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NRAO-VLA ANTENNA CONTROL TEST UNIT

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INTRODUCTION

This report describes the VLA Antenna Control Test Unit and will be both an operators manual and service manual. This test set will simulate the VLA Digital Communication System antenna servo interface and provide for manual control and monitoring of the VLA Antenna Control System. The unit will also interface with the Stand-Alone Computer Control Unit plus Hewlett-Packard 9810A calculator and provide source tracking capability from r.a. and declination plus sidereal time.

DATA SYSTEM REVIEW

The next few pages are excerpts from the E-Systems servo specification (Rev. E) and define the servo digital word format and the command and monitor word bit assignments. Each basic digital word is a 45 bit word preceded by a 10 bit start character. Each 45 bit word contains 16 bits of addressing, 5 bits of parity, and 24 bits of data.

At the Antenna Buffer - servo interface the first 8 address bits may be logic zero (the 5 bit antenna code is not checked and the 3 bit antenna control code is 000). All other bit requirements are specified in the word assignments of pages 3 through 8.

In AUTO mode the antenna control test unit transmits four commands each 100 ms, an azimuth position, a mode command, an elevation position, and a spare word. Two words are transmitted within one ms, followed 50 ms later by the second two. In each case 20 ms after two command words are sent, two Q characters are transmitted within one ms.

ANTENNA CODE	DATA SET ADDRESS (DSA)	MPLX ADDRESS	
0 - Control Room	0 - Ant. Control	0-127 Analog Monitor Data	S = Start Character
1-27 - Antennas	1 - Front End	128-191 Digital " "	P = Parity Bit
28-31 - Spare	2 - IF/LO At Ant.	192-255 Digital Commands	E = Stop Character
	3, 4 - Ant. Spare		
	5 - IF/LO At Cont. RM		
	6, 7 - Local Spare		

FIGURE 5.1 DATA WORD FORMAT

	1 – 5	6 – 8	9		18		27		36		45	
S	ANTENNA	DSA	P	MPLX ADDRESS	P	DATA	P	DATA	P	DATA	P	E

ADDRESS DATA

Parity - The parity bit shall be calculated and transmitted so that the <u>total</u> number of ones in the 9 bits comprising one data word and its parity will be <u>odd</u>.

<u>Standard word format.</u> A standard word consists of a start character plus 45 bits comprised of 40 information bits plus 5 parity bits. The 40 information bits contain a 16-bit address and 24 bits of data. The 16-bit address contains 5 bits for antenna designation, 3 bits for function, and 8 bits for multiplexer address. The 24-bit data word may be 24 bits of binary data or may consist of two 12-bit A/D converter words. In the latter case, the left-most 12-bit word is from the specified multiplex address and the right-most 12-bit word is from the specified multiplex address plus one.

<u>Start Character.</u> The start character shall be a 10-bit pattern with each bit interval being 5 micro-seconds duration. The pattern shall be 1010110100.

<u>Q Character.</u> The Q character is the same as the start character, except the pattern shall be 1010010100.

<u>Stop Bit.</u> The stop bit shall be a zero level for at least 10 micro-seconds.

TABLE 5.1a

COMMAND WORD ASSIGNMENTS

BIT	WORD 192- AZIMUTH	WORD 193- MODES
10	1	1
11	1	1
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	1
19	0	Az. Drive No. 1 Disable*
20	0	Az. Drive No. 2 Disable
21	0	Az. Limit Override
22	Az. Pos. 360° bit	Spare
23	Az. Pos. 180° bit	El. Drive No. 1 Disable
24	Az. Pos. 90° bit	El. Drive No. 2 Disable
25	Az. Pos. 45° bit	El. Limit Override
26	Az. Pos. 22.5° bit	Automatic Stow
28	Az. Pos. 11.25° bit	Stand-by Mode
29		Digital Position Mode
30		Spare
31		
32		
33		
34		
35		
37		
38		
39		
40		
41		
42	Az. Pos. 0.0013733° bit	
43	Az. Pos. 0.0006866° bit	
44	Az. Pos. .0003433° bit	Spare

Azimuth 90° shall be near the maximum CCW travel and nominally east. Rotation shall be continuous from nominally 90° to 630°.

