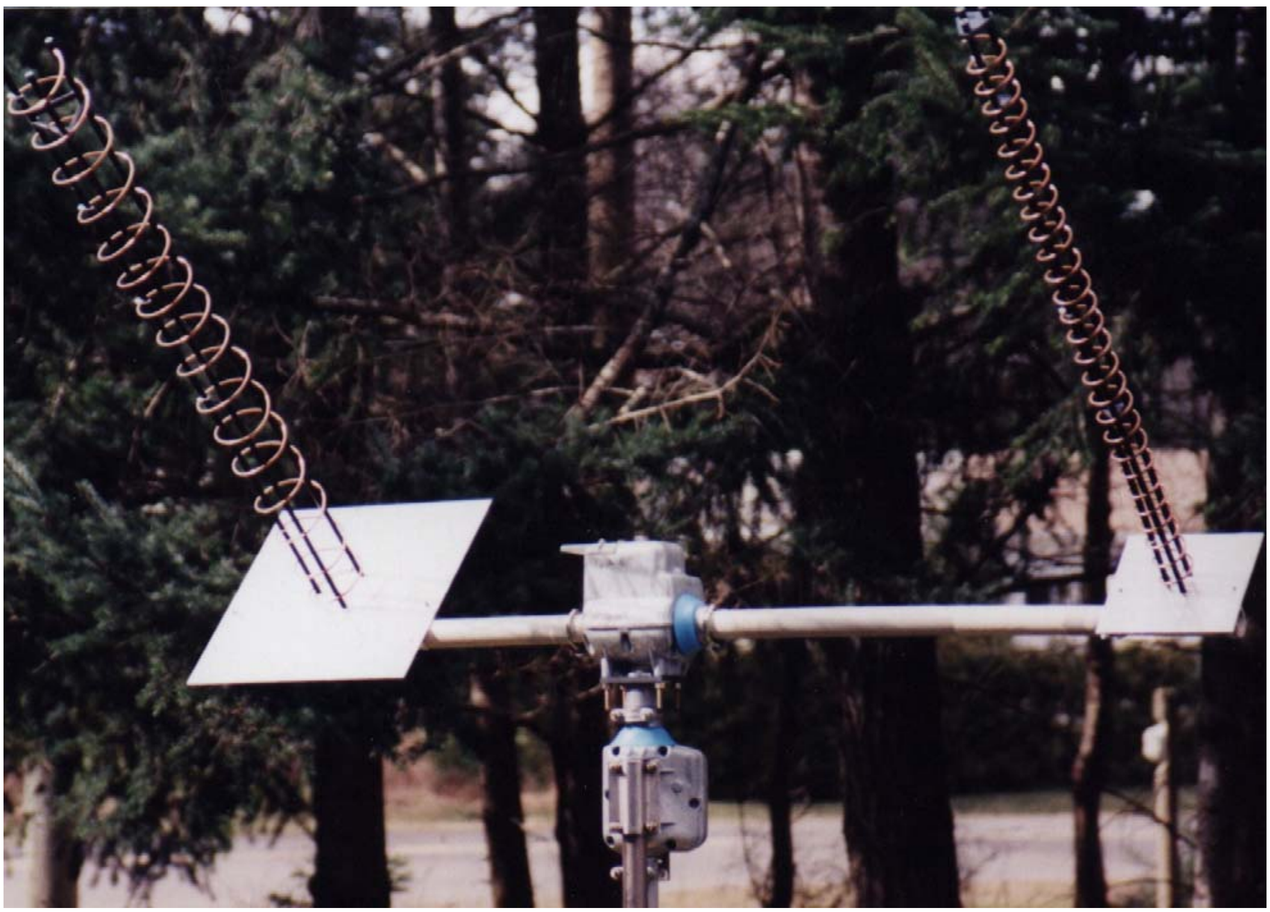
Sat*EL* Az-*EL*!



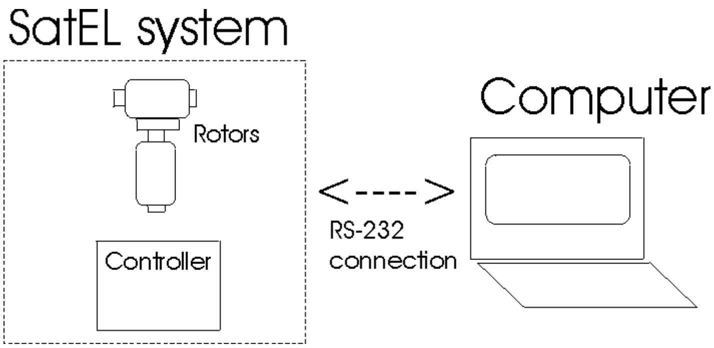
The Sat*EL* Az-*EL!*

Azimuth-Elevation Rotor System,
Rotor Controller Module, and
Windows™ Control Program

