SOFTWARE FOR THE FLIGHT DATA ACQUISITION AND PROCESSING SYSTEM (FDAPS)

Michael P. Hutchinson
Fairchild Weston
Sarasota, Florida

Since the advent of the DEC VAX 11/780 in the late 1970's, the trend in telemetry computer systems is to do more processing of data on the data acquisition system. This trend has led to more and more functions being performed on these systems. In addition, multi-user features of VAX/VMS are being used in these newer systems to enhance review and processing of the data. Lastly, a trend to systems that can be operated by users less familiar with the computer has led to changes in the interaction of software and user (for example, menu driven systems). The FDAPS system was designed as a total system with hardware and software tradeoffs made to provide a high speed, "user friendly", multi-user system.

INTRODUCTION

During the fall of 1983 the U.S. Air Force let a contract to FWSI for a complete end to end system to support the F-111 program at McClellan AFB, California. A number of significant points were important to the Air Force. First, the complete system from airborne to post processing system would be purchased from a single contractor to provide a coordinated approach to the design of the complete system. Second, the system must be user friendly to personnel that use the system only infrequently. Third, the system must be able to acquire the data in one pass of an analog tape while providing quick look capability to users of the system. Fourth, data must be quickly and easily available for analysis after it has been acquired. Last, the Air Force required a feature called Auto Trouble Shooting which would do an automatic end to end test of the system from the analog tape thru the VAX 11/780 and software.

Fairchild Weston designed the system to meet the Air Force's requirements by identifying the major problem areas and then solving the problem in the portion of the system that allowed the best overall design. In some cases this meant moving hardware proposed for the ground system to the airborne system. The FDAPS system is unique in that most of the data to be processed is some type of computer data formatted into PCM. Once the PCM synchronizers synchronized the data, one of three 715 Multiplex Processors was to convert

the computer data into a format usable internally to the 715. The data could then be compressed, EU converted, etc. The function to re-format these various data formats into a common format was moved from microcode that would run in the 715 Multiplex Processor to dedicated hardware cards in front of the 715. This allowed standard algorithms to compress data and convert data to engineering units for all the different data streams; 1553 bus data, MARK II data, SRAM data, PAVETACK data, PCM data and FM data.

Approximately ten man years of software development went into building the FDAPS system. Therefore, only a high level overview of the software can reasonably he covered in this paper. This results in some areas being skipped over while others will only be lightly touched. A user interface was designed using menus that would allow complete control of the system while automatically handling the more complex features of the system.

This approach is called a Main Menu since it allows the user to start at one menu and then select options from this menu to go to any desired function or to a lower level menu. By looking at Figure 1 you can see that twenty-five options were put on the Main Menu in six different categories. In effect this allowed the user to look at one menu and see what logically could have been broken down into seven separate menus. Using this approach on lower menus and by putting items less frequently used on lower menus, the system provides quick and easy access to all options. All portions of the system can he reached without going down more than four levels in the menus. The Main Menu categories are logically broken down into the different functions required to setup a system, acquire data, and analyze the data.

Logically the File Maintenance section is used first in preparing the system for processing. The key areas here are providing the setup required by the telemetry front end and the information required by the Parameter Data Base to identify each parameter and how that parameter is to be processed by the system.

By making the appropriate selection on the Main Menu (14 thru 21) the user can select the setup menu for one of the telemetry front end units. Figure 2 is an example of a menu for the frame synchronizer. The user can easily move to the desired field by using the arrow keys and only change the item desired. Selections for some setup parameters require actual inputs. For instance SEARCH ERRORS or WORDS PER FRAME require the user to type in the value desired for that parameter. The field FRAME SYNC PATTERN works a little differently. In this case the user is allowed to edit the frame sync pattern by using the < and > keys. The field PATTERN TYPE has a limited number of valid choices and has a interface technique to ease the user’s inputs. Each time the user strikes the TAB key one of the valid choices is displayed at the bottom of the screen. When the appropriate choice is displayed the user strikes the carriage return to select that choice which is entered into the screen menu.

