VLA Electronics Memorandum 235

Antenna Control Unit Upgrade

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1. Introduction.

The device that controls and monitors the servo system for one VLA (Very Large Array) Antenna is called the Antenna Control Unit (ACU). The ACU receives commands, and sends monitoring information over the Data Command Set (DCS) protocol to a computer in the Control Building. Through the front panel interface on the ACU itself, it is also possible for local control of the antenna for maintenance purposes.

There are two purposes for redesigning the ACU. First, the ACU hardware needs to be modernized; this will make the hardware easier to maintain, upgrade, and troubleshoot. Second, the front panel of the ACU needs be redesigned with a much smoother interface for local control and monitoring.

1.1. Hardware Upgrade

The ACU was designed with 20+ year old discrete digital (TTL) and analog parts, many of which are obsolete today. These parts make the system difficult to maintain and upgrade. The hardware redesign should include modern parts and perhaps even commercial packages. This new design needs to be more robust in functionality, while reducing hardware size and complexity.

The redesign should also consider hardware expandability, both current and future. Current expandability includes new features in the ACU now desired. For instance, two extra bits are now desired for azimuth and elevation absolute position encoding. The design should also be modular enough to allow for future expandability. If the DCS protocol is redesigned, for instance, the entire ACU shouldn't have to be redesigned to implement the new protocol.

1.2. User Interface Upgrade

Pushbuttons, toggle switches, dials, and LED's make up the front panel user interface on the ACU box itself. This interface, by today's standards, is not very intuitive. This interface needs to be redesigned to maximize the amount of information to be cleanly displayed, while minimizing user confusion (for people with a wide range of technical skills).

A slightly more modern example of a user interface can be found on the VLBA ACU. The VLBA ACU makes use of a one-line character display that allows for much cleaner output. The character stream this display provides is much easier to read than banks of LED's representing unconverted digital values. The VLBA ACU display also uses meters to display analog like variables and other features that make it a smoother user interface.

The new VLA ACU should be designed to make the interface even more intuitive. The display should include much more information, but not lose any information from the current ACU's display. This display should be designed to a great deal of information, though. Thus it is necessary for a much smoother interface to minimize user confusion in parsing through all the information.

2. Hardware

The first choice the designer of the ACU will likely face is the implementation domain of the system. One possibility, which might seem like the obvious choice, is to redesign the entire ACU from scratch. However, there are other options to be considered. For instance, a commercial package might serve nicely as the core of the ACU.

2.1. Redesigning From Scratch

Obviously, the designer has the most flexibility when designing the system from scratch. Designing from scratch allows an optimal design to be found to implement the required features. This proposal focuses on one such overall design.

2.2. A Commercial Solution

Instead of building up the core of the ACU from scratch, it might be prudent to consider commercial options. For instance, one such option would be to implement the core of the ACU as a Single Board Computer (SBC). This option allows for simple modularity between various subsystems. The Servo subsystem, for instance, could just be implemented as PCI or ISA card that plugs into the SBC.

There are some advantages to this approach. First, the task of designing a "main board" is eliminated. The only design consideration would be interfacing with the SBC, which already has a clean and documented interface. Second, the ACU could then be easily integrated with other commercial packages to enhance the system's capabilities. An Ethernet card could be plugged in to the SBC, allowing the ACU to be hooked up to a network without having to design yet another subsystem.

However, some primary disadvantages of the SBC are its interface complexity and life span. A SBC would require an Operating System (OS) such as Windows or Linux. An OS adds new complexity to each card built for the SBC. Each card would require a device driver to interface with the OS.

A SBC would also require a hard drive. The life span of a hard drive is typically a couple of years, and this is probably not an acceptable life span of the ACU. The benefits gained from using a SBC may not outweigh the problems of using it.

A design from scratch is proposed in Section 3. This proposal also considers some of the issues that may be encountered if the core of the ACU is chosen to be a commercial package like a SBC.

2.3. Microprocessor vs. Programmable Logic Device (PLD)

In many of the subsystems, the primary design concern was whether to implement certain functions in a microprocessor or a Programmable Logic Device (PLD). A microprocessor was chosen if a certain subsystem seemed easier to implement in software (C code, etc). A PLD was chosen if a certain subsystem seemed easier to implement in hardware (AND gates, etc).

These devices were chosen as primary solutions for two reasons. First, designs could be changed anywhere a programmer for each device was available. Altering functionality in the field then becomes a trivial matter of reprogramming. Second, designs could be more easily simulated in the field than using discrete components.

2.4. PLD choices

When implementing a PLD solution, both Altera and Xilinx were considered as possible options. Altera was the first option considered since it is more widely used in the Electrical Engineering Department at New Mexico Tech, and is more familiar to the students. Altera is not fully supported by the VLA, however. Thus, it would be difficult for VLA designers to change or upgrade the PLD Altera designs. Xilinx, on the other hand, is fully supported by the VLA and will be the PLD brand of choice.

3.0. Hardware Redesign

The redesign of the ACU should be split into various subsystems for modularity. The subsystems in this proposal are broken into the following sections: 1) The core of the ACU (main board and back plane). 2) The DCS interface. 3) The Servo Control Card. 4) The PC interface. In this proposal, these subsystem fit together as illustrated in Figure 1:

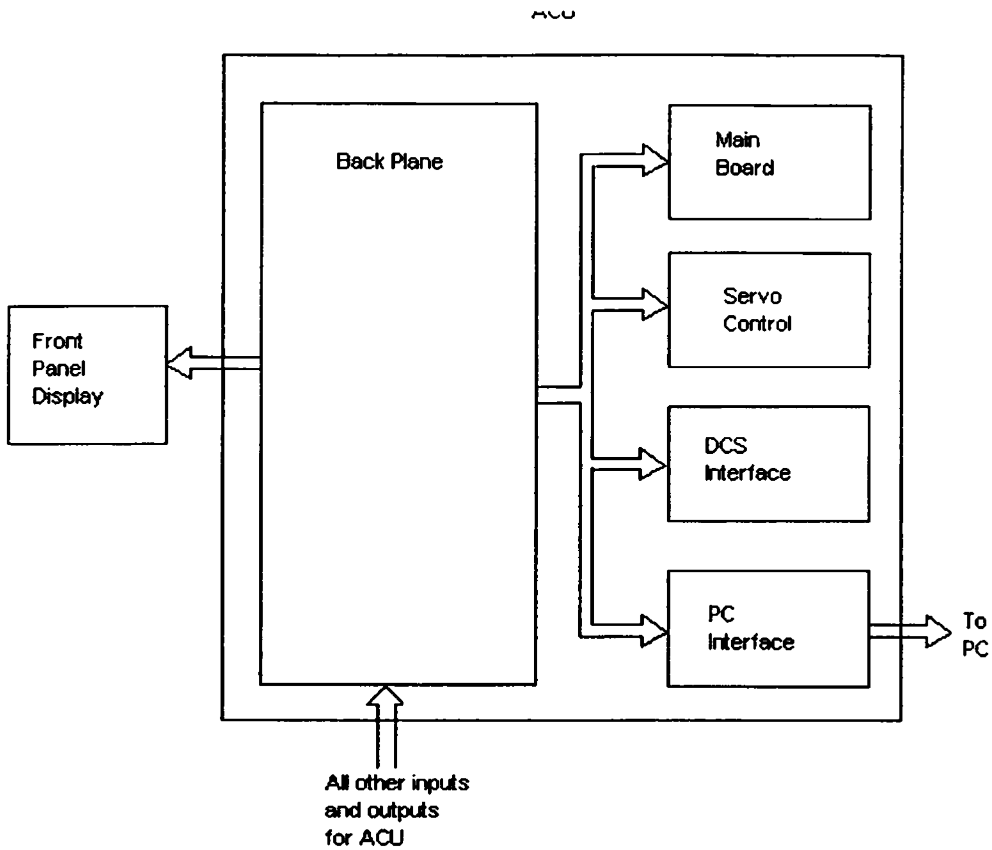


Figure 1

In each of the subsequent sections, each subsystem will be briefly analyzed in the current system and a new sample implementation proposed.

3.1. Main Board

If a SBC is not used to implement the core of the system, the subsystems will all have to be linked together through a main board. The basics of the main board should be similar to the basics of a motherboard for a modern PC. A motherboard has a CPU that does data transferring (but not necessarily all processing). A motherboard also has an electrical bus (ISA, PCI, etc), and physical slots that allow for easy addition of other devices or interfaces.

These concepts from a motherboard should also be implemented on the main board of the ACU. The main board should have a CPU that transfers all data between various subsystems. It should have an electrical bus used to communicate to all the other subsystems. It should have physical slots that allow for each subsystem to be easily plugged in and out. A main board designed in this manner allows for a very modular ACU that meets the requirements of future expandability. If a subsystem fails, needs upgrading or redesigning, a new card can be plugged in to replace the old one.

3.2. Analysis of Old Motherboard

This section explains the functionality of the current motherboard. It is intended as a guide to help explain the minimum functionality that needs to be implemented in the new motherboard.

3.2.1. Modes of Operation

The ACU operates in several modes. Most of the modes can be entered through commands sent from the Control Room or from the front panel of the ACU. Local mode can only be entered from the front panel of the ACU.

3.2.1.1. Local Control Operation

When the Local Mode button on the front panel interface of the ACU is pressed, the antenna goes into "Local Control Mode". In this mode, a technician at the antenna can use ACU to control the movement of the antenna. The modes that the local operator can use are described below.

3.2.1.1.1. Manual Mode

When the ACU is in MANUAL mode, the interface to the DCS is not used to obtain position data. Instead, azimuth and elevation rate may now be controlled using the appropriate MANUAL RATE control knobs. The range to the first limit switches is 90 degrees to 630 degrees in azimuth and 7 degrees to 125 degrees in elevation.

3.2.1.1.2. Stow Mode

If the STOW button is pressed, the antenna will then be driven into STOW mode. The antenna azimuth will be driven to reach an elevation of 92.8 degrees, and then the azimuth brakes will be applied. Once the antenna reaches the Stow position, the system will return to STANDBY.

3.2.1.1.3. Limit Back-Out

If a first limit condition has been reached, the appropriate azimuth or elevation LIMIT OVERRIDE switch may be held in override position to inhibit the limit switch. By depressing LIMIT OVERRIDE, it is possible to drive the antenna out of limit with the appropriate MANUAL RATE control knob. Any attempt to drive deeper into the limit will be inhibited.

In the event that the second limit has been entered, the appropriate limit switch can be defeated on the ACU by jumpering the proper terminal to ground, and by manually releasing brake of motor drive assy #1, of affected axis. (Manual brake release on DRIVE ASSY #1 must be actuated before axis is commanded to move or damage could result.) The appropriate jumper to override a limit switch is as follows:

EL down limit	E1 to E5
EL up limit	E2 to E5
AZ CCW limit	E3 to E5
AZ CW limit	E4 to E5

3.2.1.1.4. Disable

This mode allows for either or both of the axes to be disabled when in manual mode, primarily used to limit manual operation to only one axis.

3.2.1.1.5. Parameter Monitoring

The PARAMETER SELECT switch may switch among eleven analog parameters to the front panel analog jacks (test points on the front of the ACU to selected voltages). The central computer may continue to monitor antenna status while the ACU is operating in LOCAL control, but the only parameter sent back is the one locally selected.

3.2.1.1.6. Coordinate Reference

The cable wrap and the azimuth limit switch "flipper" is adjustable to allow the encoder to be set at 360 degrees when the antenna LOS is 180 degrees (true south). Antennas on the North Leg will have a 4-degree offset in the limit switches. Cable Wrap zero is always at 180 degrees LOS (360 degrees encoder).