Elevation 0 shall be at the horizon.

TABLE 5.1b

COMMAND WORD ASSIGNMENTS

BIT	WORD 194 - ELEVATION	WORD 195 - SPARE
10	1	1
11	1	1
12	0	0
13	0	0
14	0	0
15	0	0
16	1	1
17	0	1
19	0	Spare
20	0	
21	0	
22	0	
23	El. Pos. 180° bit	
24	El. Pos. 90° bit	
25		
26		
28		
29		
30		
31		
32		
33		
34		
35		
37		
38		
39		
40		
41		
42		
43		
44	El. Pos. .0003433° bit	Spare

TABLE 5.2a

MONITOR WORD ASSIGNMENTS

BIT	WORD 128 - AZIMUTH	WORD 129 - MODE	WORD 130 - ELEVATION
10	1	1	1
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
16	0	0	1
17	0	1	0
19	0	Mode Parity Error	0
20	0	Emergency Stop	0
21	0	Stow Pin Engaged	0
22	Az. Pos. 360° bit	Field Fault	0
23	Az. Pos. 180° bit	Circuit Breaker Fault	El. Pos. 180° bit
24	Az. Pos. 90° bit	Drive Cab Overtemp.	El. Pos. 90° bit
25		Input Breaker	
26		Motor Overtemp.	
28		Az. Parity Error	
29		Spare	
30		Az. First Limit CW	
31		Az. First Limit CCW	
32		Az. Final Limit CW	
33		Az. Final Limit CCW	
34		Az. Motor #1 Fault	
35		Az. Motor #2 Fault	
37		El Parity Error	
38		Spare	
39		El First Limit Up	
40		El First Limit Dwn	
41		El Final Limit Up	
42		El Final Limit Dwn	
43		El Motor #1 Fault	
44	Az. Pos. .0003433° bit	El Motor #2 Fault	El. Pos. .0003433° bit

TABLE 5.2b

MONITOR WORD ASSIGNMENTS

BIT	WORD 0 — AZIMUTH	WORD 1 — ELEVATION
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	1
19	Az #1 Mot. Curr., MSB	El #1 Mot. Curr., MSB
20		
21		
22		
23		
24		
25		
26	Az #1 Mot. Curr., LSB	El #1 Mot. Curr., LSB
28	0	0
29	0	0
30	0	0
31	0	0
32	Az #2 Mot. Curr., MSB	El #2 Mot. Curr., LSB
33		
34		
35		
37		
38		
39		
40	Az #2 Mot. Curr., LSB	El #2 Mot. Curr., LSB
41	0	0
42	0	0
43	0	0
44	0	0

TABLE 5.2c

MONITOR WORD ASSIGNMENTS

BIT	WORD 2 - AZIMUTH	WORD 3 - ELEVATION
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	1	1
17	0	1
19	Az Current Comm, MSB	El Current Comm, MSB
20		
21		
22		
23		
24		
25		
26	Az Current Comm, LSB	El Current Comm, LSB
28	0	0
29	0	0
30	0	0
31	0	0
32	Az Velocity Comm, MSB	El Velocity Comm, MSB
33		
34		
35		
37		
38		
39		
40	Az Velocity Comm, LSB	El Velocity Comm, LSB
41	0	0
42	0	0
43	0	0
44	0	0

TABLE 5.2d

MONITOR WORD ASSIGNMENTS

BIT	WORD 4	WORD 5
10	0	0
10	0	0
12	0	0
13	0	0
14	0	0
15	1	1
16	0	0
17	0	1
19	Phase A voltage, MSB	Phase C voltage, MSB
20		
21		
22		
23		
24		
25		
26	Phase A voltage, LSB	Phase C voltage, LSB
28	0	0
29	0	0
30	0	0
31	0	0
32	Phase B voltage, MSB	Spare Analog, MSB
33		
34		
35		
37		
38		
39		
40	Phase B voltage, LSB	Spare Analog, LSB
41	0	0
42	0	0
43	0	0
44	0	0

OPERATING MODES

Several switches control the various operating modes. These switches are located in the mode control area of the front panel.

