiver. This allows the receiver to use a relay contact closure to drive the Autopol input. One side of the relay can be connected to ground and the other side connected to the Autopol input. When the relay is active the Autopol input is connected to ground - a low level input, and when the relay is open the Autopol input floats high due to the pull-up in the RC2000B.

Here is the procedure for installing and configuring the Autopol feature:

1. Identify an output on the receiver which can be used to drive the Autopol input on the RC2000B. Note if a high level output corresponds to V polarization or H polarization.
2. Connect the Autopol input as shown in figures 3.2 or 3.3.
3. Go to CONFIG mode, use the SCROLL UP and SCROLL DOWN keys to bring up the 'AUTOPOL ENABLE' prompt, and key in 1 followed by the ENTER key to enable the Autopol function.
4. While in CONFIG mode, use the SCROLL UP and SCROLL DOWN keys to bring up the 'AUTOPOL VPOL LEVEL' item. If a high level corresponds to vertical polarization, key in 1 followed by the ENTER key. If a high level corresponds to horizontal polarization, key in 0 followed by the ENTER key.
5. Go to MANUAL mode and verify that the Autopol feature works properly. In MANUAL mode, when the Autopol feature is active the polarization display banner reads 'PLR' rather than 'PL:'.

3.8 Simultaneous Azimuth and Elevation Movement.c.:3.8 Simultaneous
Azimuth and Elevation Movement;

The RC2000B has the capability to move the azimuth and elevation axis actuators simultaneously during AUTO mode moves. The use of this feature is subject to a limitation in that the total current draw for both 36 volt actuators combined cannot exceed 8 amps. If this requirement is satisfied, simultaneous azimuth and elevation movement can be enabled by going to the CONFIG mode 'SIMULTANEOUS AZ/EL ENABLE' item and keying in 1 followed by the ENTER key.

3.9 Geostationary Satellite Setup Checklist.c.:3.9 Geostationary
Satellite Setup Checklist;

This section gives a summary of the installation and configuration procedure outlined in this chapter. The summary is presented in the form of a checklist.

1. Before power is applied verify that the line voltage is correct. Check the sticker over the power entry module.
2. Make sure that the memory has been cleared. The controller should come up in LIMITS mode.
3. Make the required electrical connections. A shielded cable must be used for the position sensors and the shield must be connected at the back of the controller and not at the antenna. Refer to figures 3.1, 3.2, and 3.3.
4. Go to LIMITS mode and verify the motor drive polarity. Set the east, west, down, and up limits.
5. Determine and enter in (via CONFIG mode) the azimuth and elevation speed codes.
6. Go to SETUP mode and program in the geostationary satellites. To help in locating the satellites, the procedure outlined in section 3.6 can be followed.
7. If desired, enable the Autopol feature to slave the controller's polarization control output to a satellite receiver. A digital output on the receiver must be connected to the Autopol input of the controller and the Autopol feature must be enabled via CONFIG mode.
8. Enable simultaneous azimuth and elevation movement in AUTO mode if the total combined current draw from both actuators is less than 8 amps over all operating conditions.

RC2000B Az/El Tracking Antenna Controller.....Chapter 4....Inclined
Orbit Satellites
RC2000B Az/El Tracking Antenna Controller.....Chapter 4....Inclined
Orbit Satellites

This chapter describes the characteristics of inclined orbit satellites and the tracking algorithms available on the RC2000B. The chapter begins with a tutorial on inclined orbit satellite operation, continues with a description of the controller's tracking algorithms, and concludes with a section that guides the user through the hardware and software configuration procedure which must be performed prior to initiating a track on an inclined orbit satellite.

4.1 Geostationary and Inclined Orbit Satellites.c.:4.1 Geostationary and Inclined Orbit Satellites;

To successfully track inclined orbit satellites with the RC2000B it is necessary to become familiar with the characteristics of the satellite's apparent motion as seen by the antenna. This section briefly reviews the orbital geometry of geostationary satellites and then discusses inclined orbit satellites.

A geostationary satellite appears fixed in space to an observer at any point on the earth. In reality, the earth is rotating about its axis, and the satellite appears to be stationary because it is orbiting the earth in the earth's equatorial plane with a period identical to the earth's rate of rotation. The earth's equatorial plane is the plane defined by the earth's equator. Please refer to figure 4.1.

Many forces act on a satellite in geostationary orbit that tend to tilt the satellite's orbital plane away from the earth's equatorial plane and to pull the satellite out of its assigned longitudinal position. These forces are due to the gravitational attraction of the moon (which also gives rise to ocean tides) and the nonspherical earth. A discussion of these forces is beyond the scope of this presentation. A geostationary satellite must expend propellant to perform station-keeping maneuvers to maintain an orbit at the proper longitudinal position within the earth's equatorial plane.

East-West station-keeping maneuvers are performed to maintain the satellite's longitudinal position and North-South station-keeping maneuvers are performed to keep the satellite's orbital plane aligned with the earth's equatorial plane. Between 20 and 40 percent of the satellite's launch weight is due to station-keeping propellant. A satellite's design life is determined by the amount of station-keeping fuel onboard. A satellite is sometimes allowed to drift into an inclined orbit to extend its operational life. For a geostationary satellite, approximately 90 percent of the propellant is expended for North-South station-keeping activities. If North-South station-keeping ceases the operational life of the satellite may be greatly extended.

The orbital plane of an inclined orbit satellite is 'inclined' with respect to the earth's equatorial plane. Note that in figure 4.1 the inclination angle between the inclined orbit satellite's orbital plane and the earth's equatorial plane is greatly exaggerated, typical inclination angles are less than 10 degrees. When satellite North-South station-keeping activities are suspended the inclination of the satellite's orbit increases by approximately 0.9 degrees per year. Whereas a geostationary satellite appears fixed in space, the apparent position of a satellite in an inclined orbit varies with time.

If an inclined orbit satellite could be viewed by an observer located at the center of the earth, the apparent motion of the inclined orbit satellite would be a figure eight centered on the earth's equatorial plane. The motion of the satellite is periodic, which means that the figure eight pattern repeats itself. The period of the motion is 23 hours, 56 minutes,

Figure 4.1 Earth's Equatorial Plane

and 4 seconds. The angle subtended by the figure eight pattern from North to South (i.e. height of the '8') is twice the inclination angle. The angle subtended by the figure eight pattern from East to West (i.e. width of the '8') is approximately the inclination angle (in degrees) squared divided by 115.

These relationships are strictly valid only if the motion is viewed from the center of the earth. The apparent motion is slightly greater and somewhat skewed when viewed from the surface of the earth. The exact shape of the pattern varies with the longitudinal position of the satellite and the place on the earth from which the satellite motion is viewed. To estimate the height and width of an inclined orbit satellite's motion as viewed from the surface of the earth, a good approximation is to multiply the results of the equations above by 1.2.

Examination of these relationships show that the figure eight pattern is much taller than it is wide. For example, if the orbital plane of a satellite is inclined with respect to the earth's equatorial plane by 5 degrees, the apparent height and width of the figure eight pattern of the satellite's apparent motion as viewed from the surface of the earth is:

Height (North to South): $1.2 * 2 * 5 = 12$ degrees
Width (East to West): $(1.2 * 5 * 5) / 115 = 0.26$ degrees

This example shows that the apparent motion of the satellite is practically a straight line oriented in a North to South direction. This knowledge of the satellite's apparent motion as viewed by the antenna is exploited by the RC2000B tracking antenna controller.

The 23 hour, 56 minute, and 4 second period of the satellite's apparent motion is referred to as a sidereal day. A sidereal day is the time that it takes the earth to complete exactly one revolution. The '24 hour' solar day is the period of time that it takes the sun to reach the same point in the sky. The solar day is longer than the sidereal day because the earth is in orbit around the sun and the earth must rotate more than 360 degrees for the sun to reach the same point in the sky.

Sidereal time refers to the time reference used to record time during a sidereal day. A sidereal time clock would progress up to 23 hours, 56 minutes, 3 seconds and then wrap around to 0 hours, 0 minutes, 0 seconds. All sidereal times used by the RC2000B controller and referenced in this manual are in seconds.

4.2 RC2000B Tracking Algorithm.c.:4.2 RC2000B Tracking Algorithm;

The tracking algorithm used on the RC2000B can be divided into 3 distinct parts, or submodes - STEP_TRACK, PROGRAM_TRACK, and SEARCH. A TRACK_ERROR submode is also implemented. These submodes are summarized here to provide an overview of the tracking algorithm. The following sections will provide much greater detail. Notice that certain words are italicized in the following subsections. The italicized text refers to parameters which are specified by the user either at the time of system installation (via CONFIG mode), when a track is initiated (via SETUP mode), or once a track has been established (via the TRACK mode menu). The idea is to get the user familiar with the parameters which he or she must either specify or adjust. All of these parameters are described in more detail in later sections.

The TRACK submodes will be described in chronological order as seen by a user initiating a track on an inclined orbit satellite. A track is initiated from SETUP mode. The user peaks the antenna on the inclined orbit satellite, selects the satellite name, longitude, inclination and band, and then sets the satellite's horizontal and vertical polarization positions. At this point the controller enters STEP_TRACK mode.

In the STEP_TRACK submode the controller periodically performs peakups on the inclined orbit satellite and saves the satellite azimuth and elevation positions where the peaks occur in non-volatile memory, into an area called the track table. The track table divides the sidereal day into 48 time segments. Whenever the current sidereal time equals the starting time for one of the 48 time segments, a peakup occurs and the antenna azimuth and elevation values are stored into the appropriate position within the track table. The track table stores a map of the satellite's apparent motion as seen by the antenna.

The PROGRAM_TRACK submode is active whenever a satellite's track table contains valid satellite position data for the current time. When PROGRAM_TRACK is active the antenna smoothly tracks the satellite by interpolating between track table azimuth and elevation position entries. Once a complete track table has been established for a satellite, the controller will remain in the PROGRAM_TRACK submode.

The SEARCH submode is active when the satellite signal is lost and track table data is not available. In this submode the controller performs a search for the satellite in the region where it calculates the satellite will be found as based on its knowledge of the satellite's apparent motion. If the satellite is found while the controller is performing a search, the STEP_TRACK submode will receive control. If the satellite is not found while performing the search, the controller will wait search retry interval minutes and perform another search. If while waiting for the search retry interval to expire the sidereal time advances to a time for which valid track table data is available, the PROGRAM_TRACK mode will become active.

The TRACK_ERROR submode becomes active whenever an error occurs. Some of the errors which can occur are: antenna jammed, antenna limit reached while tracking, antenna runaway, track table data corrupted, system CONFIG data corrupted, or a peak limit error has occurred (while peaking the antenna the controller had to move too far - possibly peaking on an adjacent satellite). Errors are described in Chapter 7.

4.2.1 STEP_TRACK.c.:4.2.1 STEP_TRACK;

In the STEP_TRACK submode, the controller will periodically jog the antenna in azimuth and elevation to peak up the signal strength. Peakups are performed, and the peak antenna azimuth and elevation position recorded into the track table, whenever the current sidereal time reaches a value that corresponds to one of the 48 track table entries. Peakups are also performed whenever the controller calculates that the time interval since the last peakup corresponds to a maximum possible antenna pointing error of one dB.

The controller makes use of its knowledge of the satellite's apparent motion and the antenna beamwidth to calculate the maximum possible antenna pointing error. The antenna beamwidth is calculated by the controller based on the antenna size and frequency band data. The azimuth and elevation movement step size used for

the peakups are based on the max track error parameter specified by the user. A smaller max track error value gives smaller step sizes.

The STEP_TRACK submode will pass control to these TRACK mode submodes on the following conditions:

PROGRAM_TRACK..receives control when the current sidereal time equals a time for which track table data is available.

SEARCH..receives control if the satellite signal is lost.

ERROR..receives control if any error is encountered.