Entering a ten (10) to the Main Menu results in the display of the Parameter Data Base menu. The user types in the name of the a parameter to be reviewed, updated, or changed. This file is a centralized repository for all the information that the user may wish to access for the selected parameter. The information stored for each parameter includes; name, type, EU label, compression requirements, coefficients, display requirements, and the stream associated with the parameter. Once the user provides the parameter information to the Parameter Data Base the other software in the system will automatically pick up the information appropriate to its function when the user selects the parameter to be processed. All inputs to the Parameter Data Base were designed to simplify user inputs. The arrow keys on the terminal are used to move about the menu displayed. The TAB and carriage return keys are used to select a desired option from a list of options. The user is not required to type in the name of the option desired. Figure 3, Figure 4 and Figure 5 are examples of the Parameter Data Base menus for an analog parameter. Other parameter types have a menu tailored for the requirements of that parameter type.

After using the FILE MAINTENANCE section of the Main Menu to store the setup of the telemetry front end and to store the information for each parameter to be processed, the next step is to acquire data. Selecting a three (3) on the Main Menu begins loading of the setup to the telemetry front end; bit sync, frame syncs, time code, etc. In addition, the 715's are loaded from the Parameter Data Base. Much of the housekeeping required to prepare the system to acquire data is done at this time. Once the telemetry equipment is loaded, acquisition can be started by selecting a four (4) on the Main Menu. If a data time slice is to be acquired from analog tape the software will automatically program the tape search unit to find the time slice and start the acquisition at the appropriate time. Selecting a five (5) on the Main Menu allows monitoring of the data acquisition to disk; any errors, number of buffers received from the telemetry front end, etc. During acquisition, data from the three 715's, in addition to being stored on disk, is automatically ,merged by the hardware into a single buffer. The datum for each parameter is immediately stored in the same location in the buffer by the Fairchild Weston 760 Suffered Data Channel. Since the same VAX memory cell always contains the latest data value for each parameter whenever accessed, this scheme is called a Current Value Table (CVT). This allows programs to provide quick look of data without sorting thru buffers of data which are designed for disk storage. Selecting a seven (7) on the Main Menu brings up the menu for the alphanumeric display if the user is at one of the VT100 terminals or the graphic display if the user is at one of the Megatek displays.

Any of the VT100 terminals maybe used to bring up the alphanumeric display. The only limitation on the number of simultaneous displays is VAX CPU time available. Figure 6 shows the menu used to select parameters for the alphanumeric four parameter display. The display format (decimal, hex, octal, binary, etc.) is picked up from the Parameter Data Base. Figure 7 is an example of the display. The parameters being displayed need not be

selected prior to starting of acquisition and may be changed interactively without leaving the data display. The data is scrolled up the screen, at the rate selected, allowing the user to look at the last 15 samples of data.

The graphic display software brings up a menu similar to the alphanumeric menu if the user is logged on to one of the Megatek displays. This menu contains six parameters and space for the plot scaling. As analog parameters are selected, the plot scaling is automatically picked up from the Parameter Data Base and displayed. Like the alphanumeric display the update rate is user selectable and parameters being displayed can be changed interactively while displaying data. Figure 8 shows a sample of the graphic display during data acquisition. Up to three simultaneous Megatek displays maybe be brought up.

If the tape search is controlling the time slice acquired, acquisition is automatically shutdown by the time code equipment and software. If the time slice is to be terminated early or if the operator is controlling acquiring the time slice then selecting item 6 on the Main Menu will stop data acquisition and do the necessary housekeeping.

Immediately after stopping acquisition the terminal users can bring up the alphanumeric or graphic analysis software. Any number of users can access the data simultaneously. The data received from the three 715s is available to all of the users as if it had been multiplexed together into a single file. The alphanumeric CRT receives the menu shown in Figure 9. Note that the user can select any parameter to be displayed without specifying the source. The users have the option of searching for events in the data; value greater than, equal to, etc. In addition the user can select the time slice to be displayed. Once these actions have been taken, typing a control G starts display of the data. Figure 10 is an example of the alphanumeric display.