Instruction Manual

Index

I. **Introduction:** Overview of the Basic System



A block diagram of the basic Sat*EL* system is shown adjacent. It consists of the controller that is mounted in a box and is powered by a 24 VAC ‘wall wart’ and the dual rotor antenna drive pair. The controller is the small PC-board carrying a microprocessor which does all the work and which stores all the positions for future motion. The rotors are actuated using solid state relays which are much more reliable than mechanical relays and which never get dirty contacts. Future times and positions for the antenna system are loaded into the controller by a computer. Once the data has been loaded into the controller via the RS-232 connection, the computer can be turned off or used for other purposes and the controller will dutifully move the rotors to the appropriate positions at the appropriate times. A program *AzElControl.exe,* described below, runs under Windows™ on the computer and provides a means of communicating with and storing data into the controller.

II. **Hardware Assembly**

<u>Assembling the table mount and rotor stack</u>

Begin by assembling the table support mount. The table support mount will be useful during the assembly and testing of the Az-El system until you mount it outdoors. The support mount is made up of a 10” gray PVC mast with a threaded attachment glued on one end and a metal lock washer screwed loosely on the threads, plus the 8” x 10” x 3/8” black base with four rubber support feet on the bottom. Attach the mast to the base and tighten the metal nut firmly.

Mount the azimuth rotor (the one *without* the small water drain hole drilled in the side of the aluminum rotor casting) to the top of the mast with the hardware provided.

Next, use the second 10” PVC mast, the one with the ~2” x ~3” rectangular coupler plate attached. Attach this plate to the base of the elevation rotor using the ¼-20 nuts hardware provided. Insert this mast into the center of the azimuth rotor and clamp it into position with the hardware provided.

A convenient horizontal boom for mounting antennas can be made using a 4-ft length of the 1” electrical conduit, available at hardware stores, the same gray electrical conduit as is used for the two 10" masts. If the antennas to be mounted are particularly heavy, you can make the horizontal boom more rigid by driving a standard 1" diameter wooden dowel, available at hardware stores, into the conduit with a hammer. This dowel is a snug but manageable fit into the 1" plastic conduit. For some antennas, depending on their mounting configuration, it is important not to use conductive metals for the horizontal boom, and this PVC + wooden dowel boom meets that requirement nicely.

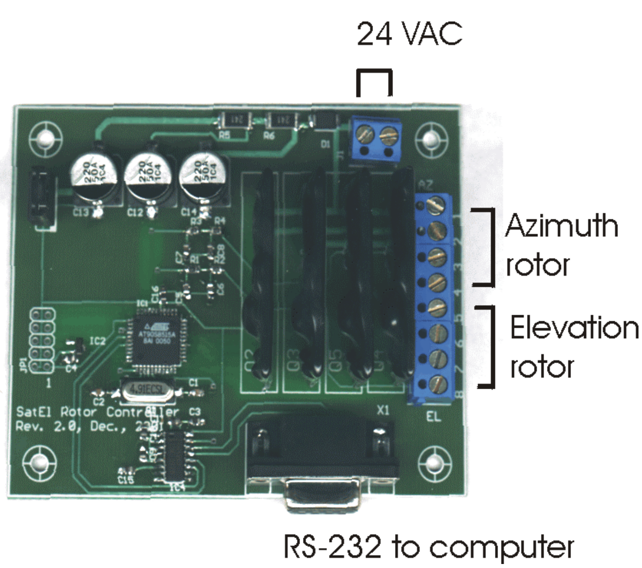
If you want a boom longer than four feet, use a longer PVC tube. Here is how to make, for example, an 8-ft. boom. Wooden dowel stock generally only comes in 4-ft. lengths, so buy two dowel lengths, drive the first one into one end of the 8-ft. long PVC with a hammer. Cut the second 4-ft. dowel in half, then drive the first 4-ft. dowel to the center of the 8-ft. PVC by driving it further in with one of the 2-ft. dowels. Finish by driving the other 2-ft. dowel into the other end. Not quite as strong as if an 8-ft. dowel were used, but probably strong enough, especially if you put your heavier antennas on the inner 4-ft span.

It may be convenient, however, not to mount the full-length horizontal boom during the testing and setup phase, as it will require a substantial turning radius, an inconvenience indoors. While setting up the Az-El rotor indoors, it may be more convenient to use a short length (~1.5 feet) of boom, made from the same 1" electrical conduit. We drilled a ¼" hole transversely at one end of a such a short boom and inserted a 6" length of ¼" wooden dowel, to serve as a "pointer", a substitute for an antenna, to be able to see easily in which sky direction a mounted antenna would be pointing.