4.2.2 PROGRAM_TRACK.c.:4.2.2 PROGRAM_TRACK;

When the PROGRAM_TRACK submode is active, the controller smoothly positions the antenna to azimuth and elevation positions derived from the track table, regardless of whether a satellite signal is present or not. The track table holds a map of the satellite's apparent motion as a function of sidereal time. The controller performs a linear interpolation between adjacent track table entries to determine the correct antenna position.

In PROGRAM_TRACK submode antenna movement occurs whenever the controller calculates that the error between the antenna's current position and the antenna's proper position as determined from the track table exceeds max track error tenths of a dB. To determine the error between the current and calculated antenna position, the controller calculates the antenna beamwidth based on the antenna size and the frequency band. If the max track error parameter is decreased in value, the antenna pointing error will be less, but the antenna will move more often, which increases wear on the antenna actuators.

The PROGRAM_TRACK submode also periodically performs peakups (similar to STEP_TRACK submode) to check the accuracy of track table entries. If the discrepancy between the pickup position and the position stored in the track table is greater than that specified by the max track error parameter, the update flag for each entry in the track table is set TRUE. The frequency at which these track table accuracy checks occur is determined by the update check parameter. The default update check interval is 72 hours, but it can be changed by the user to any value in the range of 1 to 999 hours.

If the current sidereal time reaches a value that corresponds to an entry in the track table whose update flag is set TRUE, and the current signal strength level indicates that a satellite signal is present, a pickup will occur, the track table entry will be updated, and the track table update flag is reset FALSE. If the satellite signal is not present the update flag remains set TRUE and the system will try again in 23 hours, 56 minutes, and 4 seconds. The user can view the contents of each track table entry and examine the present state of the update flag. In addition the user can invoke the force update or reset update functions to force the update flag for each entry in the track table to be either set TRUE or reset FALSE, respectively. These functions are accessible via the TRACK MENU system, which is described in more detail in the section on TRACK mode in chapter 5.

The PROGRAM_TRACK submode will pass control to the other TRACK mode submodes under the following circumstances:

STEP_TRACK..receives control when the current sidereal time reaches a value for which there are no valid track table entries and a valid satellite signal is present.

SEARCH..receives control when the current sidereal time reaches a value for which there are no valid track table entries and a valid satellite signal is not present.

ERROR..receives control when any error is encountered.

The SEARCH submode receives control whenever the satellite signal is lost and the track table does not contain antenna azimuth and elevation position data for the current sidereal time. Whenever the SEARCH submode is active the controller periodically performs a search over the region where the controller has calculated that the satellite will be found. The Intelli-Search algorithm determines the extent of the search region based on the satellite longitude, the antenna latitude and antenna longitude, the antenna beamwidth (as calculated from the antenna size and frequency band), and the elevation and azimuth scale factors.

The azimuth and elevation scale factors refer to the mapping of position counts to angle, and vice versa for the azimuth and elevation axis. These scale factors are derived from azimuth position, elevation position, and longitude data of adjacent geostationary satellites. Scale factors are discussed in more detail in the next section.

The use of the Intelli-Search algorithm relieves the user of the task of having to specify the controller's search region. Other tracking antenna controllers limit the search to a box shaped region and force the user to determine the boundaries of the search region, which is often a trial and error process. Please refer to figure 4.2. If the box shaped region specified by the user is too small the controller may not search the entire region where the satellite's apparent motion takes it, and for some segments of the satellite's movement the controller may not be able to find the satellite. If the box search region is too large, the controller may find an adjacent satellite. If the search region is not centered properly, both of the error conditions described above could occur.

The Intelli-Search algorithm calculates the shape of the search region based on easily determined physical data supplied by the user, and information derived from the antenna positions and longitudes of the geostationary satellites in the vicinity of the inclined orbit satellite which is being tracked. In most cases the search region is shaped like a parallelogram. The long dimensions of the parallelogram is calculated based on the satellite inclination angle specified by the user when the track is initiated from SETUP mode. The width (or short dimension) of the parallelogram is specified by the azim search scale factor parameter entered via CONFIG mode. The azim search scale factor has a range of values of 1 to 10, with 1 specifying the narrowest search window and 10 specifying the widest window. The default value of 3 is adequate for most situations.

If a satellite signal is found during a search, the controller switches to the STEP_TRACK submode. If a satellite signal is not found during the search, the unit waits awhile and then performs another search. If during the wait the sidereal time advances to a value for which there is valid track table data, the controller will switch to the PROGRAM_TRACK mode. The wait period between successive searches is determined by the value of the search retry interval parameter. The default value of this parameter is 10 minutes, but it can be changed to any value between 0 and 999 minutes.

The search consists of successive sweeps separated from one another by an angle corresponding to a 2 dB rolloff of the antenna pattern. The antenna pattern is calculated based on the antenna size and frequency band. The sweeps can be in either azimuth or elevation depending on the shape of the search region. The

search region is centered at the nominal position of the satellite. This is the position that the controller has calculated where the satellite would be found if the satellite inclination was zero.

Figure 4.2 Intelli-Search

4.3 Implementing the Tracking Algorithms.c.:4.3 Implementing the Tracking Algorithms;

This section describes the information needed to implement the tracking algorithms. The purpose of this section is to give the user insights into the operation of the controller and to prepare for the actual entry of the setup information in following sections.

4.3.1 Location Information.c.:4.3.1 Location Information;

The antenna latitude and longitude and the longitude of the inclined orbit satellite to be tracked must be specified in order to determine the satellite's apparent motion. In most cases the satellite's apparent motion as seen by the antenna mount is a skewed figure eight shape. This information is needed to implement the controller's Intelli-Search algorithm.

4.3.2 Antenna Scale Factors.c.:4.3.2 Antenna Scale Factors;

The antenna azimuth and elevation scale factors characterize the mount's count to pointing angle relationship. This capability is fundamental to the operation of the controller. The controller must be able to position the antenna to any desired pointing angle. The scale factors for a given inclined orbit satellite can be viewed via the TRACK mode MENU system (VIEW option - more on this in chapter 5).

The scale factors are determined automatically by the RC2000B by looking at the azimuth and elevation position count values and the longitudinal positions of the geostationary satellites. When the user initiates a track on an inclined orbit satellite, the controller uses 2 geostationary satellites (which have been previously programmed into the controller via SETUP mode) in the vicinity of the inclined orbit satellite to determine the azimuth and elevation scale factors. This is why at least 2 geostationary satellites must be available in the controller's non-volatile memory to initiate a track on an inclined orbit satellite, and why it is critical that the user specify the proper longitudinal values for the geostationary satellites. If a geostationary satellite is programmed into memory with an incorrect longitude value (angle or direction), the controller will accurately position the antenna on the geostationary satellite (when it is recalled via AUTO mode) but may not function properly if an inclined orbit satellite is specified in the vicinity of the geostationary satellite. VERIFY THE LONGITUDE VALUE OF ALL SATELLITES PROGRAMMED INTO THE CONTROLLER VIA SETUP MODE.

4.3.3 Antenna Radiation Pattern.c.:4.3.3 Antenna Radiation Pattern;

An antenna radiation pattern specifies antenna receive power versus antenna pointing angle from boresight. Boresight is the pointing angle associated with maximum received power from a given satellite. The controller calculates the shape of the antenna's radiation pattern by knowing the size of the antenna and the frequency band (C or Ku) currently in use. Antenna size data is entered via a CONFIG mode prompt. The frequency band data is specified in SETUP mode when

the user initiates a track on an inclined orbit satellite. Note that the controller also allows the user to specify a dual band inclined orbit satellite. For this case the user is prompted to supply frequency band data on entry into TRACK mode and is allowed to change the frequency band via the TRACK mode menu.

Antenna radiation pattern information is necessary to allow the user to specify a maximum allowable antenna pointing error in decibels (dB) rather than in elevation and azimuth position counts. The maximum track error is used to determine the step size in step track mode and to determine the frequency of movement in program track mode. In addition, antenna radiation pattern information is used in SEARCH mode to determine the width of the parallelogram-shaped search region and the angle between successive sweeps.

4.3.4 Real Time Clock.c.:4.3.4 Real Time Clock;

The controller contains a real time clock (powered by the same lithium battery that powers the controller's non-volatile memory) which is used to calculate the sidereal time. The period of the satellite's motion is one sidereal day. The controller maintains a track table which contains the satellite's azimuth and elevation positions as a function of sidereal time. The controller uses the time and date maintained by the real time clock to calculate the sidereal time. The user specifies the time and date via CONFIG mode prompts.

It is important that the user not change the time value when the time changes from Standard Time to Daylight Savings Time. The satellite does not experience the time shift. If the time is changed forward or backward by one hour, the data in the program track table will no longer be correct. For this reason the user should not change the time as the time standard changes. If this causes confusion the time may be specified as Greenwich Mean Time (often referred to as GMT). Note that the real time clock used in the controller will properly account for leap years.

4.3.5 Receiver AGC Signal.c.:4.3.5 Receiver AGC Signal;

To implement the tracking algorithms, the controller requires an input signal which indicates the strength of the received signal. Such a signal is generated within a satellite receiver and is referred to as an AGC signal. AGC is the abbreviation for Automatic Gain Control. On satellite receivers, this signal may also be referred to as a 'Signal Strength' or 'Tuning Meter' output. An AGC output typically varies in proportion to the received power of the transponder which the receiver is currently tuned to.

The signal strength input is used to peak up the antenna while step tracking. The step tracking operation positions the antenna so as to maximize the received signal strength. Signal strength is also used to determine whether or not a satellite transponder is currently active. If the signal strength reading falls below a threshold set by the user, the controller assumes that a satellite signal is not present. If the satellite signal is lost while step tracking the SEARCH sub-mode receives control. When the PROGRAM_TRACK sub-mode is active, the presence of a satellite signal governs whether or not track table update operations are performed. The procedures required to set up the controller for various receiver AGC configurations are covered in detail in the next section.

4.4 Configuring the Tracking System.c.:4.4 Configuring the Tracking System;

This section describes the procedures which the user must follow to configure the tracking system. The procedures for adjusting the AGC gain and offset pots, determining the AGC threshold parameters, and entering other CONFIG mode data pertaining to the tracking system, are all covered in this section.

4.4.1 AGC Adjustment and Configuration.c.:4.4.1 AGC Adjustment and Configuration;

The use of the AGC signal was described in the previous section. The controller has the provision to process two channels of AGC information. This means that two receivers can be connected to the controller (at least one receiver is required). The two channels are referred to as AGC1 and AGC2. The controller uses the stronger of the two as its AGC input. Each channel has separate gain and offset potentiometer adjustments. The installer uses the pots to transform the receiver's AGC signal swing into a range of values which is easily measured by the controller.

In addition to the potentiometers, there are three CONFIG mode items which are related to the AGC system. The three items are ...

1. AGC Polarity Flag - This flag indicates to the controller whether a stronger satellite signal corresponds to a higher AGC voltage (positive polarity) or a lower AGC voltage (negative polarity). Both AGC channels must have the same polarity. Each AGC channel contains an internal pull down resistor. This means that if one of the AGC channels is unused, its input is pulled to ground. This can cause problems if the AGC polarity Flag specifies negative polarity, because an input of zero volts (ground potential) corresponds to the strongest possible satellite signal. For this case the installer must place a jumper from connector J1, pin 11, to the unused AGC input channel and adjust that channel's potentiometers so that its signal strength value is 0. J1 - pin 11 has a potential of 5.7 volts.
2. AGC C Band Threshold - When the receiver is tuned to a C band satellite and the signal strength is above this value, it is assumed that a satellite signal is present. The same threshold is applied to both AGC channels.
3. AGC K Band Threshold - This is similar to the C Band Threshold described above, except it pertains to Ku Band. If the signal strength is above this value when the receiver is tuned to a Ku band satellite, the controller assumes that a satellite signal is present.