If analysis is selected at a Megatek terminal the graphic analysis will present a menu similar to the alphanumeric menu where the user can search for events and select the time slice to he displayed. Typing a control G will result in the software plotting the time slice requested by the user. Figure 11 is an example of a graphic analysis display. Exiting back to the menu allows interactive changing of the time slice, parameters, or plot scales. Plots can be against time or against other data parameters.

A significant feature of both the alphanumeric and graphic analysis packages is the ability to display derived parameters. The Parameter Data Base allows the specification of parameters that are made up of multiple parameters or complex mathematical equations. Each derived parameter can consist of up to eight lines of FORTRAN code. This allows the analysis software to produce any parameter required by McClellan when analyzing the data.

The last feature of the system to be covered is called AUTOTROUBLE SHOOTING. Figure 12 shows the AUTOTROUBLE menu. This menu allows the user to select different tests to checkout different portions of the telemetry front end. Using the various tests in one combination or another allows cross checking of the different units and therefore isolation of a problem to the unit level. The first fourteen tests use data simulated by the 429 Multiplex Encoder. Each of the tests can be run with or without the bit synchronizer. Selecting the /LOOP switch allows the user to specify to the test that the acquisition and verification portions of the test should be run a number of times. Test thirteen (13) runs three of the simulation tests as one test. Test fourteen (14) runs test one (1) thru (13) automatically with no operator intervention. The Analog Tape test (15) consists of three sub-tests. The first sub-test checks the data using the analog tape as a source for PAVETACK, PCM, MARK II, and 1553 busses one and two. The second sub-test substitutes SRAM data for the PAVETACK of sub-test one and then processes the time. slice from the analog tape again. The last sub-test acquires FM data from three tracks of the analog tape. In each subtest the data is checked against predetermined values. The menu also allows running of the 715 diagnostic on any of the 715s. The user can select memory testing or testing of the 715 instructions. Selection twenty-two (22) on the AUTOTROUBLE menu allows the user to change the disk assignments of the data acquisition. This allows the user to still check out the system if a particular disk is not available.

CONCLUSION

The software delivered with the FDAPS system provides the infrequent user an easy to use interface and still provides quick access for the more frequent user. The software and system allows the Air Force to acquire the data in a single pass of the analog tape while doing quick look of the data at multiple terminals, both alphanumeric and graphic. In fact the data rates that can be handled by the system are extremely high. During the pass of the analog tape the VAX processes over two million bytes per second in and out of memory. Over 800,000 bytes per second are formatted to disk during the acquisition and quick look. Once EU data is stored on disk up to eight users can simultaneously analyze the data. Plots of EU data from all or any of the diverse data formats can be analyzed seconds after the data acquisition has been completed. All of these features provided the Air Force with the capability to reduce the turn around time between a flight and the evaluation of the data while increasing user productivity at the same time.

```
FDAPS MAIN MENU (MAINMENU.COM)      TESTAC1       19-APR-1984      15:43:04
+-----------------------------------+-----------------------------------+
|   ANALOG TAPE HEADERS             |   FILE MAINTENANCE                |
|        1  HEADER INFORMATION      |        10  PARAMETER DATA BASE    |
|        2  PCM CALIBRATION DATA    |        11  VALIDATE DATA BASE & VWL
+-----------------------------------+        12  ACTIVE/INACTIVE LINKS  |
|   ACQUISITION                     |        13  MARK II STREAM SELECTION
|        3  LOAD TELEMETRY FRONT END |        14  PCM BIT SYNC           |
|        4  START DATA ACQUISITION  |        15  PCM FRAME SYNC         |
|        5  MONITOR DATA ACQUISITION|        16  PCM ID SUBFRAME SYNC   |
|        6  STOP DATA ACQUISITION   |        17  PCM SIMULATOR          |
|        7  ALPHA/GRAPHIC DISPLAY   |        18  PCM INTERFACE UNIT     |
+-----------------------------------+        19  MULTIPLEX ENCODERS     |
|   TSPI DATA                       |        20  FREQUENCY SYNTHESIZER  |
|        8  REFORMAT TAPE TO DISK   |        21  TAPE SEARCH            |
+-----------------------------------+                                   |
|   ANALYSIS                        |                                   |
|        9  ALPHA/GRAPHIC DISPLAY   |        22  SRAM/PAVETACK TFE UNITS|
+-----------------------------------+        23  MARK II TFE UNITS      |
|       EX  EXIT TO VMS             |        24  1553 TFE UNITS         |
|       LO  LOGOFF SYSTEM           |        25  COPY PCM FORMAT TO TU58 |
+-----------------------------------+-----------------------------------+
```