This completes the rotor assembly.

Connecting the rotor controller to the wall power supply

Open the controller box by loosening the four corner screws in the box bottom to reveal the controller board. The connections to the controller board are shown in the figure below. Connect the wall power supply to the controller board. The power supply is 24 VAC from the supplied wall-mount transformer. Use common lightweight stranded lamp cord, sometimes called "zip cord", to connect the wall-mount transformer to the terminals on the controller board. Tinning the ends of the lamp cord wires with solder at both ends prior to attachment to the transformer and the controller board will help avoid shorts due to wayward wire strands.



The power zip cord is connected to a two-pin terminal block mounted along the top edge of the controller board. The wall-mounted transformer has a difficult-to-replace internal fuse, so take care to avoid shorting the transformer output.

Connecting the rotor controller to the rotors and the computer

The eight wires to the two rotors go to the eight-pin terminal block along the right edge of the controller board. The four wires from the azimuth rotor go to pins 1 – 4 consecutively. The aluminum casing of the rotor has, adjacent to the area where the screw terminals are, numbers associated with the four terminals of the rotor. These numbers are molded into the aluminum casting of the adjacent case. Pin 1 on the azimuth rotor goes to pin 1 of the controller terminal block, 2 to 2, 3 to 3 and 4 to 4. The four wires to the elevation rotor consecutively go to pins 5- 8 of the terminal block: pin 1 of the elevation rotor goes to pin 5 of the terminal block, 2 to 6, 3 to 7 and 4 to 8 respectively.

You have a number of choices for cabling the rotors. For example, you can use two four-conductor cables, one for each rotor, or you can use a single 7- or 8-conductor cable. Whichever option you choose, we recommend you select stranded wire cables rather than cables with solid-core wire. Stranded wire is more reliable in this situation where the wires may be “worked” as the controller box is moved, possibly breaking the solid conductor. If you decide to use solid core wire be careful to avoid nicking the wire when stripping its insulation.

If you choose to use two 4-conductor cables, we recommend against using the common 4-conductor solid-core wire used for telephones. Such wire (typically 24 gauge) is a bit light for this application, and as mentioned above we recommend stranded wire. The conductors in the cable should be of 18 to 22 AWG. Strip and tin each cable wire end to prevent fraying and possible shorts.

You can choose to use a single 7- or 8- conductor cable. A 7-conductor cable can be used because the ground wire is common to the two rotors because each rotor has a common ‘ground’ terminal: terminal 3. That is, a single wire in the cable connected to either controller ground terminals 3 or 7 can go to both azimuth rotor terminal 3 and elevation rotor terminal 3.

The cable to the elevation rotor is conveniently routed through the center hole of the vertical “T” coupler mast that joins the two rotors. This will prevent the elevation rotor cable from getting tangled with antennas or other nearby structures.

The terminal connections are summarized in the table below.

Table of Terminal Connections

Controller terminal	Az. rotor terminal	El. rotor terminal
1	1	
2	2	
3	3 (ground)	
4	4	
5		1
6		2
7		3 (ground)
8		4

You will also need a connection from the nine-pin connector along the bottom edge of the controller board to your computer’s serial port. A standard nine-pin female to nine-pin male serial cable, of a length appropriate to your situation, is required, and this can be bought at any computer or electronics store.

This completes the cabling connections.

III. Installing the Software on your computer

Introduction to the software

The accompanying CD-ROM contains the Sat*EL* rotor control program, this instruction manual, a freeware copy of the well-known terminal program, *Kermit*, and several freeware programs for synchronizing your computer's clock to an atomic standard. Before discussing the installation of these programs, it is useful to describe the overall way the Sat*EL* controller interacts with your computer.

The Sat*EL* rotor system is an improved version of the azimuth-elevation system described in the Dec, 1999, QST article by Jim Koehler, VE5FP entitled "An Inexpensive Az-El Rotator System". Like that system, the Sat*EL* rotors are controlled by a dedicated microprocessor which keeps track of time, stores future desired pointing angles and moves the rotors to point to these positions at the appropriate times. All communication between the Sat*EL* system and your computer is via a serial RS-232 port, as it was in the earlier VE5FP system,

This improved version of the system is backward compatible with the original system. This means that you can, if you choose, control the Az-El just by running a "terminal" program such as *Kermit*; one which makes your computer act like a terminal to talk to the Sat*EL* system. In this way you can change the microprocessor date and time, move the two rotors in all directions: the elevation rotor up or down, the azimuth rotor clockwise or counter-clockwise, etc. You can also type in a list of future desired positions and the time that you want the system to point there. You can disable future automatic motion, enable it, clear the memory and interrogate the system to determine its status. A full set of the commands to the system and its response are described in the original article. A summary of these commands is found in Appendix A.