The main mode control switch is a 6 position rotary switch which allows the selection of 5 single send functions, in conjunction with the SEND pushbutton and an automatic mode which closely simulates the digital servo interface of a Digital Communication System Antenna Buffer. The first five positions - AZ Pos., MODE, EL Pos., SPARE and Q will set up the test unit such that a single word, of the type indicated, is transmitted each time the SEND pushbutton is pressed. In the case of Q, a single Q is transmitted in response to pushing the SEND swtich and the unit set-up to receive a single monitor word.

In automatic mode four words are transmitted each 100 ms, two one ms apart and two more, again one ms apart, 50 ms later. In each case two Q characters are transmitted, one ms apart, 20 ms after each two command words. A monitor word is expected after each Q and a NO RESPONSE lamp illuminates if none is received.

Two 3-position rotary switches, one each for azimuth and elevation, control the source of the azimuth and elevation position commands. In REMOTE position an external 21 bit word for azimuth and 20 bit word for elevation will be encoded into the azimuth and elevation command words. These words originated within the Stand-Alone Control Unit and are used to track sources given r.a. and declination.

In INTERNAL position the position commands are encoded with switches located in the AZIMUTH POSITION and ELEVATION POSITION areas of the front panel. A 21 bit word can be formed from the AZIMUTH POSITION COMMAND switches (MSB at bottom). A 20 bit word can be formed from the ELEVATION POSITION COMMAND switches (again MSB at bottom).

In RATE position the antenna servos can be slewed at a constant velocity, up or down, clockwise or counter-clockwise, at a rate set by a 12 bit binary weight code with MSB yielding 32°/min. The initial position from which the slew starts is the position given by the position toggle switches at the time the unit is switched from INTERNAL to RATE. All switches that control the direction and rate of slew are located in the MODE CONTROL area of the front panel.

The REMOTE/INTERNAL/RATE function of the azimuth and elevation commands are independent of each other and any mixture of modes is possible.

One additional operating mode is possible. A switch located at the rear of the unit will switch the unit into a self test mode. In this condition the command bus is connected into the monitor word port and each command word multiplex address is modified so as to be acceptable to a monitor register. In this mode the azimuth position command, monitor registers, the elevation position command and monitor registers can be checked out completely (in REMOTE, INTERNAL, RATE, AUTO, or single send modes) by the unit displaying the command word in the respective monitor register. The mode command bits will be displayed in the fault status monitor register but since only 8 of their bit positions coincide only a partial test of their functions is possible.

In AUTO mode the self test function will either put the azimuth position command word into the azimuth monitor register and the elevation position command word into the elevation monitor register or it will put the mode command word into the fault status monitor register - how the unit initializes on power turn-on will determine which.