3.2.1.2. Computer Control Operation

The control room operator (or the technician at the antenna) can put the antenna into "Computer Control Mode". When the antenna is in this mode, the antenna is under the control of the Control Room Operator via the DCS. The modes under computer control are described below.

3.2.1.2.1. Standby Mode

The System is in STANDBY mode whenever it is in neither the digital nor the AUTO STOW modes.

3.2.1.2.2. Digital Position Mode

The system has to be in digital mode to accept AZ and EL position commands for the CPU. Both the azimuth and elevation axes are enabled in this mode.

3.2.1.2.3. Auto Stow Mode

The system is commanded to go into AUTO STOW mode, which drives the antenna into its zenith position. In this case the azimuth axis is disabled and the elevation axis is left enabled until the antenna reaches 90 degrees elevation plus or minus 0.05 degrees.

An alternate means of entering this mode occurs when no legitimate digital commands have been received for the interval set in the stow timer or if winds exceed 50MPH.

Digital stow commands should cease after zenith is reached. If they are not stopped, the elevation brakes will be exercised at a high rate until their circuit breaker trips due to the system going back and forth between stow and standby modes.

3.2.1.2.4 Limit Override

Automatic elevation axis limit overrides is provided for (a) Time up Auto Stow and (b) wind Auto Stow. Wind auto stow can be reset only by momentarily energizing the "Emergency Stop" circuit and then only if the wind is less than 50 MPH.

3.2.1.2.5 Drives Disable

Any one of the two azimuth or elevation drives can be disabled by the CPU and the digital controllers convey this information to the analog circuitry.

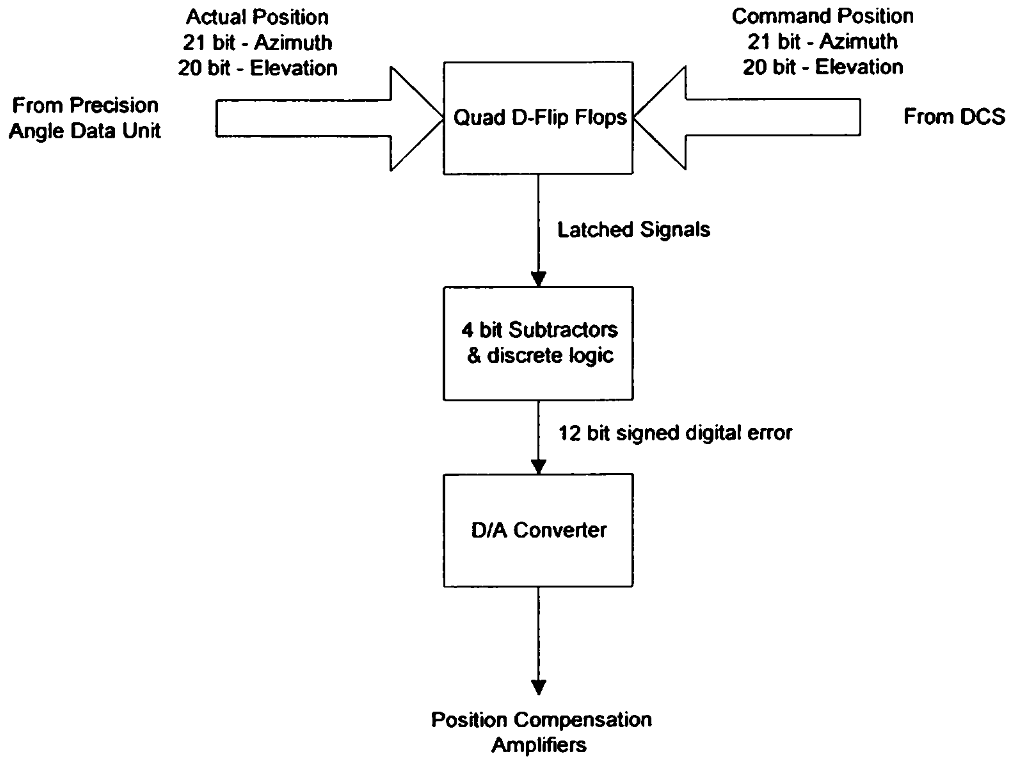
3.2.2 Command vs. Actual Position

The control room operator (or the technician at the antenna) can put the antenna into “Computer Control Mode”. When the antenna is in this mode, the antenna is under the control of the Control Room Operator via the DCS. The modes under computer control are described below.

3.2.2.1 Computer Mode

While in COMPUTER mode, the DCS subsystem reads in both the azimuth and elevation commands. These commands are fed into a closed-loop control system for precise antenna control. The position command received by the ACU is compared with the actual position and an error is formed. This error is then sent back to the drive cabinet and the antenna can more accurately reach the desired position.

The manner in which the closed-loop error is calculated is relatively simple. The actual position is received by the ACU from the encoders in the Precision Angle Data Unit. The command signal is latched in using a set of D-flip-flops, and then it is compared to the actual position using an array of 4-bit subtractors. After the subtraction is completed, a carry is calculated. If there is a carry, then the actual difference is sent to the D/A board for either azimuth or elevation depending on which signal is being compared. If there isn't a carry, then the output of chip F22 determines if the true value is sent through or if the compliment signal is sent to the D/A converter. The error signal generated is a 12-bit signed binary number. Once the error signal is converted to an analog signal, it is sent to the position compensation amplifiers on the A4 board if the signal is for azimuth or to board A5



if the signal is for elevation. How those boards manipulate the error signal is part of another project. Figure 2 illustrates the basics of this system.

Figure 2

3.2.2.2 Local Mode

When the ACU is in LOCAL mode, the commands sent from the control room are ignored and the manual rate knobs located on the front panel create the error signals for azimuth and elevation. The error signals created by the manual rate knobs are fed directly into the position compensation amplifiers where the servo control takes over.

3.2.3. DCS Subsystem

The DCS subsystem is physically located on the main board. However, since DCS is a completely separate subsystem under the new design, it will be analyzed as such in Section 3.4

3.3. Overview of the New Main Board

The main board will be split into two separate boards. One board would be the back plane. All subsystems and most outside connectors will be plugged into this board. Physically and electrically connecting all subsystems and outside plugs is the main purpose for this board.