The signal strength is displayed when MANUAL, TRACK, SETUP, and LIMIT modes are active. In MANUAL, TRACK, and SETUP modes, the signal strength of the AGC channel which corresponds to the strongest received satellite signal is displayed. In LIMIT mode, the signal strength of both AGC channels is displayed (the first value corresponds to AGC1). The signal strength is displayed as a number in the range of 0 to 1023. Note that in MANUAL, TRACK, and SETUP modes, the maximum signal strength which can be displayed is 999. A signal greater than 999 is displayed as '***'. The displayed value takes into account the setting of the AGC Polarity Flag. In other words, a greater signal strength value always corresponds to a stronger received satellite signal.

Single Receiver - Single Frequency Band.c.:Single Receiver - Single Frequency Band; Inclined Orbit Satellite AGC Setup

The following paragraphs describe the setup procedure for the simplest case - only one receiver and controller AGC input are used, and the user is tracking only C band (or only Ku band) inclined orbit satellites.

1. Align the antenna with a strong satellite (geostationary or inclined orbit) of the proper frequency band. Place a voltmeter on the receiver's AGC output, measure and record the voltage. In the description that follows, the term 'on satellite' will be used to refer to the antenna aligned with a strong satellite.
2. Jog the antenna off of the satellite so the antenna is looking at nothing. Measure and record the receiver's AGC voltage. In the description that follows, the term 'off satellite' will be used to refer to this case where the antenna is positioned well off of any satellite, looking at nothing.
3. If the difference between the two recorded values is less than 1 volt, connect the receiver's AGC output to the controller's AGC1 input. Otherwise, connect the receiver's AGC output to the controller's AGC2 input. Be sure to connect the ground return of the controller to a ground on the receiver. See figures 3.1 and 3.2.
4. If the AGC voltage associated with the 'on satellite' case is greater than that of the 'off satellite' case, the receiver has POSITIVE AGC polarity, otherwise the receiver has NEGATIVE AGC polarity. Go to CONFIG mode and use the SCROLL UP and SCROLL DOWN keys to bring up the AGC polarity Flag item. Key in the proper polarity using either the 0 or 1 key and terminate the entry with the ENTER key.
- 5a. If the receiver's AGC has NEGATIVE polarity, go to step 5b. If the receiver's AGC has POSITIVE polarity, go to LIMIT mode and examine the signal strength for the AGC channel which was not selected in step 3. If the signal strength reading for that channel is greater than 10 adjust the OFFSET and GAIN for that channel until the signal strength reading for that channel is less than 10. To lower the displayed signal strength turn the OFFSET pot clockwise and the SCALE pot counter-clockwise. Be sure not to turn the controller off while the controller is in LIMITS mode or else the limits which have previously been set will be corrupted. Proceed to step 6.
- 5b. If the receiver's AGC has NEGATIVE polarity, connect a jumper from the controller's unused AGC input channel to connector J1, pin 11. Go to LIMIT mode and examine the signal strength for the AGC channel which was not selected in step 3 above. If the signal strength reading for that channel is greater than 10, adjust the OFFSET and GAIN pots for that channel until the signal strength reading for that channel is less than 10. To lower the displayed signal strength value, turn the OFFSET pot counter-clockwise and the SCALE pot clockwise. When this is accomplished proceed to step 6.
6. In the next few steps of the procedure, the OFFSET and GAIN pots of the AGC channel connected to the receiver's AGC output are adjusted so that the 'off satellite' signal strength value is between 50 and 100 and the 'on satellite' signal strength value is between 600 and 700.

Note that the GAIN and OFFSET adjustments are implemented using 20 turn pots. A lot of turns may be required.

7. Go to MANUAL mode, position the antenna 'off satellite', and adjust the OFFSET pot (for POSITIVE polarity receivers) or the GAIN pot (for NEGATIVE polarity receivers) so that the signal strength reading is about 75.

If the AGC has POSITIVE polarity and the signal strength is too low, turn the OFFSET pot counter-clockwise. If the AGC has POSITIVE polarity and the signal strength is too high (or is '***'), turn the OFFSET pot clockwise.

If the AGC has NEGATIVE polarity and the signal strength is too low, turn the GAIN pot counter-clockwise. If the AGC has NEGATIVE polarity and the signal strength is too high (or is '***'), turn the GAIN pot clockwise.

8. While still in MANUAL mode, position the antenna 'on satellite' and adjust the GAIN pot (for POSITIVE polarity receivers) or the OFFSET pot (for NEGATIVE polarity receivers) so that the signal strength value is about 650.

If the AGC has POSITIVE polarity and the signal strength is too low, adjust the GAIN pot clockwise. If the AGC has POSITIVE polarity and the signal strength value is too high (or is '***'), adjust the GAIN pot counter-clockwise.

If the AGC has NEGATIVE polarity and the signal strength is too low, adjust the OFFSET pot clockwise. If the AGC has NEGATIVE polarity and the signal strength value is too high (or is '***'), adjust the OFFSET pot counter-clockwise.

9. Position the antenna 'off satellite'. If the signal strength is between 50 and 100, proceed to step 10. If the signal strength is less than 50 or greater than 100 perform steps 7 and 8 again.

10. Position the antenna 'on satellite'. Jog the antenna off of the satellite until the picture is just barely watchable. Note the signal strength value. Go to CONFIG mode and use the SCROLL UP and SCROLL DOWN keys to bring up either the 'AGC C Band Threshold' item or the 'AGC K Band Threshold' item, whichever is appropriate for the frequency band that the user has chosen to operate at (and has adjusted the pots at). Key in the signal strength value noted above. Terminate the entry with the ENTER key.

Single Receiver - Dual Frequency Band.c.:.:Single Receiver - Dual Frequency Band; Inclined Orbit Satellite AGC Setup

The setup procedure described above was for the case where a single satellite receiver is connected to the controller and the user is interested in tracking only satellites of a single frequency band (either C or Ku). A slight increase in complexity occurs if the user must be able to track both C and Ku band inclined orbit satellites. This is because the same AGC channel is used for both frequency bands and therefore the OFFSET and GAIN pot adjustments for that channel must be made so as to accommodate both frequency bands. At the heart of the problem is the fact that the signal strength (as seen by the receiver's AGC circuits) will vary with the frequency band selected due to differences in antenna gain, LNB gain, and the differences in output power between C band and Ku band satellites.

The adjustment procedure for the dual band case is very similar to the single band case described above. The following paragraphs describe the modifications required to adapt the single receiver - single band procedure, to the single receiver - dual band case.

1. The procedure is similar to step 1 above except that the user should align the antenna with a strong C band and a strong Ku band satellite. The voltages for each frequency band should be recorded.

2. Similar to step 2 above except that both C and Ku band AGC voltages are obtained when the antenna is looking at nothing.

3. Similar to step 3 above. The only modification is that the user should select the frequency band whose 'on satellite' and 'off satellite' receiver AGC voltage difference is the greatest to make the determination of which AGC channel to use.

4-5. No changes from steps 4 and 5 which are outlined above.

6. As outlined above, in the next few steps the user will adjust the GAIN and OFFSET pots of the AGC channel which is connected to the receiver. The difference is that in steps 7 through 9 the term 'on satellite' must be replaced with 'on satellite, strong band' and the term 'off satellite' must be replaced with 'off satellite, weak band'. These terms are described below.

The term 'on satellite, strong band' refers to the case when the antenna is aligned with a satellite of the frequency band that has the greatest gain. For a POSITIVE AGC polarity receiver this is the band for which the greatest voltage was recorded in step 1. For a NEGATIVE AGC polarity receiver, this is the band for which the lowest voltage was recorded in step 1.

The term 'off satellite, weak band' refers to the case when the antenna is positioned off of any satellite and the receiver is tuned to the frequency band which has the lowest gain. For a POSITIVE AGC polarity receiver this is the frequency band for which the lowest voltage was recorded in step 2 above. For a NEGATIVE AGC polarity receiver this corresponds to the frequency band for which the greatest voltage was recorded in step 2 above.

7. Similar to the step 7 outlined above. In place of 'off satellite' use the term 'off satellite, weak band' as described above.

8. Similar to the step 8 outlined above. In place of 'on satellite' use the term 'on satellite, strong band' as described above.

9. Similar to the step 9 outlined above. In place of 'off satellite' use the term 'off satellite, weak band' as described above.

10. Similar to the step 10 outlined above except that jogging the antenna 'on satellite' and then slightly off should be performed for each frequency band to obtain both the AGC C Band Threshold and the AGC K Band Threshold. Both of the threshold values should be entered into the controller via CONFIG mode as outlined above.

Using Two AGC Channels.c.:::Using Two AGC Channels;

Connecting a second receiver to the controller is straightforward. The controller AGC input channel GAIN and OFFSET adjustments have enough range to handle any possible receiver AGC scheme as long as the AGC level is less than six volts. In step 3 of the adjustment procedure, the installer is instructed to select the controller AGC input channel based on the range of the receiver's AGC output. AGC input channel 1 is designed to handle 'small' AGC signal swings and AGC input channel 2 is designed for 'large' AGC signal swings. There is enough adjustment range, however, so that either channel may be connected to any receiver AGC output.

If two receivers are used both must have the same AGC polarity and the GAIN and OFFSET pots of each channel must be adjusted so that the same threshold values are appropriate for each channel. When two receivers are used, the controller will use as its AGC input the stronger of the two signals. If two receivers are used, all pot adjustments will have to take place in LIMITS mode because this is the only mode where the voltages which correspond to each AGC channel may be viewed simultaneously and unambiguously.

Amplifier Gain vs. Frequency Characteristics.c.:::Amplifier Gain vs. Frequency Characteristics;

An amplifier's gain vs. frequency characteristic, or gain flatness, is the variation of the amplifier's gain with changing frequency. The ideal response is to have a flat gain characteristic (the gain does not vary with frequency). Amplifiers with poor gain flatness characteristics can cause problems for the tracker. This section describes a simple test (no equipment required) that the user can carry out to check the receiving system's gain flatness.

There are four places in a satellite receiving system that may have gain flatness problems that can affect the operation of the tracker. These are the LNB, the coaxial cable connecting the LNB to the receiver, line amps (or bullet amps) inserted in the 950 - 1750 MHz IF, and the receiver's IF or AGC stages. If a spectrum analyzer is connected into the receiver's block IF line, the gain flatness of the LNB and any line amps present can be observed. When the antenna is pointed away from any satellite, the spectrum analyzer displays the received noise, which should be constant with frequency. If the display is not a horizontal line then some gain variation with frequency is present.

To understand how a poor gain flatness characteristic can cause problems, remember that the purpose of the AGC input is to let the controller determine whether a satellite signal is present or not and to provide relative signal strength information when peaking the antenna. A signal is assumed to be present whenever the AGC input is above the threshold level for whichever band - C or Ku - has been selected. When the receiver is tuned to various transponders, gain flatness problems could cause the AGC signal to be above the threshold when in fact no satellite signal is present. For certain transponders, gain flatness problems could also cause the controller's AGC input scaling network to be saturated when the antenna is aligned with a strong satellite, making it impossible for the controller to detect changes in signal strength when attempting to peak the antenna.

To test the gain flatness of the satellite receiver, perform the following procedure. The procedure assumes a single receiver, single frequency band system.

1. Position the antenna well off of any satellite. Tune the receiver to each transponder. Make sure that the signal strength reading is below the threshold assigned via CONFIG mode.
2. Align the antenna with a strong satellite. Tune the receiver to each active transponder on the satellite. Make sure that the signal strength is well above the threshold and below 999.

If the system fails either of the tests above, then the user can either attempt to correct the problem by readjusting the GAIN and OFFSET pots (using the procedure outlined earlier) or correcting the gain flatness problem. Most gain

flatness problems can be traced to a problem with the coaxial cable connecting the antenna to the receiver (sometimes called a 'suck-out') or to bullet amplifiers. Some bullet amplifiers have been observed to have really terrible gain flatness characteristics.

To perform the above tests on a dual frequency band system, repeat the test for each frequency band. On a dual receiver system, simply perform the test on each receiver. On a dual frequency system the tests should be performed with the controller in LIMIT mode so that there is no confusion as to which AGC input channel the displayed signal strength reading corresponds to.