COMMAND AND MONITOR PANEL FEATURES

The switches and lamps in the AZIMUTH POSITION, ELEVATION POSITION, FAULTS STATUS, MONITOR and COMMAND areas of the front panel all represent bits in the command or monitor words specified on pages 3 through 8. The COMMAND switches under AZIMUTH POSITION program the azimuth command word (p.3); the toggle switches under COMMAND program the modes word (p.3); the COMMAND switches under ELEVATION POSITION program the elevation position command word (p.4); the ACTUAL lamps under AZIMUTH POSITION display the contents of the last received azimuth monitor word (p.5); the ACTUAL lamps under ELEVATION POSITION display the contents of the last received elevation monitor word (p.5); and the lamps under MONITOR may be selected so as to display the contents of any of the monitor words defined in pages 6, 7 or 8 using the select rotary switch. Th monitor word displayed by the MONITOR lamps will be the last monitor word, of the type selected after the select rotary switch was positioned. If, for example, the select switch is rotated from IM1A/IM2A (word 0, AZ No. 1 motor current and AZ No. 2 motor current) to $\phi A/\phi B$ (word 4, phase A voltage and phase B voltage) but no word 4 monitor words are received, the MONITOR lamps will continue to display the old word 0 monitor word.

METER DISPLAYS

Two front panel meters display the pointing error of the servos as determined from the difference between the command and monitor position words. Both azimuth and elevation error meters display errors in the range 0 to $\pm 0.025°$. An azimuth error in the counter-clockwise direction indicates that the antenna is counter-clockwise of its commanded position and an elevation error in the down direction indicates that the antenna is below its commanded position. If position errors greater than $\pm 0.025°$ occur the respective OVERRANGE lamp illuminates and the meter reading is meaningless.

ERROR STATUS

The NO RESPONSE lamp is set each time a Q character is transmitted and reset upon reception of the S character portion of a monitor response. If no monitor word is received (or if the S character is incorrect) this lamp will remain illuminated. It can, however, be reset by depressing the PARITY RESET switch.

The SERVO PARITY lamp will be latched each time incorrect (not odd) parity is detected in a monitor word. This lamp can only be reset by depressing the PARITY RESET switch.

The PARITY SELECT switch programs the operation of parity bit 45 (p.2) only and allows intentional bad parity to be transmitted in command words. All other parity bits of all command words continue at all times to send correct (odd) parity. In self test mode, however, parity bit 18 will be incorrect and the parity lamp will illuminate when any word is transmitted. The NO RESPONSE lamp does not function properly in self test mode.

LOGIC DESCRIPTION

On page 12 is a table that gives a breakdown of the antenna control test unit card requirements:

Card Location

B*	Command Board	
D*	Monitor Board	
F	Monitor Register	D13500L36
G	Az/El Rate Control	D13500L35
H	Command Word Transmit Control	D13500L34
K	Az/El Rate Control	D13500L35
L	Monitor Register	D13500L36
M	Receiver Logic	D13500L32
N	Control Logic	D13500L33

*Cards optional - only to be used with the Stand-Alone Computer Control Unit.

CARD N, CONTROL

The control card develops both transmit and receive timing signals used in control of other unit functions. This card contains a 1 MHz crystal oscillator, 3G, from which all timing is derived. The divider string, 3F, 4F, 4E, 4D and 3D, count down this clock to produce the basic 100 ms repetition cycle within the transmit portion of the unit.

The signal S ($\overline{G5}$) produces two 10 μsec positive pulses, one ms apart, that occurs every 50 ms (each time the S portion of a command word is to be transmitted). The signal Q ($\overline{G3}$) is a similar double pulse occurring 20 ms after the S double pulse; that is, each time a Q character is to be sent. These two signals are combined to make the signals Q Or S, Xmit Q, S Gate and Xmit S Gate. The signal Q Or S loads register 1F of card H with an S or a Q in preparation of transmission, the signal Xmit Q, S Gate will gate the S character or Q character unto the transmit bus, while the signal Xmit S Gate loads the command register with command data to be transmitted when the S character has been transmitted. IC's 5A9, 5D8, 1C12, and 5E8 yield proper signals for implementation of the single send function in the unit. The various signals above are interrupted in such a manner as to perform only the function desired when the SEND switch is depressed.

The signal C97.090 is divided down from the 1 MHz oscillator by divider string 3F, 4C, 4B and is a 97.090 Hz clock used on the rate cards.