Figure 1 - FDAPS MAIN MENU

```
   FILE MAINTENANCE                      TESTAC1          19-APR-84 10:02:50
   FRAME SYNCHRONIZER FOR PCM DAS
+-------------------------------------------------------------------------+
|  SEARCH ERRORS = 0            (0-7)                                     |
+-------------------------------------------------------------------------+
|  CHECK  ERRORS = 0            (0-7) |  CHECK FRAMES = 1             (0-7) |
+-------------------------------------------------------------------------+
|  LOCK   ERRORS = 0            (0-7) |  LOCK  FRAMES = 7             (1-7) |
+-------------------------------------------------------------------------+
|  FRAME SYNC PATTERN = 1 111 010 111 100 101 100 110 000 000           LBT |
+-----------------------------------+-------------------------------------+
|  DATA SOURCE = BSY         (BSY,SIM) |  PATTERN TYPE = NOR(NOR,ACC,SCC,APO) |
+-----------------------------------+-------------------------------------+
|  2'S COMPLIMENT DATA = NO  (YES,NO) |  MSB 1ST BIT XMIT = YES     (YES,NO) |
+-----------------------------------+-------------------------------------+
|  DATA WORDS/FRAME = 26       (4-1023) |  COMMON WORD LENGTH    = 10  (4-16) |
+-------------------------------------------------------------------------+
|  ALTERNATING WD LENGTH =     (4-16)    disable ALT WD LENGTH with 'CTRL D' |
+-------------------------------------------------------------------------+
```

Figure 2 - FRAME SYNCHRONIZER SETUP MENU

```
D A T A B A S E   E D I T O R - TESTAC1                    19-APR-84 11:01:00

Parameter Name= WD1                                  ENG.UNITS= EUCNTS
Parameter Type= ANALOG                             FORTRAN TYPE= REAL
   Stream Type= PCM                              DATA CONVERSION= OFF.BINARY

    NO.OF BITS= 10                          LIMIT CHECKING:  ON/OFF   LIMIT
      WORD NO.=    1                                HIGH LIMIT= ON          976.0000
     FRAME NO.=___                                 LOW LIMIT= ON          962.0000
      INTERVAL=___
  DAS CHAN NO.= 21212                        DEFAULT PLOT RANGE:
                                                    MAXIMUM VALUE=         980.0000
                                                    MINIMUM VALUE=         960.0000

  PARAM.STATUS= ACTIVE                          ADDITIONAL DATA:
  E.U.CONVERSION METHOD= POLYNOMIAL                              COMPRESSION
  CALIB ON/OFF STATUS= OFF                                       E.U.CONVERSION


CTRL-Keys:        P=PRINT      D=DELETE      U=CANCEL      [Name]N=NEXT

(Enter HELP if you need instructions)
A 8 INPUT:
```