4.4.2 CONFIG Mode Data.c.:4.4.2 CONFIG Mode Data;

This section briefly describes each of the CONFIG mode items and how they relate to the tracking system. The names of CONFIG mode items appear in italics. The installer should go through this section and enter in the relevant data. Be sure to terminate each entry with the ENTER key. If an entry is terminated by depressing the SCROLL UP or SCROLL DOWN keys the data entered by the user is not saved into non-volatile memory. After all of the data has been entered the user should go through the data items again to verify that all entries were properly recorded.

The Autopol enable and Autopol vpol level items are described in section 3.6. In TRACK mode the Autopol feature works the same as it does in the other modes. When a movement is in progress while TRACK mode is active, the Autopol signal may not be immediately recognized. It will be recognized when the movement ceases.

The simultaneous az/el enable CONFIG mode item is not relevant in TRACK mode as no movements in TRACK mode occur about each axis simultaneously. This item is only applicable to movements which occur in AUTO mode.

The time and date are entered via the CONFIG mode. The use of time and date information by the tracker is described in section 4.3.4. Note that once a track is established for a satellite the time and date should not be changed. If this is a problem, the user might set the time and date to Greenwich Mean Time (GMT). Please refer to section 4.3.4.

The AGC polarity flag, AGC C band threshold, and the AGC K band threshold CONFIG mode items are discussed in section 4.4.1. Please refer to that section for more information on these items.

The antenna latitude and antenna longitude are required by the tracking algorithms to predict the apparent motion of the satellite. The data is entered in a degrees.tenths_of_degrees format. Most maps show latitude and longitude data in a degrees.minutes format. Below is a table of minutes versus tenths_of_degrees.

minutes	degrees	minutes	degrees
06	0.1	36	0.6
12	0.2	42	0.7
18	0.3	48	0.8
24	0.4	54	0.9
30	0.5		

The latitude and longitude data entry must also specify a direction. For latitude the options are North or South, and for longitude the options are East and West. Locations in North America and South America have westerly longitudes, while locations in Asia have easterly longitudes. Section 2.1 describes the keys used to specify the direction associated with latitude or longitude data entry.

The antenna size parameter specifies the antenna diameter in centimeters. Use the table below to convert feet or meters into centimeters.

Feet	Meters	Centimeters
5.9	1.80	180
8	2.44	244
10	3.05	305
12	3.66	366
15	4.57	457
20	6.10	610
23	7.00	700
24	7.32	732

The max track error and azim search scale factor CONFIG mode items are discussed in section 4.2. The default values are 10 and 3, respectively. The max track error is specified in tenths of a dB. When initiating a track on an inclined orbit satellite for the first time, it is probably best to leave these parameters at their default values. See the section on tracking problems at the end of this chapter for more information on the max track error parameter.

The azim slow speed and the elev slow speed codes are discussed in section 3.4. These speed codes should be initialized because the tracking system uses these values to determine how fast to move the antenna when making movements.

The angle display enable, azim scale factor, azim offset, elev scale factor, and elev offset CONFIG mode items are used to display the azimuth and elevation positions in an angle format. These items are determined using the procedure outlined in section 3.6. It is not necessary for the angle display feature to be enabled for the tracking system to operate. Note that the azim scale factor referred to here is different than the scale factors mentioned elsewhere in this chapter, which relate position counts to antenna pointing angles.

4.4.3 Initiating a Track on an Inclined Orbit Satellite.c.:4.4.3 Initiating a Track on an Inclined Orbit Satellite;

This section describes the process of initiating a track on an inclined orbit satellite. The steps are very similar to those required for saving the azimuth, elevation, and polarization positions for a geostationary satellite (described in section 3.5). A track is initiated from SETUP mode. The user must position the antenna on the inclined orbit satellite, use the SCROLL UP, SCROLL DOWN, and ENTER keys to select a satellite name, and then verify the satellite longitude. This is identical to the procedure for the geostationary satellites.

At the prompt that asks if the satellite is an inclined orbit satellite, the user should respond with the YES key. The user is then prompted for the satellite inclination. This refers to the inclination angle of the satellite's

orbital plane to the earth's equatorial plane (discussed in section 4.1). Refer to figure 4.3, which gives the inclination angle for a number of satellites and a nomograph for calculating the inclination for any date between 1993 and 2000. The following example uses figure 4.3 to determine the inclination of the Intelsat V F4 satellite in June, 1995.

1. Use the table that is part of figure 4.3 to determine the inclination of the satellite on January 1, 1993. For the Intelsat V F4 satellite the value is 3.5 degrees.
2. Start at the origin of the graph (in figure 4.3) and move up the vertical axis to the inclination value found in step 1. Make a mark at that location. For this example, a closed circle has been placed on the vertical axis of the graph at 3.5 degrees.
3. In this step the current inclination value of the satellite is determined. With a small pointer, move upwards and to the right on the graph parallel to the diagonal lines. Position the pointer so that it is just over the position on the horizontal axis which corresponds to the date of interest - in this case June 1995 (or about half way between the 1995 and 1996 tick marks). Read the satellite inclination off of the vertical axis. For this example, an open circle has been placed on the graph. The horizontal coordinate of the open circle corresponds to June, 1995. The vertical coordinate of the open circle is the satellite inclination in June, 1995. The vertical coordinate is read off of the vertical axis. For the Intelsat V F4 satellite in June, 1995, the satellite inclination is 5.5 degrees.

If a satellite is not listed in figure 4.3, remember that the satellite inclination increases at a rate of about 0.9 degrees per year. If it is known what year the satellite went into an inclined orbit, the inclination of the orbital plane can be calculated. The maximum inclination angle for an Intelsat satellite is typically 5 degrees. The GSTAR 3 satellite is in an inclined orbit due to a bad launch. Its inclination was around 5 degrees in 1992.

Figure 4.3

The inclination value specified by the user is used by the Intelli-Search algorithm to calculate the long dimension of the parallelogram-shaped search region. If there is no data available on the inclination of the satellite, use the default value of 5 degrees. After keying in the satellite inclination the user is prompted to specify the satellite band. The user may select either C band, Ku band, or both for a dual band satellite.

Next the user is prompted to specify the H and V polarizations in a manner identical to that for a geostationary satellite. The controller will then prompt for an initial track polarization. At this point the user should tune the receiver to the desired transponder and hit either the H or V key to specify the polarization. The controller will then switch to TRACK mode and display the 'INITIALIZING - PLEASE WAIT' message. The message will be displayed for approximately 1 minute and then the controller will enter the STEP_TRACK submode and begin step tracking. Normally the controller will remain in the STEP_TRACK submode for 23 hours and 56 minutes while the track table is compiled.

To test the Intelli-Search algorithm, the user can exit TRACK mode and then reenter TRACK mode via the AUTO mode. When the controller reenters TRACK mode a search will be performed and when the satellite is found, step tracking will resume. This is also a good way to test if the elevation limits are set wide enough to allow the antenna to track the satellite's movements. Note that when a search takes place, the controller will search the entire region and then return to the position where the greatest signal strength occurred.

The user should review the documentation on the TRACK mode in chapter 5 of this manual. A TRACK mode menu is available whenever TRACK mode is active and the controller is idle (i.e. initialization or movement not in progress). The menu system allows the user to view the sidereal time, the azimuth and elevation scale factors, and the track table data. The user can also view and modify a number of other parameters including the track table update flags, the max track error parameter, the frequency band (for dual band satellites), the update check interval, and the search retry interval.

4.4.4 Tracking Problems.c.:4.4.4 Tracking Problems;

This section discusses problems which can occur while tracking an inclined orbit satellite. TRACK mode contains an ERROR submode, which displays an error message when it is active. Chapter 7 discusses all of the possible errors which can occur. This section discusses the more common problems.

The LIMIT error occurs when an antenna limit (either azimuth or elevation - usually elevation) is encountered when tracking a satellite. If this error occurs while the STEP_TRACK or PROGRAM_TRACK submodes are active, it usually means that the elevation limits are not set wide enough. If this error occurs during a search it means that either the limits are not set wide enough, or that too great a satellite inclination angle was specified.

A PEAK LIMIT error indicates that the antenna moved too far during a step track operation. The maximum movement of the antenna about the starting position for the step track operation is limited. This is to prevent the antenna from peaking up on an adjacent satellite during a search operation. This error can

be caused by having a mount with too much play or by specifying the wrong antenna diameter. If the error occurs while the PROGRAM_TRACK submode is active, it can indicate that the update check interval is set too large.

Play, or looseness, in the mount can cause many problems. The user can test for play by shaking the antenna. Another test is to see if the antenna peaks on a satellite at different count values depending on which way the antenna approached the satellite. Here's an example. In one case the peak is approached by jogging the antenna up and the peak occurs at 110 counts. In another case the peak is approached by jogging the antenna down and the peak occurs at 103 counts. This indicates that there are 7 counts of play in the system. The solution is to get rid of the play. In some cases, increasing the max track error parameter can help. In general, however, the controller is not very tolerant of looseness in the mount.

If a linear actuator is used to drive the antenna about an axis, it usually forms one side of a triangle. As the length of the linear actuator changes, the opposite angle varies and the pointing angle of the antenna is changed. If the linear actuator has some play in it, the change in the antenna pointing angle due to the play in the actuator can be minimized if the other sides of the triangle are made longer. In some cases, the ball pivot often found on one side of the linear actuator is also loose. Anything which can be done to tighten up the ball pivot will help.

It is usually best to choose an antenna mount which uses longer linear actuators because the 'sides of the triangle' formed by the mount and the linear actuator are longer. With longer 'sides of the triangle', looseness in the linear actuator translates into smaller antenna pointing angle variation.

4.5 Inclined Orbit Satellite Setup Checklist.c.:4.5 Inclined Orbit Satellite Setup Checklist;

1. Connect the AGC output from the satellite receiver to one of the controller AGC input channels. Determine the AGC polarity. Enter the polarity into the controller via CONFIG mode.
2. Adjust the GAIN and OFFSET pots for the selected AGC channel so that when the antenna is aligned with a strong satellite the signal strength level is around 650, and when the antenna is well off of any satellite the signal strength level is around 75.
3. Determine the values for the AGC C Band Threshold and/or the AGC K Band Threshold, depending on which frequency bands are used. The threshold values are used to determine whether or not a satellite signal is present.
4. With the antenna positioned well away from any satellite, tune the satellite receiver across all transponders to verify that the noise floor is below the threshold.
5. With the antenna aligned with a strong satellite tune the satellite receiver across all bands and verify that the signal strength level does not reach saturation and remains above the threshold.
6. Enter in the following data via CONFIG mode: the antenna latitude and longitude, the time and date, and the antenna size (in centimeters). Note -

once the time is set and the controller is tracking, do not change the time (i.e. Standard to Daylight savings) as this will invalidate the data in the track table.

7. Go to setup mode and program in an inclined orbit satellite. As a test of the search algorithm, the user can go to AUTO mode and select the inclined orbit satellite from the list of satellites programmed into non-volatile memory. The controller should then perform a search. When the search is complete, if the satellite is found, step tracking will resume.

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RC2000B Az/El Tracking Antenna
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.c.Chapter 5 MODES In-Depth Function Description;

The Operational Mode Group consists of three modes: MANUAL, AUTO, and TRAK. Programming Mode Group consists of several modes: LIMITS, SETUP, RESET, DELETE, RE-SYNC, and CONFIG.

5.1 MANUAL Mode.c.:5.1 MANUAL Mode;

AZ:178.4 EL: 44.2 PL: 15 H SS:635 MANUAL
SBS 2 97.0 W SPEED:FAST

This mode allows the user to manually jog the antenna east and west, or up and down, as well as toggle the polarization between the H and V positions (after one satellite has been stored in memory). Additionally, fine-tuning the polarization with the CW/CCW keys is possible in this mode. The H and V keys will select the preset H and V polarizations for the satellite closest to the antenna's present position. Polarization control is available in this mode only if Autopol is disabled. When enabled, the polarization will be set according to the level present on the H/V input, and PLR: will be displayed instead of PL:.