The lower portion of logic diagram D13500L33 is the receive timing portion of the unit. Receive 100 and 200 kHz clocks are divided down from the 1 MHz oscillator in 2F and is synchronized with the receive data by 1G3, 1G8 and 1G6 gates. The receive clocks are started by the leading edge of the first bit of the incoming S character and will free-run for the remainder of that word. Receive clock initialization should be such that the positive going edge of 200 kHz clock occurs in the middle of receive S character bits and the positive edge of 100 kHz clock occur in the middle of receive data bits.

Counters 2E, 2D, 2C, 2B and 2A count down the receive clock to produce the various gates needed to break out the contents of the monitor word. S Gate is used to gate the received S character into a register, Parity Gate is used to check the incoming data for correct parity, MUX Gate is used to gate off the MUX address bits of the monitor word and Data Gate is used to separate out the actual monitor word data bits.

CARD G AND K, Az/El RATE CONTROL

The rate control card produces the two position command words from one of three sources - Front panel toggle switches; the external Stand-Alone Computer Control Unit (cards B and D); or the result of an on card integration involving the storage register at logic diagram top, the adder register in the middle and the EX-OR gates in the lower portion of the diagram. In INTERNAL or REMOTE modes this card provides storage for the parallel input data from front panel switches or the Stand-Alone Computer Control. In RATE position the last position command word (that before unit is switched into rate) is integrated at 97.090 Hz with the 12 bit binary rate word from the front panel toggle switches. EX-OR gates 1E, 1F and 1G are provided to yield up and down integrations.

Card G produces the azimuth command word and card K the elevation.

CARD H, COMMAND WORD TRANSMIT CONTROL

This card produces the command data bus. Data for the four possible command words are applied to this card in parallel, are multiplexed, and shifted out serially in sequence prefixed with proper S characters and interspaced with Q characters. Counter 1A and 1B sequence through the four command words amd steer the 4 into one multiplexers loading the parallel-in serial-out main register. These flip-flops are controlled via direct sets and resets in single send modes so as not to count. Parity encoding is also accomplished on this card. Odd parity is encoded except that bit 45 may be selected via the front panel PARITY SELECT switch for even or odd parity.

CARD M, SERVO TESTER RECEIVE LOGIC

This card contains the receive bus optical coupler, 1H, which terminates the monitor bus and recovers monitor data. Three basic functions are accomplished on this card--checking incoming word parity, checking incoming word for a valid start character, and decoding the incoming word MUX address.

Parity check is accomplished in flip-flop 1D and results are stored in 1C. The monitor word start character is checked in 2F and 2G with results stored in 1G8. The MUX address is stored in register 2E and decoded in the associated combinational gates.

CARDS F, L, MONITOR REGISTER

This card stores the data portion of monitor words for display and position error calculation.

Position monitor data is sifted serially into register 3C, 3B, 3A, which drives the adder register and the front panel displays. The adder register subtracts the data response from the command word position to develop the positional error. This error is converted into analog by the D-A on this card and used to drive the respective position error meters. Over range detection logic is also contained on this card.

The register 2C, 2B, 2A shift in store and display the non-position monitor words. Card F stores the azimuth position monitor and the mode monitor word, card L the elevation and 0 through 5 monitor words.

INTERFACE

Two connectors at the unit rear panel are provided. Connector P1 is the servo interface and P2 is the Stand-Alone Computer Control Unit interface. Below is the P1 pin assignment. The monitor bus input is designed to terminate a twisted pair and looks like the Antenna Buffer monitor bus termination.

P1 Pin Assignment

Pin	Signal
30	Transmit Data
31	Transmit Data Return
36	Monitor Data
37	Monitor Data Return

POWER REQUIREMENTS

All unit power is derived from the 120 VAC 60 Hz line. A 3 amp fuse is located in the back panel for short circuit protection. Internal cooling fans are driven from the 60 Hz line input. DC power for the Stand-Alone Computer Control Unit is derived from this unit.