However, this way of controlling the rotor system is tedious and prone to error. The original controller was very memory limited and so had very limited input checking. It was, therefore, prone to locking up if commands were mistyped. The new controller has more sophisticated command parsing, but using a plain terminal and typing desired future positions is still tedious and error-prone.

To simplify things, Sat*EL* provides a program to facilitate control of the rotors. This program is named *AzElControl.exe* and can be installed from the accompanying CD-ROM. *AzElControl.exe* will allow you to quickly upload data from ephemeris files produced by either the *InstantTrack* or *Nova for Windows*™ satellite prediction programs. You can enable or disable motion, clear the memory, synchronize the controller clock to your computer clock, etc, all using the Sat*EL* Windows™-resident *AzElControl.exe* program.

Most computer clocks are very inaccurate and so it is advisable to reset them correctly once a day or so. The time synchronizing programs will do that via the Internet.

Installing the Windows™ control program, *AzElControl.exe*

On the CD-ROM, there is a directory named 'Sat*EL* control program'. You can look at the contents of the CD-ROM by using either Windows™ Explorer or My Computer. In this directory, there is an entry named *'setup.exe'*. You run this program to install *AzElControl.exe* onto your hard disk and you do this by simply double-clicking *setup.exe*. The program will automatically be installed on your computer. Before running it for the first time, it is advisable to use a simple terminal program, such as the shareware *Kermit* program included on the CD-ROM, to determine which serial port is connected to the nine-pin RS-232 connector on your computer. Finding the correct serial port is described below.

Installing the *Kermit* terminal program

On the CD-ROM, there is another directory named 'Terminal program' and, in this directory there is a single entry named *'kw32v085.exe'*. This is a program that, on being double-clicked, will install a terminal program named *Kermit* to your hard disk. Those of you with any long background in microcomputers will recognize the name *Kermit* as one of the most useful of a long series of terminal and data transfer programs used on simple machines twenty years ago. This is a simple Windows™ version of the program.

Finding the correct serial port

We will use *Kermit* to identify which port number is associated with the nine-pin RS-232 connector which you will use to interface to the Sat*EL* system. If you haven't already done so, plug in the cable between the RS-232 connector on your computer and the RS-232 connector on the Sat*EL* controller and then power up the Sat*EL* system by plugging in the wall wart. The rotors should ***not*** move – if they do, you have a problem and it is likely with the wiring between the rotors and the controller. If the rotors do not move, you can proceed to the next step, which is to run the *Kermit* program. You can find it by clicking Start| Programs | Kermit | Kermit. A window should open up on your desktop with a black background. This is the terminal screen.

You need to first configure *Kermit* to 9600 baud and you do this with Configure | Communications. Set the baud rate to 9600. All the other default settings are fine for now. Notice that Port 1 is selected. Now, click the Session pull down window and check Connect. The *Kermit* program is now connected to your computer's Port 1. You can determine whether that is the serial port going to your Sat*EL* controller by typing a single question mark character;'?', without an *Enter* or *CR*. If the connection is correct, you will see the controller response: the word 'SatEL' will appear on the screen. If so, you are done and you can now use the terminal, if you wish, to interact with the Sat*EL* controller. Typing a single 'z', for instance, will elicit a response from the controller that will return the current status of the controller. If you've turned it on for the first time, it will show that motion is disabled, the time is at the beginning of the year 2000, and there are no stored positions in memory.

If you did not get the 'SatEL' response, it means that the controller is not connected to Port 1. Disconnect the program from Port 1 by pulling down the Session window and un-checking Connect. Now, pull down Configure again and select Communication again but this time check the Port 2 button. Again pull down the Session window and check Connect. You are now connected to Port 2. Again, type in a single question mark. If you get the 'SatEL' response, you are now connected and you know that Port 2 is the correct port for your interface. If not, go through this sequence again but selecting Port 3. Repeat with Port 4 if necessary.

Once you have determined the correct port for your interface, you can use the Kermit program to interact directly with the Sat*EL* controller at any time. Normally, however, you will just want to use the *AzElControl.exe* program which you can run by selecting Start | Programs | AzElControl.exe. Its operation is described later.