All other functions would be implemented on a second card, which would then be plugged in the back plane. Implementing the rest of the main board's functionality like this allows for this subsystem to be as modular as any other subsystem.

3.3.1. CPU

Storing and transferring information from all of the subsystems is the primary purpose of the CPU. The CPU then becomes the only subsystem that the rest of the ACU internally communicates with. For instance, the Servo Card does not have to be designed to communicate with the DCS subsystem. The CPU itself will provide a consistent interface among all subsystem.

A microprocessor seems like an ideal choice for the CPU. In this case, a 16-bit CPU (like the Motorola HC12) would be preferable to an 8-bit one (HC11). With the elevation and azimuth position encoding exceeding 20 bits each, it would be easier to manipulate these data types in software with more data for the hardware bus. The HC12 also has a much more robust address bus that will come in handy when designing the main board's electrical bus.

3.3.2. Electrical Bus

Probably the easiest and most robust way to design the electrical bus is to extend the microprocessor's internal data and address buses to outside interfaces. Extending these buses as such allows for "memory mapping" of other devices to various addresses in the microprocessor's memory space. However, a separate bus design could be considered if this is not possible or adequate.

3.3.3. Other Main Board Functions

The main board would be an ideal place to store all information in a central location available to all subsystems. It is then possible for these subsystems to easily share information (including any debugging information) with each other and the front panel interface. For instance, if the position data was accessible from the central CPU, any other subsystem could simply access that data via the main bus. This data would also be available for displaying on the front panel without having the front panel communicate directly with the servo system.

The front panel interface will also be controlled through the CPU. The interface, which is proposed in Section 4., would be a static interface. This interface would not need to be changed in hardware – all changes would occur in a software level. Thus, a separate card would not be needed to control the interface. The CPU could take over the controlling of the front panel.

If the CPU does not have enough I/O lines to interface with the front panel, a small PLD can be used to supplement the design. The PLD then serves as the primary interface between the front panel and the CPU. All of the PLD's functionality can then be memory mapped just as easily as any other device. Hence, the front panel display can be memory mapped as well.

3.4. DCS Interface

Currently, the DCS interface is physically located on the main board of the ACU. However, the DCS's location makes it extremely difficult to upgrade or redesign the DCS protocol, as the main board would also have to be altered. Thus, the DCS subsystem should be put on a card that can be plugged into the main board (or SBC). This separation is essentially considering that there are plans to change the DCS protocol with the VLA upgrade.

Currently, Wayne Koski has already designed the receiver end of the DCS protocol using a Xilinx PLD chip. The easiest, and probably fastest way to design the DCS subsystem would be to take his design and extend it to the transmitter end, implementing the whole design on one Xilinx chip. In any case, a PLD is preferable to a microprocessor since the entire DCS protocol is to interface with a complex digital signal. A PLD is ideal for this type of digital interfacing.

3.4.1. DCS Signal

The entire DCS protocol consists of parsing and generating one complex digital signal. This signal determines whether or not the control computer is sending a command to the ACU or requesting monitoring information from it. This signal also transfers all data to and from the control computer and the ACU. Figure 3 illustrates this signal.

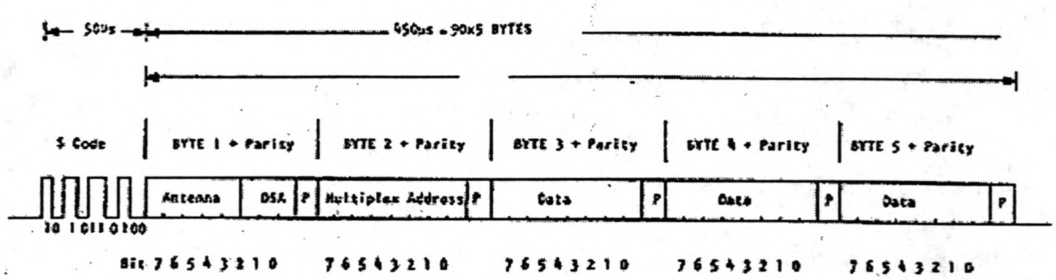


Figure 3

The *Antenna Control System* manual explains this signal in detail on pages 3-28 to 3-55, and includes some interface logic. Page 3-28 includes an ACS (Antenna Control System) Operation State Diagram that illustrates the various states needed to process this DCS signal.

3.4.2. DCS Subsystem

There are essentially two inputs and two outputs to be considered to parse and generate the above DCS signal. The two *DATA* lines, as shown in the block diagram of Figure 4, bring in the above signal for parsing. The two Xmit lines output a signal similar to above generated by the DCS subsystem.

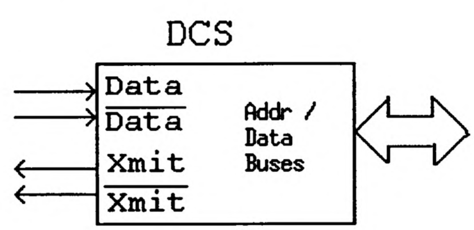


Figure 4

Note that this block diagram above includes address and data buses. These are the lines that interface the DCS subsystem with the rest of the ACU.

3.5. Servo Control Cards

The servo cards were not within the scope of this project. Tamara Barbara and Shawn Sharp have done extensive research with the current Servo Control Hardware. This section will briefly explain proposes a simple solution involving that research.

3.5.1. Current Servo Hardware

Currently, there are two servo control cards. One card has the control loops (rate and position) for the elevation control, and the other for the azimuth control. Currently, these control loops are implemented in old style analog circuits.

3.5.2. New Servo Design

Trying to keep things robust, it might be a good idea to re-implement all control loops in the digital realm. This allows a microprocessor to replace just about all the old analog circuitry in both cards, reducing the hardware complexity to one card and perhaps even one chip.