If an externally supplied AGC voltage is connected to the proper terminals of J1, a relative signal strength indication will appear after the SS field. The range of this field is 0-999. This field can be used as an aid when storing satellites to help establish the optimum position. Adjust the AGC pots such that the display peak value is less than 850 to minimize the possibility of sense circuit saturation. This adjustment is explained in detail in section 4.4.1, AGC Adjustment and Configuration.

When the antenna is within 45 counts of an azimuth position AND 20 counts for elevation for a stored satellite, the satellite name will appear in lower case letters. When the antenna is moved to within 15 counts of its azimuth position AND 10 counts for elevation, the name of the satellite will be displayed in capital letters. The conditions for azimuth and elevation position must simultaneously occur to have a name appear. Any satellite names that have not been assigned will not display.

Likewise, as the polarization is within approximately 40° of the target value, a lower case h or v appears in the display. The indication changes to upper case H or V when the probe is within 10°. No indication for polarity means the probe is positioned between h and v.

1. Toggle the MODE key to enter MANUAL mode.
2. Jog the antenna as desired using the east, west, up, and down arrow keys.
3. Adjust the polarization with the CW and CCW keys. (Once a satellite is stored in memory, the H and V keys will toggle the polarotor to those preset positions if Autopol is disabled.)

5.2 AUTO Mode.c.:5.2 AUTO Mode;

SELECT A SATELLITE: PANAMSAT-1 AUTO
USE SCROLL UP/DOWN, ENTER TO SELECT

Satellites which have been stored in the controller's non-volatile memory (via SETUP mode) can be recalled from AUTO mode. Azimuth, elevation, and H/V polarization data for up to fifty (50) satellites may be stored in non-volatile memory. If simultaneous azimuth and elevation movement (see CONFIG mode) is enabled, the antenna will move about the azimuth and elevation axis simultaneously when performing automatic moves. Simultaneous azimuth and elevation movement may only be enabled if the total current draw of the two axis is less than 8 amps.

1. Toggle the MODE key to enter AUTO mode.
2. SCROLL UP or SCROLL DOWN to the desired satellite name.
3. Press ENTER to select the satellite. The controller will then prompt for H or V polarization. Once this is selected, the controller will move the azimuth axis first, then the elevation, then fine-tune these positions. The polarization prompt will not be presented to the user if Autopol is enabled, in which case it will follow the level of the H/V input.
4. The move can be stopped at any time by pressing the STOP key.
5. When the move is completed, the mode will automatically change to MANUAL mode if the target is a geostationary satellite. This helps to eliminate accidental moves. If the target is an inclined satellite, the controller moves the antenna first to its nominal position in the arc. The controller then switches over to TRAK mode and begins either SEARCH or PROGRAM mode, depending on the status of the track data associated with the satellite. If a SEARCH is conducted, the mode will switch to STEP after the satellite position is peaked, and the controller will begin accumulating data on the particular satellite being viewed.

NOTE: WHEN THE POWER IS TURNED OFF, THE POLAROTOR PROBE MAY SLIGHTLY SHIFT POSITIONS. WHEN THE POWER IS REAPPLIED, THE POLAROTOR PROBE WILL MOVE BACK TO THE POSITION IT WAS AT BEFORE POWER WAS REMOVED. FOR THIS REASON, ALWAYS LEAVE THE CONTROLLER ON.

5.3 TRAK Mode.c.:5.3 TRAK Mode;

AZ:178.4 EL: 44.2 PL: 73 V SS:621 TRAK K
GSTAR 3 PROGRAM IDLE 15.56.0-MENU

The non-volatile memory of the RC2000B can hold track data for up to five inclined orbit satellites. The complex tasks of data collection, management, and maintenance are performed in TRAK mode (the tracking algorithms are described in detail in section 4.2). There are three main sub-states in TRAK mode: SEARCH, STEP, and PROGRAM, that break the large task down into smaller

units. The track sub-mode which is currently active is displayed to the right of the satellite name, followed by information specific to that sub-mode. The current frequency band, either C or Ku, is displayed in the upper right hand corner of the LCD.

Upon entering TRAK through AUTO mode, the controller checks for the presence of data stored in memory that may describe the satellite's path. If this data is not present, or is incomplete, the SEARCH mode is entered and the unit performs an intelligent search over the user defined inclination range.

When the SEARCH sub-mode is active, the following messages may be displayed:

SEARCH - A search is in progress.

SEARCH IDLE - A search has been performed and a satellite was not found. The controller is waiting to perform another search. The TRAK menu function may be used to immediately initiate another search or to change the search retry interval parameter.

After the SEARCH is completed, the antenna is returned to the position of strongest AGC input if an AGC signal greater than the appropriate threshold was recorded. The controller then switches to STEP mode, and performs a signal peaking function. This screen is shown below.

```
AZ: 1340 EL: -21 PL: 73 V SS:598 TRAK K
GSTAR 3 STEP SIG OK PEAKING
```

Once the peaking function is finished, PEAKING is replaced with IDLE XX.XX-0-MENU, where IDLE describes the current phase of STEP mode, XX.XX is the time in hours.minutes format, and 0-MENU describes a user keyboard option (more on this later). The . behind the time should flash at one second intervals, signifying that the software is running properly.

Based on the user inputs of frequency band and antenna size (entered in CONFIG mode), the controller will periodically change from IDLE to PEAKING and re-optimize the displayed signal strength, then return to IDLE. If left in this mode for approximately 24 hours, sufficient data will be collected and the sub-state will change to PROGRAM. If not left for this amount of time, the unit may find the satellite via a SEARCH the next time AUTO mode is invoked, or it may be able to use PROGRAM data.

When the STEP sub-mode is active, the following messages may be displayed:

STEP SIG OK IDLE - The AGC input indicates that a satellite signal is present and the controller is waiting to perform another peaking operation.

STEP SIG OK PEAKING - The antenna is currently being jogged to find the azimuth and elevation position which corresponds to the maximum received signal strength.

STEP NO SIG IDLE - The AGC input indicates that a satellite signal is not present (the AGC level is below the appropriate threshold level). The controller will wait approximately 5 minutes for the AGC to return before activating the SEARCH sub-mode.

In the PROGRAM sub-mode, the controller periodically adjusts the antenna position, shown as REPOSITION on the display, based on the user input for MAX TRACK ERROR. Smaller values for this input correspond to more frequent moves (and more wear on the jacks/motors) while larger values may cause perceptible picture degradation. For consumer quality mounts/actuators, a good initial value of 10 is recommended. In any event, maintaining good mount/actuator tolerances and minimizing component looseness is necessary for good tracking performance.

When the PROGRAM sub-mode is active the following messages may be displayed:

PROGRAM IDLE - The PROGRAM track sub-mode is active. The controller is waiting to reposition the antenna.

PROGRAM REPOSITION - The controller has determined that the antenna pointing error is greater than that specified by the max track error parameter, and is currently repositioning the antenna to a position derived from the track table.

PROGRAM PEAKING - The controller is performing a step track operation to either check the accuracy of or update a track table entry.

5.4 TRAK - MENU .c.:5.4 TRAK - MENU ;

The RC2000B allows the user access to key data while in SEARCH IDLE, STEP IDLE, or PROGRAM IDLE states. By pressing the 0 key when IDLE is displayed, the following menu is presented to the user.

```
1.VIEW 2.MODIFY 3.XXXXXX:_ MENU TRAK K
SAT NAME ENTER TO EXIT
```

Pressing 1, followed by ENTER, yields the following screen of data.

```
TM,AZ,EL TTTTT AAAAA EEEEE MENU TRAK K
SAT NAME SCROLL ^v,ENTER TO EXIT
```

Where

TTTTT is the sidereal time in seconds
AAAAA is the azimuth scale factor in counts per radian
and EEEEE is the elevation scale factor in counts per radian

Subsequent toggles on the SCROLL UP/DOWN keys display the following information from the track data table.

```
II TTTTT AAAAA EEEEE F MENU TRAK K
SAT NAME SCROLL ^v,ENTER TO EXIT
```

Where

II is the entry index, 0-47
TTTTT is the sidereal time in seconds for the entry
AAAAA is the azimuth position
EEEEEE is the elevation position
and F denotes the state of the update flag. '.' indicates that the update flag is set, a blank indicates that the update flag is reset.

After the 47th entry has been displayed, the first screen will appear again and the entire process will repeat. To exit this option, press ENTER to return to the MENU screen.

Pressing the 2 key, followed by ENTER, produces the following MODIFY screen.

```
UPDATE CHECK 0-999 HRS: 72   MENU TRAK K
SAT NAME          SCROLL ^v,ENTER TO EXIT
```

There are 8 data items that the user is allowed to modify with this option. Each is successively accessed by pressing the SCROLL UP/DN keys and advancing through the list. Each entry is explained in Table 1.

TABLE 1

Entry Name	Range	Description
UPDATE CHECK	0-999 HRS	The period of time between track table basepoint update checks.
SEARCH RETRY	0-999 MINS	The period of time between successive SEARCH attempts when no signal is present and PROGRAM track is not valid.
BAND: C,K	1 or 2	For dual band inclined orbit satellites, this prompt allows the user to change the frequency band. Note that the current band is displayed in the upper right hand corner of the LCD.
CLEAR TRACK	0 or 1	Press 1 to clear the track table entries or 0 to leave as is. Be careful with this one!
RESET UPDATE	0 or 1	Press 1 to clear the UPDATE flags for the track data, 0 to leave set.
FORCE UPDATE	0 or 1	Press 1 to set UPDATE flags, 0 to leave set. (Opposite function of RESET UPDATE.)
MAX ERROR	1-30	Specifies the maximum tracking error in tenths of a dB. Recommend nominal value of 10 for consumer mounts.
SEARCH FACTOR	1-10	Specifies a normalized scaling factor that increases or decreases the width of the search window. Values greater than 5 increase it, less than 5 decrease it. Recommend 4 as nominal value.

To exit this option, press ENTER any time to return to the MENU screen.

The value in the third field of the menu screen, denoted XXXXXX in the example, can take on either of three actions, depending on the particular sub-state the controller is in. This is described in Table 2.

TABLE 2

Sub-mode	XXXXXX	Action
STEP the antenna.	REPEAK	Causes the controller to immediately repeak
SEARCH search.	SEARCH	Causes the controller to initiate another
PROGRAM	.ALIGN	Will cause the controller to reposition the antenna per the current basepoint values.

Initiating any of the three possibilities here will abort the MENU screen and return control to the TRAK mode. It should be pointed out that all TRAK functions are halted while in MENU mode. For this reason, it is not advisable to leave the RC2000B in this mode for an extended time period.

5.5 LIMITS Mode.c.:5.5 LIMITS Mode;

Whenever the limits have been corrupted, the system will come up in LIMITS mode, forcing the user to re-enter the LIMITS before using the controller. In this mode the user can jog the antenna in any direction, set the limits, and adjust the polarization. The entry point screen for LIMITS mode is shown below.

```

SET EAST/WEST AND-OR UP/DOWN LIMITS
HIT ANY KEY TO CONTINUE
    
```

NOTE: To set limits, there MUST be someone outside at the antenna location to let the programmer know when the antenna has reached its physical limits of travel, because in LIMITS mode no software precautions are taken. It is critical that as the antenna is jogged using the direction keys, the antenna moves in the corresponding direction. If it does not, pins on J2 are reversed. Recheck Figure 3.1 and correct.

```

***** WARNING *****
THERE ARE NO RESTRICTIONS ON ANTENNA MOVEMENT
WHEN IN THE LIMITS MODE - USE CAUTION!
*****
    
```

1. Go to LIMITS mode and press ENTER. The screen will prompt for the East limit for azimuth and the Down limit for elevation. The EAST limit must be set before the WEST limit, and the DOWN limit must be set before the UP limit.

```

AZ: 5000 EL: 5000 SS1,2: 2, 1 LIMITS
7 - SET EAST LIMIT 9 - SET DOWN LIMIT
    
```

2. With an assistant at the antenna to notify you that the antenna is near its physical limit, move the antenna to the EAST limit and press the 7 key. The AZ count will reset to 30.