Before closing Kermit and getting on with things, you should now try some of the simple commands to move the elevation rotor in the upward direction (typing a single 'U'; upper or lower case, either works) or downward (a single 'D'). Typing an 'S' will always stop the motion. Typing an 'R' causes the azimuth rotor to rotate clock-wise (increasing azimuth) while an 'L' makes it go the other way. Appendix A gives a brief summary of the commands and their effects. Notice that, as you have moved the rotor about, that the controller is keeping track of the present position. Typing a 'Z' causes it to give its' status and that status includes where it is presently pointing. NOTE: to keep from causing large current surges, it is advisable to stop the rotors between motions. That is, do not go directly from an upward motion of the elevation rotor to a downward motion. Instead, while it is moving upward, first stop it and then start the downward motion.

Finally, to put the rotor system into a known state, type the 'cx' command (***lowercase only!***). This command will cause the two rotors to go to a known position and will set the internal stored pointing position to an azimuth and elevation of both zero. In other words, the rotors are now set up to be pointing at the horizon to the north.

How to use *Kermit* to aim your antennas during setup

You have just set the internal EEPROM values for azimuth and elevation set to zero. Ideally, you would then just mount the rotors in their final position and put the antennas on them so that they are pointing due north at the horizon. Then, when you next apply power, it will be positioned correctly and there'd be nothing more to do.

Well, is that true? How do you know which way is up? We are talking about the elevation rotor, of course! Depending on which way you look at it, either direction could be up. If you are facing north and you have the rotor system in front of you, the elevation axis will be horizontal and you should unclamp the section of conduit holding the elevation rotor and rotate it so that the elevation axis is running EW. The correct orientation is when the axis is EW and when the blue rain shroud that covers one end of the elevation rotor's axis is on the west side; that is, your left. Then, an antenna clamped to the boom running through the elevation rotor and pointing north, will move in the correct direction. That is, it will rotate upward when the system is pointed to a higher elevation and will rotate downward when it is pointed to a lower elevation.

Now, if you know which way north is and can easily point the antenna at the northern horizon, you are completely done.

The problem comes when you don't exactly know where true north is or when trees, mountains or other obstructions obscure the northern horizon. It turns out that there are other ways of solving the problem and we'll describe them here.

Elevation is easy since, with the controller indicating that the system is pointing at (0, 0), you just have to mount the antenna(s) so that they are horizontal. A carpenter's level can determine that easily.

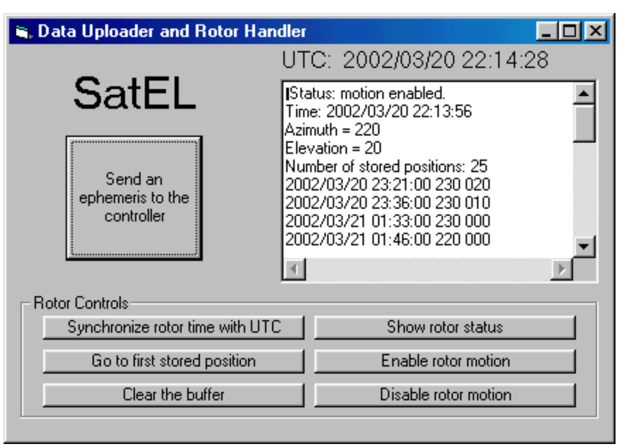
Azimuth is a little more difficult but there are solutions. For example, in the northern hemisphere of the earth, the pole star, Polaris, indicates the direction to the north. If you have the elevation already set, you just need to point the antenna (using the P command – see Appendix A) at an azimuth of zero and an elevation of your latitude and it should then be pointing at Polaris. So, looking along the antenna axis, you just need to loosen the clamps and rotate the elevation rotor (don't loosen the clamps holding the boom in the elevation rotor – you don't want to disturb the elevation setting) till the antenna points at Polaris. For example, if you live in Arizona at a latitude of 34 degrees, you would point the antenna using the command 'P0 34' and the antenna would move to that position. Actually, it would move to an azimuth of zero and an elevation of 30 degrees because it moves in ten degree steps. This means that Polaris would be 4 degrees higher in the sky than the direction the antenna is pointed but it would be pointing at exactly the correct azimuth.

If you have mounted the whole system at the top of a tower, you might not like the idea of climbing the tower at night in order to see Polaris and we certainly don't recommend it. In fact, we caution you against doing that.

An alternative is to use the sun on a clear day. All satellite prediction programs allow you to calculate the position of the sun during the day. If you look at the predictions of the sun's position, you can find the time when the sun is exactly to the south of your location; i.e., when the sun is at an azimuth of 180 degrees. So, using the P command, point your antenna at the southern horizon ('P180 0'). Then the axis of your antenna should be horizontal and pointing at the direction directly under the sun at the time determined above. At that time, you loosen the clamps and orient the axis so that your antennas point in that direction. If the sun is very high and you can't easily determine the exact position directly under the sun, you can hold a string with a weight on it in front of and over the end of the antenna. Then the sun's shadow of the string should lie along the axis of your antenna when the antenna is pointed at the azimuth of the sun.