The control of the antenna then becomes a software issue. Software makes it easy to re-implement the control should there be a desire to change the control parameters, or even to extend the ACU to control another type of antenna (VLBA, etc).

A beefy microprocessor, like the HC12, should be chosen to implement this. The HC12 has a wide data bus (16 bit), with a fast 8 MHz clock, which should provide enough processing power for both control loops. Implementation of these control loops would be extremely difficult in a PLD.

3.6. PC Interface

For troubleshooting purposes, access to more complex debugging information is desirable. For instance, information that might be useful to a debugger would be the internal state of the DCS interface, or position values from the Servo Control Card. However, much of this information may be too complex to display on even a robust front panel user interface.

The solution is to provide an interface to a PC - ideally a laptop. This interface would consist of another card that plugs into the main board. Through this interface, the PC would be able to gather any information needed (as long as the other subsystems supported this type of debugging). Programs could then be easily written to process and display information on the target computer, providing a very high level interface for both hardware and software troubleshooting.

3.6.1. Hardware

The whole functionality of the PC interface would be to gather information through the other various systems, and send the information over to the PC. This is easily done with a single microprocessor or a PLD.

3.6.2. Software Interface

In it's simplest form, the interface between the PC Interface card could be a serial interface. Using a microprocessor that already supports this would make implementation simple enough.

Ideally though, one would like this interface to be as robust as possible. For an ambitious design, one could design an Ethernet interface. This would allow the possibility of troubleshooting and monitoring over a network line. This is a very robust option, but quite difficult to implement using a non-standard main board. However, with a SBC, a commercial Ethernet card could just be plugged in.

4. Front Panel User Interface

The front panel should be totally redesigned for a much more intuitive user interface. Using a multi-line LCD display and a few input buttons, just about the entire user interface could be designed into a ATM-like menu system. The user interface then mostly becomes a matter of software, and can be easily changed without having to add new hardware.

4.1. Description of Old Interface

This section will describe the various feature of the current interface. A picture of this interface is available in Appendix B.

4.1.1. LED's

The current interface uses several LEDs to display a wide variety of information. Following is a description for each LED or set of LEDs:

- Azimuth Position LEDs. The line of LEDs on the far left of the front panel displays the 21 bit "actual" digital position of the azimuth drive. This is very difficult to read, as you must convert the numbers to an angle before you have any useful information. The next line of LEDs to the right displays the 21 bit "command" digital position of the azimuth drive. This is the command signal sent to the ACU from the control room computers.
- Elevation Position LEDs - These LEDs is almost identical to the azimuth position ones except that they have only 20 bits of resolution.
- Azimuth Fault Status LED's - The azimuth drives has two limits, one for each direction, CW (clockwise) or CCW (counter-clockwise). The first limit can be

overridden to drive the antenna out of the limit. The second or final limit requires additional internal jumpering in the ACU to drive the antenna out of the limit. These limit conditions are indicated by LEDs under the heading "Fault Status" to the right of the "Position" LEDs on the front panel.

- Elevation Fault Status LEDs – Similar to the Azimuth Fault Status LEDs. However, instead of CW and CCW, there are two UP limits and two DOWN limits.
- Temp LEDs - These LEDs indicate a "motor over temperature" (overheated) condition. There are two motors for each axis so there are a total of four motors. When a "motor over temperature" condition occurs, the appropriate motor power amp is disabled.
- Field LEDs - These LEDs indicate a "motor loss of field" condition. When this condition occurs, the appropriate motor power amp is disabled.
- Circuit Breakers (CKT. BRK.) LEDs - These four LEDs indicate that the blower circuit breaker, the lube pressure switch (azimuth drive), or the drive circuit breaker of a given motor is open. The drive circuit breaker will not only give the indication, but also adjust gains and compensation for single motor operation on the appropriate axis.
- Emergency Stop - This indicates that all the drives are disabled by one or more of the three emergency stop buttons being actuated or by the array operator through the Wye-Com. The specific emergency switch must be manually reset to resume normal operation.
- Stow Pin Engaged - This LED lights up when the Stow Pin is in place.
- Cabinet Temperature - This LED is activated when the cabinet temperature has exceeded approximately 115° F. No disabling occurs.
- Input Breaker LED - This indicates that the three phase 100 amp breaker is open and hence all drives are disabled, or an encoder heater/blower fault.
- Parity Error LEDs - These LEDs indicate a parity error in the command word from the computer. There are three, one for the azimuth angle command, one for the elevation angle command, and one for the mode command.
- Drive Fault Indicators - The purpose of these LEDs is to indicate a drive fault condition in one or more of the four drives. Drive fault conditions are initiated only by one or more of the following conditions:
  1. Motor Over Temperature
  2. Motor Drive Circuit Breaker
  3. Motor Field Loss
  4. Motor Armature Current Fault
  5. Computer Disable Command of Individual Motor
  6. Brake Circuit Breaker
- Digital Monitor LEDs - The parameter select switch selects what parameter the LEDs are displaying. Table 2.1-1 in the *Antenna Control System Instruction Manual* shows the different parameters that the LEDs monitor and how to read them.
- Computer Control LEDs - These indicate which mode the system is in. It can be in Standby, Digital Position Mode, or Auto Stow mode. The modes are described in section 3.2.1.

- Limit Override LEDs - These simply indicate that the Limit Override switch has been actuated.
- Spare LEDs - There are two spare LEDs that are just below the computer control LEDs. They are not connected.