3. Repeat step 2, but with the WEST limit this time. Upon pressing the 7 key, the controller will ask the user to be sure of the selection. If limits are indeed to be set, press the BKSP key, else press ENTER. The controller will confirm a limit set with * AZIM LIMITS SET *. Position the antenna on a satellite near the center of the arc.

4. Move the antenna to the DOWN limit, again with an assistant to monitor the physical limit, and press 9 to set the limit. The counter will be reset to 30.

5. Move the antenna to the UP limit, press 9, then BKSP to confirm the selection.

NOTE: If LIMITS mode is exited before both endpoints of a limit are set, the RC2000B will ignore the partial limits and retain the previous values. If the controller powers down while LIMITS mode is active, all limit data may be lost.

5.6 SETUP Mode.c.:5.6 SETUP Mode;

POSITION ANTENNA, SELECT SETUP
SATELLITE USING SCROLL UP/DOWN,HIT ENTER

SETUP mode allows the user to jog the antenna and enter a satellite name, position, and polarization settings into memory. Once this information has been stored, the satellite name will appear in the list available in AUTO mode. The maximum number of stored satellite names is fifty (50). The display screen lists the SAT location the user is currently at (if a satellite is currently stored at this location) and allows the user to SELECT from a list of available satellite names. The display also informs the user of the current AZ, EL, and POL positions, AGC signal strength level, as well as the H/V and speed designations.

Store all geostationary satellites first before storing any inclined orbit satellites. The RC2000B uses information derived from fixed satellites to predict certain parameters associated with the mount. For this reason, at least two fixed satellites, separated by a minimum of 20, must be stored in memory before inclined satellites can be saved.

AZ: 1292 EL: 10 PL: 66 H SS:612 SETUP
SAT: SELECT:SBS 2 FAST

To store geostationary satellites, use the following procedure. For storing inclined orbit satellites, please refer to section 4.4.3.

1. Proceed to SETUP mode, and move the antenna to the easternmost satellite position you wish to program by pressing the appropriate direction keys. Use the SS indication to optimize the pointing accuracy of the antenna.

2. The satellite names will display in the order of their position in the arc, east to west. The predefined list of satellite names can be found at the end of this section. Scroll through the entries if the satellite you wish to program is included on the appropriate list. If the satellite name is not included on the list, proceed to 3b to enter a user-defined name into memory.

3a. Press ENTER to assign the name to this position. If the name has already been assigned to another position in memory, the system will prompt you for a confirmation before overriding this prior assignment.

4. The system will prompt the user to answer yes or no if this is an inclined orbit satellite. Since this section of the SETUP deals with geostationary satellites, answer NO.

5. The system will now prompt for entry of the longitude of this particular satellite, as well as an E/W designation. Enter a new value or select the default if it is correct by pressing ENTER.

6. The screen will now prompt for entry of polarization values. For the first satellite being programmed, the user MUST designate both an H and a V polarization. Use the CW and CCW keys to adjust the polarization, and press the H or V key to designate the polarization being set. The system will issue an acknowledgement of the selection, and prompt for the second polarization. The system will acknowledge with a "DATA ACCEPTED" message after these inputs are set.

On subsequent polarization assignments, the following screen will appear:

```
SELECT SPACENET 2 H/V POL DATA?   SETUP
1-H/V DATA FROM NEAREST SAT,2-USER ENTRY
```

The system will ask the user whether to assign the H/V data from the nearest satellite (typically the last entry), or whether new data will be entered.

7. The system will remain in SETUP mode, returning to the last name assigned. In this way, if all satellites are programmed in the order of their position in the arc from east to west, finding and assigning names is simplified. The user can then jog to the next satellite to be programmed, and follow the same procedure to assign the name and enter the longitudinal position. The system will then prompt for new H & V values, and if none are entered, will assign the same H & V pol from the nearest programmed satellite.

3b. If the satellite name is not in memory, you can assign a new name of up to ten (10) alphanumeric characters (A-Z, 0-9, or space) by accessing the USER entry mode as follows.

a. SCROLL DOWN until USER is shown as the satellite name.

b. Press ENTER - a star prompt (*) will appear in the first space.

c. To enter a letter, SCROLL UP through the alphabet.

To enter a number, SCROLL DOWN through numbers.

To enter a space, SCROLL UP once, then DOWN once.

(Letters and numbers are on a continuous scroll, so if you pass the desired value, simply back up by pushing the opposite key.)

d. When you reach the desired letter, number, or space, press ENTER.

e. The star (*) will prompt for second character - repeat entry.

f. When the name has been entered, press ENTER while at the star (*) to continue with the SETUP procedure.

Return to step 4.

TO SAVE AN INCLINED ORBIT SATELLITE

The procedure for an inclined orbit satellite is similar to that for a geostationary satellite. In addition to the data which must be supplied for a geostationary satellite, the user must also specify the satellite's frequency band (either C, K, or both for dual band satellites), and the inclination of the satellite's orbital plane to the earth's equatorial plane. See Sections 4.1 and 3.3.4. After the satellite's polarization has been entered, the user is prompted to select the initial track polarization. At this point the user should tune the receiver to a transponder which will be active for as long as possible, and select the polarization appropriate for that transponder. The controller will then switch to track mode and display the screen shown below.

```
AZ: 1246 EL: -36 PL: 72 V SS:736 TRAK K
SBS 2      INITIALIZING - PLEASE WAIT
```

The RC2000B begins an initialization process THAT CANNOT BE INTERRUPTED until the PLEASE WAIT message disappears. This process takes about one minute and is necessary to establish track data associated with this satellite. DO NOT INTERRUPT THIS PROCESS OR ALL DATA WILL BE LOST WITH REGARD TO THIS SATELLITE!

After initialization is complete, the RC2000B will switch to the TRACK mode STEP sub-mode. In this sub-mode the controller will track the satellite by jogging the antenna periodically to peak up the antenna. The track table is also compiled in the STEP sub-mode. If the user wishes to program in additional satellites, he or she may exit TRACK mode (by use of the MODE KEY) and activate SETUP mode.

RC2000B Preset Satellite Names - WEST SET

RC2000B Preset Satellite Names - EAST SET

5.7 RESET Mode.c.:5.7 RESET Mode;

AZ: OK 0 EL: OK 0 RESET
1 - RESET AZ, 2 - RESET EL, MODE - EXIT

The RESET mode is used to display drive fault conditions and re-enable the drive outputs in the event the microcontroller shuts an axis down. The messages that can be displayed are explained below. (Each axis is separately controlled.) The number following the status message is the status code - see the troubleshooting guide in Chapter 7 for the key to the status code displayed.

OK : Normal state - drive is enabled for operation.

JAMMED : Drive was shut down due to the absence of position counts during drive activation. Possibly a bad sensor or antenna is stuck.

RUNAWAY : Drive was de-activited because the processor sensed movement when drive was supposed to be inactive. The probable cause - an errant position pulse was recorded - possibly a damaged MOSFET.

DRIVE : Axis was de-activited due to an overload condition. Either the output lines shorted or the drive current is in excess of 8 amps.

LIMIT : The processor sensed the antenna was moving through the limit and shut the drive down.

Pressing 1 will reset the azimuth, and pressing 2 will reset the elevation.

In addition to processor shutdown capability, the RC2000B drive supply is protected by a circuit breaker, located on the back panel. This breaker is independent of computer generated error checking. Should the output current become excessive, this breaker may trip, and an antenna jammed condition will generally occur. Reset this breaker by pressing it in until it snaps into place. Check to make sure the status is OK via the RESET mode.

5.8 DELETE Mode.c.:5.8 DELETE Mode;

SELECT A SATELLITE: PANAMSAT-1 DELETE
USE SCROLL UP/DOWN, ENTER TO SELECT

This mode is used to delete a satellite entry.

1. Proceed to DELETE mode.
2. Scroll through the ASSIGNED satellite names.

3. When the desired satellite name is shown, press ENTER. The system will display the message

A SAT DATA DELETION HAS BEEN REQUESTED
BKSP TO CONFIRM, ANY OTHER KEY TO EXIT

Pressing BKSP will automatically delete this satellite from memory.

5.9 RE-SYNC Mode.c.:5.9 RE-SYNC Mode;

SELECT A SATELLITE: PANAMSAT-1 RE-SYNC
USE SCROLL UP/DOWN, ENTER TO SELECT

The RE-SYNC feature allows the controller to make a graceful recovery from sensor failure or in the unlikely event of an errant pulse count. By using this feature, the user simply has to correct for one satellite location, and the RC2000B automatically will correct all others.

1. While in MANUAL mode, peak the antenna on a satellite whose location was previously stored in memory.
2. Proceed to RE-SYNC mode.
3. Scroll through the list of assigned satellites (in alphabetical order) until the correct satellite name is displayed.
4. Press the ENTER key. The system will respond with the message

AN AZ/EL RE-SYNC HAS BEEN REQUESTED
BKSP TO CONFIRM, ANY OTHER KEY TO EXIT

5. Press BKSP to recalibrate all stored satellite locations. The system will confirm with the message

RE-SYNC ACCOMPLISHED

and will return to MANUAL mode.

6. With an assistant out at the antenna, validate the accuracy of the limits by moving the antenna to all four values.

NOTE: RE-SYNC CANNOT BE PERFORMED ON AN INCLINED ORBIT SATELLITE! THE
REFERENCE USED MUST BE A GEOSTATIONARY (FIXED) SATELLITE.

5.10 CONFIG Mode.c.:5.10 CONFIG Mode;

The CONFIG mode allows the user to view and/or modify various controller parameters and to enable or disable certain features. When this mode is active, the SCROLL UP and SCROLL DOWN keys may be used to select various items for either viewing or modification. To change the value of a parameter the user can simply key in a new value. The BKSP (backspace) KEY is active. If a new value is keyed in, for the change to take effect and update the parameter's value in the controller's non-volatile memory, the entry must be terminated with the ENTER key. If the present value of the parameter is invalid, '*' characters will be displayed in the item's data field. If the user terminates a data entry with the ENTER key and the value is accepted, the next CONFIG mode item will be displayed. If the user terminates a data entry with the ENTER key and the data is not accepted, the CONFIG mode item will not change. The MODE key can be depressed at any time to exit CONFIG mode.

AUTO-POL OPTIONS.c.:AUTO-POL OPTIONS;

AUTOPOL ENABLE:* CONFIG
0-DISABLE, 1-ENABLE ENT,BKSP,SCROLL ^v

Upon entering the CONFIG mode, the user is prompted to enable or disable the Autopol feature. This feature slaves the RC2000B polarization toggle to an externally generated signal, normally provided by a commercial receiver. With this mode enabled, the RC2000B will change the antenna's receive polarity as the controlling receiver's channel index is advanced. Enter a zero (0) to disable the feature, and a one (1) to enable it. For consumer applications, disabling Autopol is recommended.

AUTOPOL VPOL LEVEL:* CONFIG
0-LOW, 1-HIGH ENT,BKSP,SCROLL ^v

If the user chooses to enable Autopol, it is also necessary to designate whether the vertical polarization coincides with a high level (example: 12V) or low level (0V). Entering 0 corresponds to the low level, and 1 to a high level.

NOTE: When this feature is ON, the CW/CCW and the polarization H/V keys are disabled in MANUAL mode. The system denotes this feature is enabled by changing the display readout for polarization from PL: to PLR: on the manual mode screen.

SIMULTANEOUS AZ/EL ENABLE.c.:SIMULTANEOUS AZ/EL ENABLE;

SIMULTANEOUS AZ/EL ENABLE:* CONFIG
0-DISABLE, 1-ENABLE ENT,BKSP,SCROLL ^v

The second feature that can be enabled in this mode is the simultaneous AZ/EL movement. The default antenna positioning is azimuth first, then elevation, then fine-positioning azimuth. By enabling simultaneous movement, the controller will move the antenna along both axis at the same time, minimizing

the move time. When the antenna is close to the target azimuth and elevation, the system will pause, then fine-tune the azimuth, then fine-tune the elevation. The drive system will stop between each of these moves to allow the antenna to stabilize. The operator should be alert to this sequence to avoid hastily pressing a key which would stop the move prematurely.