IV. Operating the System

The *AzElControl.exe* program



This program provides some of the simple controls to handle the Sat*EL* azimuth-elevation rotor system and to upload data into the system controller. When the program is running, you will see the window adjacent. You will notice that there are three main areas of the window. The top button on the left is used to select the data file to be sent to the rotor controller and to subsequently send it. The text window is at the top right, and the six buttons on the bottom are used to send direct commands to the rotor system.

Running the program the first time.

When the program is run the first time, it creates a file in the directory where the program is located. The file name is *SatEL.ini* and it contains a single line: “Comm port 1”. This is the default serial port that the program expects to use for communicating to the Sat*EL* controller. During the installation, you will have used a terminal program to test the communications interface and to determine the correct port number for communicating with the controller. If it was port 1, you need do nothing more. If not, you will have to edit the *SatEL.ini* file. To do so, close *AzElControl.exe* and, using a simple text editor like Notepad, change the number in the *SatEL.ini* file to the value that you previously determined. Do not change anything else. The AzElControl program is very simple-minded and it just opens this file and looks for the third word and then interprets that third word as a number. Be sure not to use a complex editor like Microsoft™ Word because, in its normal mode, Word adds many non-printing characters to a text file. Doing so will confuse the AzElControl.exe program. After you have edited the SatEL.ini file, run the program again and the program should find the controller on the correct port and indicate that it has found the controller in the text window.

The rotor control buttons.

Your computer time, corrected to UTC, can be sent to the rotor controller by clicking the ‘Synchronize rotor time with UTC’ button. This assumes that your computer clock is showing the correct time. There are a number of Windows™ programs which communicate with some atomic clocks in the USA and set your computer clock appropriately. If you are tracking fast moving satellites, it might be worthwhile to run one of these programs (there are two such freeware programs on the CD-ROM in a directory named ‘NIST time finders’) before updating the controller clock with the ‘Synchronize’ button. The controller clock typically keeps time accurate to a few seconds per day.

The ‘Show rotor status’ button is probably the one that you will use the most often. It causes the controller to be interrogated for its status. The controller status is then displayed in the text window.

The ‘Enable rotor motion’ and ‘Disable rotor motion’ buttons control the automatic operation of the controller. If rotor motion is disabled, the controller will not move the rotors at the times they should be moved in response to the stored memory locations. You would want to disable motion before working on the antennas, for example. In order for automatic operation to take place, you must re-enable rotor motion.

Preparing satellite pass data using *Nova for Windows*™

You should refer to your *Nova for Windows*™ manual for general instructions on *Nova,* and for detailed instructions on satellite pass data file generation. This description, based on our *Nova for Windows* 32 ver. 2.0, assumes you know how to run *Nova* and that you have it up and running.

From the pull-down menus, left click on Utilities | Listing. This opens the Satellite Pass Data window. Click the Setup switch (center bottom) and designate the satellite you want to track as the “Listing Satellite.” Also assure your location is listed as “Observer #1,” and set the min and max elevations to 0 and 90, respectively. Near the bottom, check the box “Default to current" to set the "Start Date/Time" to the current UTC. Select the number of days (the "Duration") you want to collect data for: one or two days for LEO satellites, up to 4 or 5 days for AO-40 and similar slow, deep-space satellites. Set the "Increment" to perhaps 1 min for LEO satellites, 5 to 10 min for AO-40. Do not click "Only optically visible", as that excludes elevation data close to the horizon. Click "OK" when done to return to the "Satellite Pass Data" screen.

<u>Preparing satellite pass data using *InstantTrack*™</u>

Again, you should refer to your *InstantTrack*™ manual for instructions. We include this explanation to assist you in figuring out the process. We used Version *InstantTrack* V1.50 in preparing this description.

From the Main Menu, press "3" ("Satellite Position Table (Ephemeris)"}. From the Satellite Selection Menu, select and type the satellite number, followed by [enter] (E.g., for example, if you see "51. AO-40", enter "51" followed by [enter]. From the Satellite Position Table, Parameter Entry screen, you see, "Starting at mm/dd/yy hh:mm:ss [03/21/2002 06:18:13 UTC]:__", where the UTC time shown in square brackets is what your computer believes is your current UTC time. If you want to start searching for pass data starting at this time, simply press [enter], since that is the default time. Otherwise enter the date and time you want.

A new screen appears, showing, "Time Increment in minutes [11.0]__", where the increment in square brackets is a default value suggested by InstantTrack.. This time interval is longer for slow SATs like AO-40, and shorter for LEO SATs. Select the default by pressing [enter], or type your own interval then press [enter].