4.1.2. Switches

There are numerous switches that act as various inputs to the ACU. Following is a description of each:

- Parameter Select switch - This is a twelve position switch that selects what the digital monitor LEDs are monitoring and what the analog jacks are monitoring. On the analog jacks, HI is the positive reference and LO is the signal ground.
- Local/Computer switch - This button switches between local control from the ACU or Computer control from a remote computer.
- Stow switch - This switch puts the system into Stow Mode, which is described, in section 3.2.1.1.2.
- Manual switch - This switch puts the system into Manual Rate Control Mode, which is described, in section 3.2.1.1.1.
- Standby switch - When depressed this switch puts the system into Standby Mode, which is described in section 3.2.2.2.1.
- Limit Override switches - When a limit switch has been actuated, actuating and holding the appropriate switch will allow manual mode to be entered and the antenna to be driven out of the first AZ or EL limit by means of the appropriate manual rate control.
- Enable/Disable switches - These switches allow enabling or disabling of the AZ or EL drives when in Local control.
- Manual Rate Control Knobs - These two knobs are basically potentiometers to control the rate of the given drive (AZ or EL). When the antenna is in Local Mode, these can be used to drive the antenna.

4.2. New Interface

The new interface consists of a multi-line LCD display, perhaps 40 characters wide by 4 lines depth. On one or both sides of the display could be four input buttons, one button that corresponds to a single display line. For entering more complex data, there could also be a numeric keypad. This allows for an ATM-like menu system for all input, simple or complex. As long as the menu system is programmed to be consistent and simple, the user interface would be intuitive enough for most users. Appendix B has a representation of a sample user interface.

4.2.1. Misc. Interfaces

There are a number of signals, like certain error bits, that should be displayed at all times. This is where keeping the current implementation is a good idea – a single LED for a single bit is the simplest interface. For instance, the "Stow Pin Engaged" bit could be displayed in this fashion. This is not a bit you would want to search through a menu system to find, and is useful enough to display at all times.

For local control of the antenna, the manual rate dials could be kept. For simple and direct control, these dials are the simplest way to control each axis of the antenna. However, for more precise control, the menu system will also provide functionality for setting precise rates and positions.

5. Conclusion

This proposal has consisted of a general overview of one way to redesign the ACU. When a group decides to tackle this hefty project, this document can be used as a starting point. It can also be a supplement to the current ACU documentation, Shawn Sharp and Tamara Barber's research into the control system, and other VLA documentation that can be found.

Appendix A: Plug and Connector Listings

Connector Designator	Connector #	Signals
J1	MS3112E20-16	Az/El Coarse Synchro Bits
J2	MS3112E22-55S	Interlocks and Limits
J3	MS3112E16-26PY	Az/El Motor Status
J4	MS3112E22-55P	Az/El Motor Status
J5	MS3112E16-26PX	Az Position Data
J6	MS3112E16-26P	El Position Data
J7	MS3112E12-10S	Transmit/Data lines

Plug Listing

DP1 on A11 Board:

1	Elevation Position Bit 14
2	Elevation Position Bit 15
3	Elevation Position Bit 16
4	Elevation Position Bit 17
5	Elevation Position Bit 18
6	Elevation Position Bit 19
7	Elevation Position Bit 20
8	
9	
10	
11	Elevation Hold Input
12	GND
13	
14	Elevation Position Bit 1
15	Elevation Position Bit 2
16	Elevation Position Bit 3
17	Elevation Position Bit 4
18	Elevation Position Bit 5
19	Elevation Position Bit 6
20	Elevation Position Bit 7
21	Elevation Position Bit 8
22	Elevation Position Bit 9
23	Elevation Position Bit 10
24	Elevation Position Bit 11
25	Elevation Position Bit 12
26	Elevation Position Bit 13

DP2 on A11 Board:

1	Azimuth Position Bit 14
2	Azimuth Position Bit 15
3	Azimuth Position Bit 16
4	Azimuth Position Bit 17
5	Azimuth Position Bit 18
6	Azimuth Position Bit 19
7	Azimuth Position Bit 20
8	
9	
10	
11	Azimuth Hold Input
12	GND
13	
14	Azimuth Position Bit 1

15	Azimuth Position Bit 2
16	Azimuth Position Bit 3
17	Azimuth Position Bit 4
18	Azimuth Position Bit 5
19	Azimuth Position Bit 6
20	Azimuth Position Bit 7
21	Azimuth Position Bit 8
22	Azimuth Position Bit 9
23	Azimuth Position Bit 10
24	Azimuth Position Bit 11
25	Azimuth Position Bit 12
26	Azimuth Position Bit 13

P1 on A3 Board:

1	-15V
2	-15V
3	
4	+15V
5	+15V
6	
7	EL Error
8	EL GND
9	AZ Error
10	AZ GND
11	
12	
13	
14	+ #1 ANN. Input
15	- #1 ANN. Input
16	+ #2 ANN. Input
17	- #2 ANN. Input
18	#1 ANN Output
19	#2 ANN. Output

P2 on A3 Board:

1	Motor Circuit Breaker
2	Field Loss
3	Motor Temp
4	
5	
6	
7	
8	
9	

10
11
12
13
14 #1 AZ Motor Temp
15 #2 AZ Motor Temp
16 #1 EL Motor Temp
17 #2 EL Motor Temp
18 #1 AZ Field
19 #2 AZ Field
20 #1 EL Field
21 #2 EL Field
22 #1 AZ Motor Circuit Breaker
23 #2 AZ Motor Circuit Breaker
24 #1 EL Motor Circuit Breaker
25 #2 EL Motor Circuit Breaker

CP2 on A11 Board:

1 Emergency Stop
2 Stow Pin Engaged
3 First AZ CW Limit
4 First EL Up Limit
5 First AZ CCW Limit
6 First EL Down Limit
7 Second AZ CW Limit
8 Second EL Up Limit
9 Cabinet Temp
10 Second AZ CCW Limit
11 Second EL Down Limit
12 Input Circuit Breaker
13 #1 AZ Drive Fault
14 #1 EL Drive Fault
15 #2 AZ Drive Fault
16 #2 EL Drive Fault
17
18
19
20
21
22
23 ANBIT 0
24 ANBIT 1
25 ANBIT 2
26 ANBIT 3

AP2 on A11 Board:

1	/BEGIN TIME	
2	/TIME OVER	
3	Enable EL Command	
4		
5	Manual Mode	
6	#1 AZ Drive Disable Command	
7	#2 AZ Drive Disable Command	
8	AZ Limit Override Command	
9	#1 EL Drive Disable Command	
10	#2 EL Drive Disable Command	
11	EL Limit Override Command	
12	EL .05	
13	Prestandby	
14	Power On Reset	
15		
16		
17		
18		
19		
20		
21		
22		
23	Motor Temp	(Pin 3 of P2 on A3 Board)
24	Field Loss	(Pin 2 of P2 on A3 Board)
25	Motor Circuit Breaker	(Pin 1 of P2 on A3 Board)
26	MPX Analog	

Socket A20 on A3 Board and Socket F26 on A11 Board:

1	Azimuth Error Bit 12
2	Azimuth Error Bit 11
3	Azimuth Error Bit 10
4	Azimuth Error Bit 9
5	Azimuth Error Bit 8
6	Azimuth Error Bit 7
7	Azimuth Error Bit 6
8	Azimuth Error Bit 5
9	Azimuth Error Bit 4
10	Azimuth Error Bit 3
11	Azimuth Error Bit 2
12	Azimuth Error Bit 1

Socket A30 on A3 Board and Socket E26 on A11 Board:

1	Elevation Error Bit 12
2	Elevation Error Bit 11
3	Elevation Error Bit 10
4	Elevation Error Bit 9
5	Elevation Error Bit 8
6	Elevation Error Bit 7
7	Elevation Error Bit 6
8	Elevation Error Bit 5
9	Elevation Error Bit 4
10	Elevation Error Bit 3
11	Elevation Error Bit 2
12	Elevation Error Bit 1

CP1 on A11 Board:

1	
2	Smoke Detector
3	
4	
5	+15V
6	+15V
7	
8	-15V
9	-15V
10	
11	
12	
13	
14	
15	
16	
17	
18	GND

BP2 on A11 Bo50ard:

1	/DATA
2	DATA
3	
4	
5	XMIT
6	/XMIT
7	
8	
9	

10	Lead Switch
11	Return
12	Lag Switch
13	Return
14	****Not Labeled****
15	ANN #1
16	ANN #2

BP1 on A11 Board:

1	IM1A-0
2	IM2A-1
3	IM1E-2
4	IM2E-3
5	ICA-4
6	VA-5
7	ICE-6
8	VE-7
9	0A-10
10	0B-11
11	0C-12
12	Spare
13	GND Return
14	Standby
15	Standby Return
16	Manual
17	Manual Return
18	Stow
19	Stow Return
20	Local/Computer
21	Local/Computer Return
22	Common Return

* Note: Pins 1-11 are connected to the PARAMETER SELECT SWITCH and the numbers following the description represent the corresponding switch position for each command.

AP1 on A11 Board and P7 on A10 Board:

1	Parity
2	Parity
3	Parity
4	
5	
6	
7	

8	
9	Standby Lamp DR
10	Manual Lamp DR
11	Stow Lamp DR
12	Local Lamp DR
13	Computer Lamp DR
14	Digital Monitor Bit 1
15	Digital Monitor Bit 2
16	Digital Monitor Bit 3
17	Digital Monitor Bit 4
18	Digital Monitor Bit 5
19	Digital Monitor Bit 6
20	Digital Monitor Bit 7
21	Digital Monitor Bit 8 (MSB)
22	Computer Control Standby
23	Computer Control Digital Position
24	Computer Control Auto Stow
25	Computer Control Spare
26	Computer Control Spare

EP2 on A11 Board and P4 on A10 Board

1	Elevation Position Command Bit 14
2	Elevation Position Command Bit 15
3	Elevation Position Command Bit 16
4	Elevation Position Command Bit 17
5	Elevation Position Command Bit 18
6	Elevation Position Command Bit 19
7	Elevation Position Command Bit 20 (MSB)
8	
9	
10	
11	
12	
13	
14	Elevation Position Command Bit 1
15	Elevation Position Command Bit 2
16	Elevation Position Command Bit 3
17	Elevation Position Command Bit 4
18	Elevation Position Command Bit 5
19	Elevation Position Command Bit 6
20	Elevation Position Command Bit 7
21	Elevation Position Command Bit 8
22	Elevation Position Command Bit 9
23	Elevation Position Command Bit 10
24	Elevation Position Command Bit 11

25 Elevation Position Command Bit 12
26 Elevation Position Command Bit 13

EP1 on A11 Board and P3 on A10 Board:

1 Elevation Position Actual Bit 14
2 Elevation Position Actual Bit 15
3 Elevation Position Actual Bit 16
4 Elevation Position Actual Bit 17
5 Elevation Position Actual Bit 18
6 Elevation Position Actual Bit 19
7 Elevation Position Actual Bit 20 (MSB)
8
9
10
11
12
13
14 Elevation Position Actual Bit 1
15 Elevation Position Actual Bit 2
16 Elevation Position Actual Bit 3
17 Elevation Position Actual Bit 4
18 Elevation Position Actual Bit 5
19 Elevation Position Actual Bit 6
20 Elevation Position Actual Bit 7
21 Elevation Position Actual Bit 8
22 Elevation Position Actual Bit 9
23 Elevation Position Actual Bit 10
24 Elevation Position Actual Bit 11
25 Elevation Position Actual Bit 12
26 Elevation Position Actual Bit 13

FP2 on A11 Board and P2 on A10 Board:

1 Azimuth Position Command Bit 14
2 Azimuth Position Command Bit 15
3 Azimuth Position Command Bit 16
4 Azimuth Position Command Bit 17
5 Azimuth Position Command Bit 18
6 Azimuth Position Command Bit 19
7 Azimuth Position Command Bit 20
8 Azimuth Position Command Bit 21 (MSB)
9
10
11
12

13
14 Azimuth Position Command Bit 1
15 Azimuth Position Command Bit 2
16 Azimuth Position Command Bit 3
17 Azimuth Position Command Bit 4
18 Azimuth Position Command Bit 5
19 Azimuth Position Command Bit 6
20 Azimuth Position Command Bit 7
21 Azimuth Position Command Bit 8
22 Azimuth Position Command Bit 9
23 Azimuth Position Command Bit 10
24 Azimuth Position Command Bit 11
25 Azimuth Position Command Bit 12
26 Azimuth Position Command Bit 13