To enable simultaneous movement, enter a 1. Entering a 0 will disable the feature.

NOTE: If the total current draw from both motors exceeds 8 amps, it is not possible to utilize this feature. Trying to enable it in this case will cause a breaker to open, which will disable the drive and generate an antenna jammed error.

TIME/DATE SETTINGS.c.:TIME/DATE SETTINGS;

ENTER TIME (HH.MM.SS): 08.46.00 CONFIG
USE 0-9 OR . ENT,BKSP,SCROLL ^v

The real-time clock must be set to establish a time reference for all tracking data stored in the controller. Enter the local time using the 0-9 keys and the . key to separate the hours, minutes, and seconds fields. Each field must have two digits entered; i.e., 8 must be entered as 08 or the unit will not accept the entry. The time cannot be changed for daylight-savings time purposes once valid track data is stored or the unit will not function properly.

ENTER DATE (MM.DD.YY):07.03.92 CONFIG
USE 0-9 OR . ENT,BKSP,SCROLL ^v

Enter the current data in the format shown. Again, use the 0-9 keys to enter the month, day, and year fields, and use the . key to separate fields. Single digit fields must be entered with a 0 preceding, as shown in the example for 07.03.92.

AGC SETTINGS.c.:AGC SETTINGS;

AGC POLARITY FLAG;1 CONFIG
0-NEGATIVE 1-POSITIVE ENT,BKSP,SCROLL ^v

This entry tells the controller what the sense is on the input AGC voltage used for tracking. A positive sense is defined as one that increases in magnitude as the RF signal strength increases. If the AGC voltage decreases as the RF signal increases, its sense is considered negative. Enter the appropriate value, either 0 or 1, followed by ENTER to key in the value.

AGC C BAND THRESHOLD:125 CONFIG
0 - 999 ENT,BKSP,SCROLL ^v

When the receiver is tuned to a C band satellite and the signal strength is above the AGC C BAND THRESHOLD value, it is assumed that a satellite signal is present. The same threshold is applied to both AGC channels.

```
AGC K BAND THRESHOLD:150          CONFIG
0 - 999                          ENT,BKSP,SCROLL ^v
```

This is similar to the C band threshold described above, except it pertains to Ku band. If the signal strength is above the AGC K BAND THRESHOLD value when the receiver is tuned to a Ku band satellite, the controller assumes that a satellite signal is present.

These AGC parameters are critical to the proper operation of the controller when tracking inclined orbit satellites. Refer to section 4.4.1.

```
.c.::;
ANTENNA PARAMETERS;
```

```
ANTENNA LATITUDE LL.L: 38.9 N      CONFIG
TENTHS AFTER DEC. PT  ENT,BKSP,SCROLL ^v
```

```
ANTENNA LONGITUDE LLL.L: 97.5 W    CONFIG
TENTHS AFTER DEC. PT  ENT,BKSP,SCROLL ^v
```

The antenna/downlink location is necessary for the satellite track path prediction algorithm. The format for these entries is degrees.tenths of degrees (as opposed to degrees.minutes as on a map). A conversion table from minutes to tenths of degrees is shown below.

Minutes	Tenth of Degrees
6	.1
12	.2
18	.3
24	.4
30	.5
36	.6
42	.7
48	.8
54	.9

After entering the latitude/longitude using the 0-9 and . keys, press ENTER. The RC2000B will prompt for the appropriate direction terminator, E/W for longitude, N/S for latitude. Enter the correct value using 2-North, 8-South, 4-East, or 6-West.

```
ANTENNA SIZE (40 - 700):366        CONFIG
CENTIMETERS                       ENT,BKSP,SCROLL ^v
```

The antenna size is used to calculate various parameters associated with TRAK mode and is entered in this screen. The size is specified in centimeters, and the following table lists some common sizes.

Diameter in Feet	Meters	RC2000B Input
------------------	--------	---------------

5.9	1.8	180
8.0	2.44	244
10.0	3.05	305
12.0	3.66	366
15.0	4.57	457
20.0	6.1	610
23.0	7.0	700

Use the 0-9 keys followed by ENTER to input the antenna diameter.
MAX TRACK ERROR.c.:MAX TRACK ERROR;

MAX TRACK ERROR(1-30):10 CONFIG
IN TENTHS OF A dB ENT,BKSP,SCROLL ^v

The MAX TRACK ERROR, given in tenths of a dB, is used to define the step size of antenna movement during STEP TRACK peaking and during PROGRAM TRACK mode. Because of this, care must be taken not to specify too tight of an error (value less than 10) for mounts/actuators with excessive endplay or slop. A sign of this problem will be the display of the PEAK LIMIT error that can occur in TRAK mode. Should this happen, adjust the MAX TRACK ERROR to a higher value. See section 4.2 and 4.3 for more information.

AZIM SEARCH SCALE FACTOR.c.:AZIM SEARCH SCALE FACTOR;

AZIM SEARCH SCALE FACTOR:3 CONFIG
1-10 NOMINAL = 3 ENT,BKSP,SCROLL ^v

This scale factor affects the width of the search window, in the polar plane, used during the SEARCH operation. A value of 5 allows the antenna to search over a nominal +/-1.8 degree path. If problems arise with locking onto adjacent satellites during SEARCH mode, try decreasing this value to 1 or 2, or use a larger antenna. See section 4.2.

SLOW SPEED SETTINGS.c.:SLOW SPEED SETTINGS;

AZIM SLOW SPEED 0-254:150 CONFIG
 ENT,BKSP,SCROLL ^v

ELEV SLOW SPEED 0-254:150 CONFIG
 ENT,BKSP,SCROLL ^v

The Adapti-Drivem system allows the user to specify a slow speed code for each axis and then will maintain a consistent speed through the implementation of a digital servo loop. The range on the slow speed code is 0-254, with 254 equating to full speed and 0 essentially stopped. Please refer to section 3.4 for the procedure used to determine the azimuth and elevation slow speed codes.

AZIMUTH AND ELEVATION ANGLE DISPLAY.c.:AZIMUTH AND ELEVATION ANGLE DISPLAY;

The RC2000B has the ability to display azimuth and elevation position in an angle format. This feature can greatly facilitate the process of locating satellites for systems which use an elevation over azimuth type antenna mount. Please see section 3.6 for more information on how to enable and calibrate this feature.

Briefly, to calibrate the angle display feature, the user locates two satellites and records their azimuth and elevation position count values. The scale.exe PC program (for IBM compatibles - in the back of this manual) is then used to calculate azimuth and elevation scale factors which are entered into the controller via the CONFIG mode items described in this section. The scale.exe program prompts for the antenna latitude and longitude, and the longitude, azimuth position count, and elevation position count values for a pair of satellites which have been located with the controller.

When the Angle Display Enable CONFIG mode item is set to 1 (enabled), azimuth and elevation positions are displayed in an angle format using the other items described in this section.

```
ANGLE DISPLAY ENABLE:0          CONFIG
0-DISABLE, 1-ENABLE    ENT,BKSP,SCROLL ^v
```

The Azim Scale Factor and Azim Offset items are used to calibrate the display of azimuth position according to the following formula:

```
Display_Angle = 180.0 +
((10 * (Azim_Position_Cnt - Azim_Offset)) / Azim_Scale_Factor)
(Northern Hemisphere)
```

```
Display_Angle = 360.0 -
((10 * (Azim_Position_Cnt - Azim_Offset)) / Azim_Scale_Factor)
(Southern Hemisphere - Note the displayed angle is adjusted by adding or
subtracting 360.0 so that the result is in the range of 0 to 360.0 degrees. )
```

```
AZIM SCALE FACTOR:    1          CONFIG
                      ENT,BKSP,SCROLL ^v
```

```
AZIM OFFSET:         0          CONFIG
                      ENT,BKSP,SCROLL ^v
```

The Elev Scale Factor and Elev Offset items are used to calibrate the display of elevation position according to the following formula:

```
Display_Angle = (10 * (Elev_Position_Cnt + Elev_Offset)) / Elev_Scale_Factor
ELEV SCALE FACTOR:    1          CONFIG
                      ENT,BKSP,SCROLL ^v
```

```
ELEV OFFSET:         0          CONFIG
                      ENT,BKSP,SCROLL ^v
```

```
RESET SYSTEM DATA.c.:RESET SYSTEM DATA;
```

RESET SYSTEM DATA: 0 CONFIG
ENTER CODE ENT,BKSP,SCROLL ^v

The RESET SYSTEM DATA option is generally reserved as a means to clear test data from the controller by factory personnel. After preliminary testing, alignment, and burn-in, the units' memory is cleared by entering the code of 41758. Caution must be exercised before using this feature in the field, in that all data will be lost if it is used, and complete re-programming will be necessary!

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Specifications
RC2000B Az/El Tracking Antenna Controller.....Chapter 6...
Specifications

Inspect unit for any damage caused during shipping. If any exists, notify shipper immediately.

A. PHYSICAL

Size: 19.0" x 3.5"H x 9.0"D (Rack)
15.0"W x 3.5"H x 9.0"D (Desk)
Weight: 12.5 lbs.
Temperature: 0-50oC
Input Power: 115/230 VAC, 50/60 Hz., 48 W

B. DRIVE

Output: 12-36VDC, 8.0 Amps
280VA
Sensor Input: Reed, Hall Effect, Optical
Polarization: Standard Polarotortm Interface

C. TRACK MODE

Antenna Size: 0.4 - 7.0 meters
Tracking Accuracy: Mount Dependent
0.1 - 3.0 dB, selectable
Maximum Inclination: +/- 10 deg., standard
Tracking Modes: Intelli-Searchtm, Step Track, Program Track
AGC Input Range: 0-6.0 VDC
AGC Input Impedance: 2M ohm
AGC Inputs: 2
Inclined Satellites: 5 Max.

D. Drive Transfer Function

See Figure A1 in Appendix.

E. Non-Volatile Memory Battery

Duracell DL2450

F. AC input and drive supply lines are protected by circuit breakers. There are no user replaceable fuses in this unit.

RC2000B Az/El Tracking Antenna Controller.....Chapter 7
Error Codes
RC2000B Az/El Tracking Antenna Controller.....Chapter 7
Error Codes

The alarm system monitors important system parameters and flashes a message on the bottom line of the LCD display if an error is found. The parameters monitored include the condition of the lithium battery, status of the azimuth and elevation antenna drive systems, and the values of certain variables. Some error codes have priority over others. Alarm conditions are sampled sequentially, with the highest priority sampled first. As corrective action is taken for each error, the code is eliminated, and if there is a lesser error, it will then appear. The error codes can be categorized as system or track mode related, and following is a description of each one and the corrective action prescribed.

I. SYSTEM ERROR CODES.c.:I. SYSTEM ERROR CODES;

LOW BATTERY.c.:LOW BATTERY;

The RC2000B constantly monitors the level of the lithium battery. When the power level is low, this error code will appear. Replace the battery with a Duracell DL2450. Take care to hold the battery tab away from the battery housing while replacing the battery, and it will not be necessary to reprogram the memory.

AZIM LIMITS CORRUPTED & ELEV LIMITS CORRUPTED.c.:AZIM LIMITS CORRUPTED & ELEV LIMITS CORRUPTED;

One of the antenna software limits has been corrupted. Go into LIMITS mode and reset the software limits. See Section 5.5.

AZIM COUNT CORRUPTED & ELEV COUNT CORRUPTED.c.:AZIM COUNT CORRUPTED & ELEV COUNT CORRUPTED;

The internal position count has been corrupted. Manually find a satellite and go into RE-SYNC mode to update positions. See Section 5.9.

ANTENNA AZIM ERROR & ANTENNA ELEV ERROR.c.:ANTENNA AZIM ERROR & ANTENNA ELEV ERROR;

This error code will appear when one of four conditions occurs: a runaway antenna, a jammed antenna, the drive circuitry has detected an overcurrent, or a limit violation occurred. Go to RESET mode to determine which condition occurred, remedy the condition, and Reset the controller. See Section 5.7.