The screen then lists a screen full of text lines, each with Times, Azimuth Angles, Elevation Angles for the selected SAT pass, plus other data we don't use. The cursor flashes in the upper left of the screen. At this time, type "F" (for "Filename"), without an [enter]. This brings up the "File or Printer" parameter entry screen. Ignore the printer suggestions, and enter a file name, no more than 8 characters, followed by ".out". For example, you might name your file "E032002B.out", where the "E" stands for Ephemeris (obviously), the next 6 digits are today's date, and "B" suggests this is the second ephemeris file you have saved today. Choose your own scheme. Use of the ".out" suffix will ease the use of the file with the *AzElControl.exe* program in a moment. After entering the file name, hit [enter], and you will be returned to the previous data screen. But now your new filename appears at the upper left of the screen.

If the upcoming pass is not complete on this screen (i.e., if no dashed line appears across the screen with the words "end of pass" in the middle), then hit [enter] once, or more, until you see such an "end-of-pass" marker line. When you see this terminator line, you should stop pressing [enter], unless you want to store data for more than one pass. (But there is a limit to how much satellite pass data you can store at one time in the processor, so for now limit it to a single pass.) Close this screen by typing "Q" (for "Quit"). Hit "Q" again to quit the InstantTrack program. If you are running "InstantTrack using an MSDOS window under MS Windows™, you will need to close this window by clicking on the "X" switch at the upper right (for Windows 95).

Your data file will have been stored in the Directory in which you have stored the InstantTrack program. Usually this is called “IT”. You can look there for your data file using Explorer, and examine it using a simple word program such as WordPad or NotePad.

The data file controls.

The program is designed to read the output data files produced by either *InstantTrack* or *Nova for Windows*™. When you click the ‘Send an ephemeris to the controller’ button, a file window opens to allow you to select the ephemeris data file produced by one of these programs. The default file type is one which ends in ‘.out’; for example, ‘ao40.out’, ‘moon.out’, etc. However, you can have it look for files of any type by clicking the down arrow in the file name box. After you have selected the appropriate file, the program may take a second or two to apparently digest this file. It is, in reality, parsing the data in the file and writing it to internal memory and then sending it to the controller. The program does some elementary data checking and it can make a guess at detecting files that are not produced by either *Nova for Windows* ™ or *InstantTrack*. However, this ability is pretty rudimentary and shouldn’t be relied upon – in other words, it is best to make sure the file you select is truly either an *InstantTrack* or *Nova for Windows*™ output file.

If the controller has previously been loaded with some data for an existing pass, you can upload data for subsequent passes by opening the data file and sending it to the controller as described above. It will be loaded into the controller’s memory after the data that is already there. However, the controller only has the capacity to remember 50 data points and if you exceed that limit, the subsequent data will be lost. You may clear the controller’s memory by clicking the ‘Clear the buffer’ button in the rotor controls section of the window. You would normally do this before starting the upload of a series of passes into the controller or when you wish to erase the data already in the controller for any reason.

The remaining rotor control button, ‘Go to first stored position’, instructs the controller to immediately go to the first data position stored in its memory. This is useful for a satellite pass that will take place sometime in the future when the satellite appears over the horizon. It will cause your antennas to be pointed to that location right now and not wait until the predicted time of the satellite appearance before starting to move. This instruction also enables the subsequent automatic motion of the rotors at the times for each successive position.

A hint about ephemeris data files.

The Sat*EL* rotor system only moves in steps of ten degrees in either azimuth or elevation so the *AzElControl.exe* program automatically rounds off satellite azimuth and elevation into steps of ten degrees. In order not to fill up the controller memory with unneeded data points, it only sends those times and positions when the azimuth or elevation have changed by ten degrees.

Ten degree steps are sufficiently fine for amateur radio satellites, because antenna beam angles are typically not narrower than about 20 degrees. With 10 degree steps, the antenna is assured of never being more than 5 degrees off in elevation plus 5 degrees off in azimuth, for a worst-case error of ~7 degrees. This error is small compared to the typical 20 degree or more of the antenna beam width.

Low orbit satellites move across the sky in times of just a few minutes while Phase 3 Satellites move much more slowly. For this reason, when creating the ephemeres by either the InstantTrack or Nova programs, make sure the time steps are fairly small – typically, one minute. The resulting file may be extremely large with very many lines but the *AzElControl.exe* program will pare them down to the minimum possible number. If that is still more than the 50 that can be uploaded into the controller, the controller will ignore the excess.

Appendix A. Running the controller using a terminal

The original VE5FP Az-El system was described in an article in the December 1999 issue of QST. This article has been subsequently republished in the ARRL Satellite Anthology.