FP1 on A11 Board and P1 on A10 Board:

1 Azimuth Position Actual Bit 14
2 Azimuth Position Actual Bit 15
3 Azimuth Position Actual Bit 16
4 Azimuth Position Actual Bit 17
5 Azimuth Position Actual Bit 18
6 Azimuth Position Actual Bit 19
7 Azimuth Position Actual Bit 20
8 Azimuth Position Actual Bit 21 (MSB)
9
10
11
12
13
14 Azimuth Position Actual Bit 1
15 Azimuth Position Actual Bit 2
16 Azimuth Position Actual Bit 3
17 Azimuth Position Actual Bit 4
18 Azimuth Position Actual Bit 5
19 Azimuth Position Actual Bit 6
20 Azimuth Position Actual Bit 7
21 Azimuth Position Actual Bit 8
22 Azimuth Position Actual Bit 9
23 Azimuth Position Actual Bit 10
24 Azimuth Position Actual Bit 11
25 Azimuth Position Actual Bit 12
26 Azimuth Position Actual Bit 13

P5 on A10 Board:

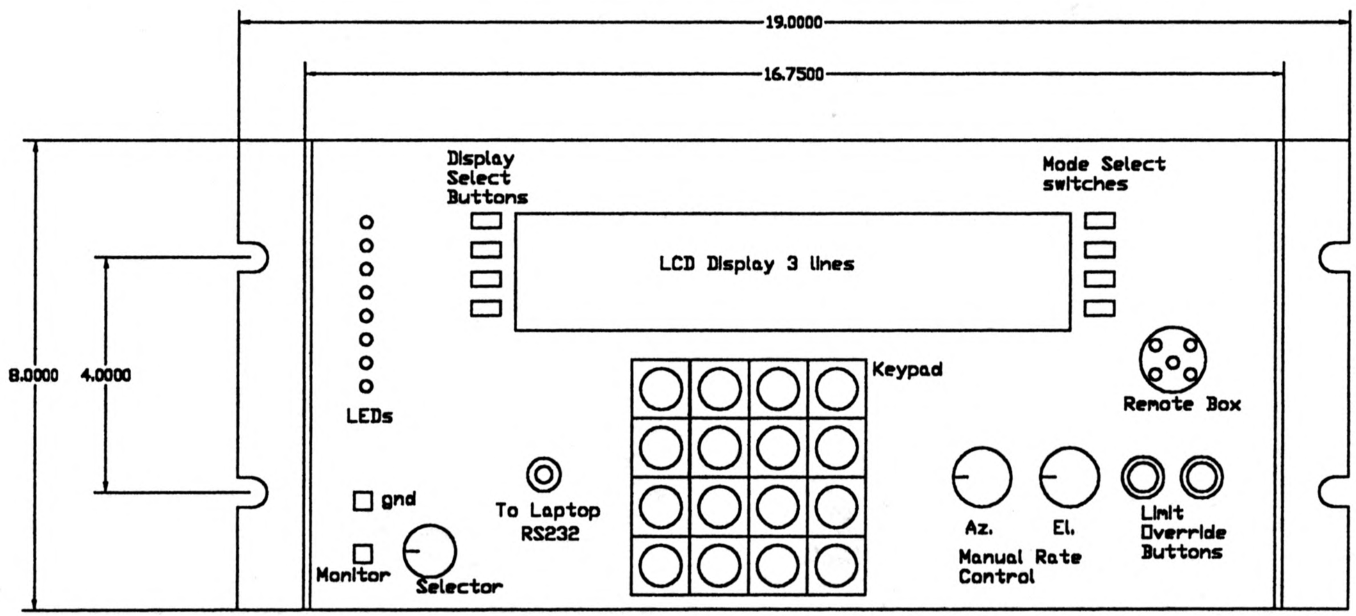
1	First Azimuth CCW Limit LED
2	Second Azimuth CCW Limit LED
3	First Azimuth CW Limit LED
4	Second Azimuth CW Limit LED
5	
6	#2 Elevation Drive Fault LED
7	#1 Elevation Drive Fault LED
8	#2 Azimuth Drive Fault LED
9	#1 Azimuth Drive Fault LED
10	
11	#1 Elevation Motor Circuit Breaker LED
12	#2 Elevation Motor Circuit Breaker LED
13	#2 Elevation Field LED
14	#1 Azimuth Motor Temp LED
15	#2 Azimuth Motor Temp LED
16	#1 Azimuth Field LED
17	#2 Azimuth Field LED
18	#1 Azimuth Motor Circuit Breaker LED
19	#2 Azimuth Motor Circuit Breaker LED
20	First Elevation Up Limit LED
21	Second Elevation Up Limit LED
22	First Elevation Down Limit LED
23	Second Elevation Down Limit LED
24	#1 Elevation Motor Temp LED
25	#2 Elevation Motor Temp LED
26	#1 Elevation Field LED

P6 on A10 Board:

1	
2	
3	Elevation Limit Override LED
4	Azimuth Limit Override LED
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	Emergency Stop LED
15	Stow Pin Engaged LED
16	Cabinet Temp LED

17	Input Circuit Breaker LED
18	GND
19	GND
20	
21	
22	
23	
24	
25	
26	

Appendix B: Front Panel Display



Front

Dim. in inches

VLA ACU Upgrade

Don Jenkins 4-12-99

Appendix C: List of Useful Contacts

Clint Janes – cjanes@aoc.nrao.edu: Site Manager for the VLA.

Tom Frost – tfrost@aoc.nrao.edu: Servo Shop Lead man

Lew Serna – lserna@aoc.nrao.edu: Deputy Division Head

Wayne Koski – wkoski@aoc.nrao.edu: Electronics Engineer

Bob Broilo – bbroilo@aoc.nrao.edu: Supervisor