A Reset mode JAMMED indication may mean that the drive breaker "broke". This can occur if simultaneous movement is enabled, and the total current draw from both motors exceeds 8 amps. Reset the breaker by pressing it back into place, and disable Simultaneous AZ/EL movement. See Section 5.10.

AZIM SLOW SPEED CODE CORRUPTED/ELEV SLOW SPEED CODE CORRUPTED.c.:AZIM SLOW SPEED CODE CORRUPTED/ELEV SLOW SPEED CODE CORRUPTED;

The code entered by the user for the azimuth or elevation slow speed has been corrupted. Go to the corresponding speed mode and reenter the slow speed code. See Section 5.10.

AUTOPOL CONFIG DATA CORRUPTED.c.:AUTOPOL CONFIG DATA CORRUPTED;

The user has the option to configure the system for Autopol ON or OFF, and to denote a HI or LO level for the vertical polarization. If either of these values is corrupted, this error will appear. Go to CONFIG mode and reenter the correct values. See Section 5.10.

SIMULTANEOUS AZIM/ELEV CONFIG CORRUPTED.c.:SIMULTANEOUS AZIM/ELEV CONFIG CORRUPTED;

The user has the option to enable/disable the simultaneous AZ/EL movement of the antenna. If this value is corrupted, this error code will appear. Go to CONFIG mode and reenter the correct value. See Section 5.10.

.c.TRACK CONFIG ERROR.c.:.c.:TRACK CONFIG ERROR;

This error indicates an invalid entry in memory for at least one of the following pieces of data:

	Variable	Range
1.	MAX TRACK ERROR	(1-30)
2.	AZIM SEARCH SCALE FACTOR	(1-10)

Proceed to the CONFIG mode and correct all entries that are either out of range or incorrect for the system used. Section 5.10

ANT/RCVR CONFIG ERROR.c.:ANT/RCVR CONFIG ERROR;

This error indicates an invalid entry in memory for at least one of the following pieces of data:

	Variable	Range
1.	AGC POLARITY FLAG	(0 or 1)
2.	AGC C BAND THRESHOLD	(0-999)
3.	AGC K BAND THRESHOLD	(0-999)
4.	ANTENNA SIZE: CENTIMETERS	(40-700)
5.	ANTENNA LATITUDE	(0-90, N or S)
6.	ANTENNA LONGITUDE	(0-180, E or W)

Proceed to the CONFIG mode and correct all incorrect or out of range entries. Section 5.10

TIME/DATE ERROR.c.:TIME/DATE ERROR;

An error of this type indicates the system clock has not been set or has been corrupted. It is also possible that the lithium battery used to power the non-volatile memory is too low to keep the clock running, although the LOW BATTERY alarm should be flashing if this is the case.

Proceed to the CONFIG mode and enter the proper time in HH.MM.SS format, and then advance one screen to enter the proper date in MM.DD.YY format. Section 5.10

ANGLE DISPLAY ERROR.c.:ANGLE DISPLAY ERROR;

This alarm indicates that the CONFIG mode items associated with the display of azimuth and elevation position in an angle format have been corrupted. Check the Angle Display Enable, Azim Scale Factor, Azim Offset, Elev Scale Factor, and Elev Offset CONFIG mode items.

II. TRACK MODE ERRORS.c.:II. TRACK MODE ERRORS;

Should one of the following errors occur during TRAK operation, the controller will display an error message mid-position of the second row on the display. Also, all tracking operations will halt until the error is corrected.

JAMMED.c.:JAMMED;

If the controller does not sense feedback/position pulses from the reed or hall-effect sensor while it asserts the drive lines, it will halt the drive signals and display the JAMMED message. Check to make sure the drive circuit breaker has not tripped, or mode to RESET and reset the axis that was shut down. Section 5.9

LIMIT.c.:LIMIT;

The controller encountered an azimuth or elevation limit during a track movement operation. This represents a serious error because it means the limits have to be changed to allow tracking of this satellite, and all position values will become invalid when the limits are moved. Be sure to set the limits wide enough to allow ample tracking over the entire range.

DRIVE.c.:DRIVE;

This error indicates a runaway or unexpected count input on the sensor lines. The controller will shut down the drive experiencing this error, and will have to be reset in RESET mode. Section 5.9

PEAK LIMIT.c.:PEAK LIMIT;

This error signifies to the user that the peaking window limit was encountered while the controller was implementing a peaking operation; either in STEP mode or while updating a base point in the track table. The cause for this error is typically excessive play in the mount/actuator system or a MAX TRACK ERROR that is too low for a particular antenna. Try increasing the MAX TRACK ERROR, in CONFIG mode, Section 5.10, or replace the actuator to remove excessive mount play.

SCALE FACTOR.c.:SCALE FACTOR;

The controller automatically computes azimuth and elevation scale factors, in counts per radian, from data derived from fixed satellites stored in memory. This error indicates that either the memory has become corrupted, or the controller could not compute the scale factor from the satellites stored. For a valid computation to occur, the controller must find two fixed satellites in memory that are spaced greater than 2 degrees. If two fixed satellites are not stored that satisfy this criterion, proceed to SETUP mode and add satellites to memory that will satisfy this condition. Section 5.6

SYSTEM.c.:SYSTEM;

System errors were summarized in the previous list of SYSTEM ERRORS. Mode to MANUAL and note which error is displayed. Take the appropriate action as described in the SYSTEM ERRORS section.

CHECKSUM.c.:CHECKSUM;

This error indicates the memory in the satellites' track table or header has been corrupted. The only way to correct this error is to re-initialize the satellite by re-storing it in SETUP mode. Section 5.6

OPERATIONAL TROUBLESHOOTING TIPS.c.:OPERATIONAL TROUBLESHOOTING TIPS;

SYMPTOM * CAUSE * SOLUTION

Drive error fault in fast mode * Position pulses not returning during move *
Check sensor/cables to make sure of proper operation.

Drive error fault in slow mode * Position pulses not returning in time during
move * Increase the SLOW speed code value.

Non-volatile memory corrupted after power was off * Battery voltage too low to
maintain memory * Replace battery with Duracell DL2450.

DRIVE FAULT ERROR CODES (Reset Mode).c.:DRIVE FAULT ERROR CODES (Reset Mode);

ERROR CODE	DRIVE FAULT STATE	DESCRIPTION
0	NONE	Normal condition - OK
1	Brake/Coast	Fault occurs when the drive is in brake or coast modes; possible cause is a damaged MOSFET.
2	Configure	Fault detected while drive was being configured for a move; possible causes include shorted drive wires,damaged MOSFET.
3	Move	Fault detected while drive was attempting to move antenna; possible causes include malfunctioning sensor or locked antenna (JAMMED message), overload condition (DRIVE message), due to excessive simultaneous AZ/EL load or greater than 8 amp single axis load.

RC2000B Az/El Tracking Antenna
Controller.....Appendix
RC2000B Az/El Tracking Antenna
Controller.....Appendix

APPENDIX.c.APPENDIX;

Restoring Non-Volatile Memory

This appendix outlines a procedure which allows the user to restore the contents of non-volatile memory. A number of events can make it necessary to restore the contents of non-volatile memory, including:

- i) changing the battery which powers the non-volatile memory and allowing the center tab of the battery holder to touch the base of the battery holder,
- ii) performing maintenance on the controller,
- iii) swapping one controller out for another, or
- iv) upgrading to a newer version of the software which uses a memory map different from the original memory map.

Here is the procedure ...

1. In manual mode, jog the antenna to the west and up limit. Record the position count value for each axis just before the limit is reached. (If position display in degrees is enabled, disable that feature before starting this procedure - this feature is available only for certain software versions).
2. Go to CONFIG mode and record the value of each CONFIG mode item.
3. Using AUTO mode, position the antenna on each of the geostationary satellites stored in non-volatile memory. Record the azimuth and elevation positions and the longitude value of each geostationary satellite. Use the H and V keys to position the polarotor. Record the H and V positions for each satellite. (If polarization position display in degrees is enabled, disable that feature. This feature is available only for certain software versions.)
4. If the RC2KPOL option is installed, move the polarization to the positions just within the CW and CCW limits. Record these values.
5. Move the antenna to the position just before the east and down limits are reached. This should correspond to a position count value of 30 for both the azimuth and elevation axis.
6. Turn the unit off, unplug the unit from the AC power, and perform whatever maintenance is required. If the EPROM is replaced, be sure to insert the chip into the socket properly. The notch on the end of the chip should line up with the notch of the outline silk-screened onto the printed circuit board under the EPROM socket. When the maintenance has been performed, power the unit up. If the non-volatile memory has been corrupted, the unit will either go to LIMITS mode or will flash an error message on the bottom line of the display. If this occurs, the following steps of this procedure will have to be performed to restore the non-volatile memory.
7. Go to LIMITS mode. WITHOUT MOVING THE ANTENNA set the down and east limits. AFTER THE EAST AND DOWN LIMITS HAVE BEEN SET, jog the antenna to the positions for the west and up limit recorded in step 1. Set the west and up

limits. After the west and up limits have been set, exit LIMITS mode by hitting the MODE KEY.

8. If the RC2KPOL option (which allows the RC2000A to control a polarization motor with potentiometer feedback) is installed, go to POL LIMITS mode and restore the polarization limits.

9. Go to CONFIG mode and key in the data recorded in step 2 above. Each entry must be terminated with the ENTER key. After the data has been entered scroll through the CONFIG mode items (using the SCROLL UP and SCROLL DOWN keys) and make sure that the data has been entered correctly.

10. In this step, the positions of the geostationary satellites are stored in non-volatile memory. Go to SETUP mode. Position the antenna on each of the satellites which were recorded in step 3 above. Select the satellite name, enter the satellite longitude, and move the polarotor to the recorded H and V positions in response to the appropriate SETUP mode prompts.

Recovering From Unexpected Memory Upsets.c.Recovering From Unexpected Memory Upsets;

The key to restoring the non-volatile memory is getting the azimuth and elevation limits and position counts right. The position counts are initialized to 30 when the east and down limits are set. If the antenna can be unambiguously placed at the east and down limits, non-volatile memory can be restored quite easily. It is probably a good idea to use a punch or a waterproof magic marker to mark the antenna and mount assembly so that the east and down limit positions can be identified. In addition, it may be useful to identify and mark other places on the mount where slippage could occur. This would allow the mount to be restored to its original configuration.

If the contents of non-volatile memory are recorded as outlined in steps 1-4 above, recovery from an unexpected memory upset can be readily accomplished. If the memory is corrupted, the antenna can be moved (in LIMITS mode) to the east and down limit with the aid of an assistant stationed at the antenna. Next, steps 7-9 can be used to restore the contents of non-volatile memory.

Note that the procedure for restoring non-volatile memory only works if the count characteristics of the actuators are not changed. If the actuator count characteristics are changed, the count values that correspond to the west and up limit will change, as will the positions of all of the satellites.

FIGURE A-1 DRIVE TRANSFER FUNCTION

FIGURE A-2 DRIVE BOARD LAYOUT

FIGURE A-3 PROCESSOR BOARD LAYOUT

RC2000B AZ/EL TRACKING

ANTENNA CONTROLLER

v 1.07

CONTENTS SUBJECT TO CHANGE
12-5-95

RESEARCH CONCEPTS, INC.

LENEXA, KS

(913) 469-4125

(Please read this manual before operating the RC2000B;
that is why we wrote it!)

REVISION HISTORY

5.25.93 v 1.01

* Original code - derived from the RC2000B Polar version 1.03 code.

12.5.95 V 1.07

* The default value of the Azim Search Scale Factor CONFIG mode item was changed from 5 to 3. This will decrease the default search width.

* The east and west satellite lists were upgraded.

* A slight error in the floating point math routines was corrected. The error caused the azimuth pickup step size, azimuth search width, and azimuth peak limit error window to be smaller than they should be.

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