The VE5FP Az-El system was designed to be operated by a terminal connected to the controller by an RS-232 serial port. There were a number of ‘commands’ each of which consisted of a single letter typed at the terminal. For example, the letter, ‘x’, would clear the controller’s memory. The letter ‘z’ would cause the controller to send back a status report. The controller did not echo back these commands and neither does the Sat*EL* controller. These commands, which could be in either upper or lower case, are summarized in the table below.

x	Clears the controller ephemeris memory
c	Starts the calibration procedure
t	Display the controller’s current time[*]
u	Start the elevation rotor moving upwards
d	Start the elevation rotor moving downwards
r	Start the azimuth rotor moving clockwise
l	Start the azimuth rotor moving counter-clockwise
s	Stop the rotors (if moving), disable automatic motion
g	Enable automatic motion
p	Point the rotors to a particular azimuth and elevation[**]
2	The start of an ephemeris time/position data point for storage into memory[***]
z	Display the controller’s current status

- * If the single ‘t’ is followed by the <*Enter*> key, the controller responds by outputting it’s own internal clock’s time. If it is followed by a number, that number plus the next characters must consist of the value of time to be loaded into the controller’s memory. For example, T2002/02/14 12:20:30<*Enter*> would set the controller’s internal clock to 12:20:30 14 February, 2002. The time/date order is yyyy/mm/dd hh:mm:ss.
- ** For example, the command P20 40<*Enter*> would cause the rotors to move to an azimuth of 20 degrees and an elevation of 40 degrees. There is no space between the P and the first character of the azimuth but there is between the azimuth and the elevation. Automatic motion must be enabled to allow rotor movement. If automatic motion is disabled, the controller ignores this command.

- *** For example, 2002/03/14 19:45:30 40 60<*Enter*> stores into the controller's internal memory that at 19:45:30 on 14 March, 2002 the antenna system should be pointed to an azimuth of 40 degrees and an elevation of 60 degrees. The controller will cause this to happen if automatic motion is enabled. If automatic motion is disabled, the controller will not move the antennas at the appointed time.

The Sat*EL* system is backward compatible with the VE5FP system and will behave in exactly the same way except for one command that doesn't apply: that is the 'c' or Calibrate command. The Sat*EL* system does not need calibrating in the same way as the VE5FP system did so this command does nothing.

Using a separate terminal or running a program such as *Kermit* which turns your computer into a terminal, and using all the above commands, you can run the rotors, clear the memory, set the time in the controller and do everything you need to do. But, to try to load the controller with an ephemeris by hand this way is a slow, tedious, finicky and error-prone process. It is much easier to use *AzElControl.exe* to do it automatically*.*

For the Sat*EL* system, three new commands have been added. These are summarized in the following table.

*	Resets the controller – the same as turning the AC power to the controller off and then back on
?	Asks for identification. The controller responds by sending back *SatEL*
cx	Sets azimuth and elevation and clears internal EEPROM

The 'cx' command (the characters 'c' and 'x' typed without any spaces between them) is only used during setup. It causes the controller to drive the azimuth to the closest counter-clockwise 10 degree point and the elevation to drive downward to the nearest 10 degree point. It then sets the internal EEPROM values for azimuth and elevation to zero. This is the ***only*** command that affects the internal stored values azimuth and elevation in the EEPROM. The EEPROM is normally only changed by the running program inside the controller and then only in response to motion of the rotors.

You would normally never use the cx command except if somehow the internal EEPROM got scrambled or you want to reset the apparent position of the rotors without actually moving them very far.

The reset command, *, is used as a convenient way to get out of a situation where you may have put the controller into an undefined state. This will never happen if you are using *AzElControl.exe* but might if you make a mistake while typing in one of the long commands directly to the controller. One remedy is to just unplug the power supply. Doing so causes the controller microprocessor to reset itself but does not lose track of where it is pointed. The * command (typing just a single asterisk) does exactly the same thing. This command may be given at any time and it acts immediately.

Warranty

The rotors are separately warranted by the supplier: Norm's Rotors, 5263 Agro Drive , Frederick, Maryland 21703. Please contact them at www.rotorservice.com if you have any mechanical problems.

The electronics box is warranted against any faults not caused by mishandling for one year from the date of purchase. During that year, the electronics box will be repaired or replaced for a flat $20 handling fee. After one year, the electronics box will be repaired or replaced for a flat fee of $130 plus a $20 handling fee. Please ship the faulty unit, along with a note describing the problem and a copy of the purchase receipt showing the date of purchase to: SatEL, 763 Franklin Dr., Brentwood, CA, 94513.