Figure 3 - ANALOG PARAMETER DATA BASE MENU

```
D A T A B A S E   E D I T O R  - TESTAC1                  19-APR-84 11:01:13

Parameter Name= WD1

                        COMPRESSION ALGORITHM SETUP

  BIT CHANGE ___      MASK= XXXX  XXXX  XXXX  XXXX
  BIT MATCH  ___      MASK= XXXX  XXXX  XXXX  XXXX
  NO MATCH   ___      MASK= XXXX  XXXX  XXXX  XXXX
  IN LIMIT   ___     LOWER=_____________________  UPPER=_____________________
  OUT LIMIT  ON       LOWER=                962.   UPPER=                976.
  ZFN        ___     LIMIT=_____________________
  NTH SEQU'N ___     COUNT=______                 INIT.=______

  CHAINING =  OFF                CHAIN DUMP-PARAMETER=_____________________


  PORT #1= ON           PORT #2= OFF           PORT #3= ON


CTRL-Keys:                              P=PRINT                    R=RETURN

TAB cycles, RETURN selects: OFF
```

Figure 4 - ANALOG PARAMETER DATA BASE COMPRESSION MENU

```
D A T A B A S E   E D I T O R - TESTAC1                    19-APR-84 11:01:22

Parameter Name= CHAN1

                        Order of fit= 1

                    INPUT COEFFICIENTS:
                        COEFF(0)=     0.0000000E+00
                        COEFF(1)=      1.000000
                        COEFF(2)=_________________
                        COEFF(3)=_________________
                        COEFF(4)=_________________
                        COEFF(5)=_________________

                   Last Input Date= DD-MMM-YY HH:MM


CTRL-Keys:                          P=PRINT                    R=RETURN

G16 INPUT:
```

Figure 5 - ANALOG PARAMETER DATA BASE COEFFICIENT MENU

```
A C Q U I S I T I O N   M E N U  - TESTAC2          24-APR-84 09:55:18
DISPLAY TITLE = TESTAC2


     PARAMETERS TO DISPLAY:
                          1 WD1
                          2 WD3
                          3 WD4FR2
                          4 WDIO


        UPDATE DISPLAY RATE =          1.000 SECONDS




CTRL-Keys:

  P=Print screen          List nameW=Write list          G=Go to RUN state
                          List nameL=Recall list         Z=Exit
(Enter HELP if you need instructions)
F16 INPUT:
```

Figure 6 - ACQUISITION ALPHA DISPLAY MENU

Acquisition of Data for TESTAC1 6-JUL-84 12:54:36

TIME	MK2T1A2 EUCNTS	MK2T2A4 EUCNTS	MK2T2A8 EUCNTS	MK2T2A16 EUCNTS
12:59:55:391	14043.00	-18724.00	-520.0000	-1040.000
12:59:56:385	14043.00	-18724.00	-520.0000	-1040.000
12:59:57:385	14043.00	-18724.00	-520.0000	-1040.000
12:59:58:385	14043.00	-18724.00	-520.0000	-1040.000
12:59:59:385	14043.00	-18724.00	-520.0000	-1040.000
13:00:00:385	14043.00	-18724.00	-520.0000	-1040.000
13:00:01:391	14043.00	-18724.00	-520.0000	-1040.000
13:00:02:385	14043.00	-18724.00	-520.0000	-1040.000
13:00:03:386	14043.00	-18724.00	-520.0000	-1040.000
13:00:04:388	14043.00	-18724.00	-520.0000	-1040.000
13:00:05:385	14043.00	-18724.00	-520.0000	-1040.000
13:00:06:388	14043.00	-18724.00	-520.0000	-1040.000
13:00:07:385	14043.00	-18724.00	-520.0000	-1040.000
13:00:08:390	14043.00	-18724.00	-520.0000	-1040.000

CTRL-Keys:
P=Print screen Parameter nameN=New parameter name R=Return to menu
List nameL=New parameter list Z=Exit
Horizontal ARROW KEYS select parameter to replace

Figure 7 - ACQUISITION ALPHA DISPLAY

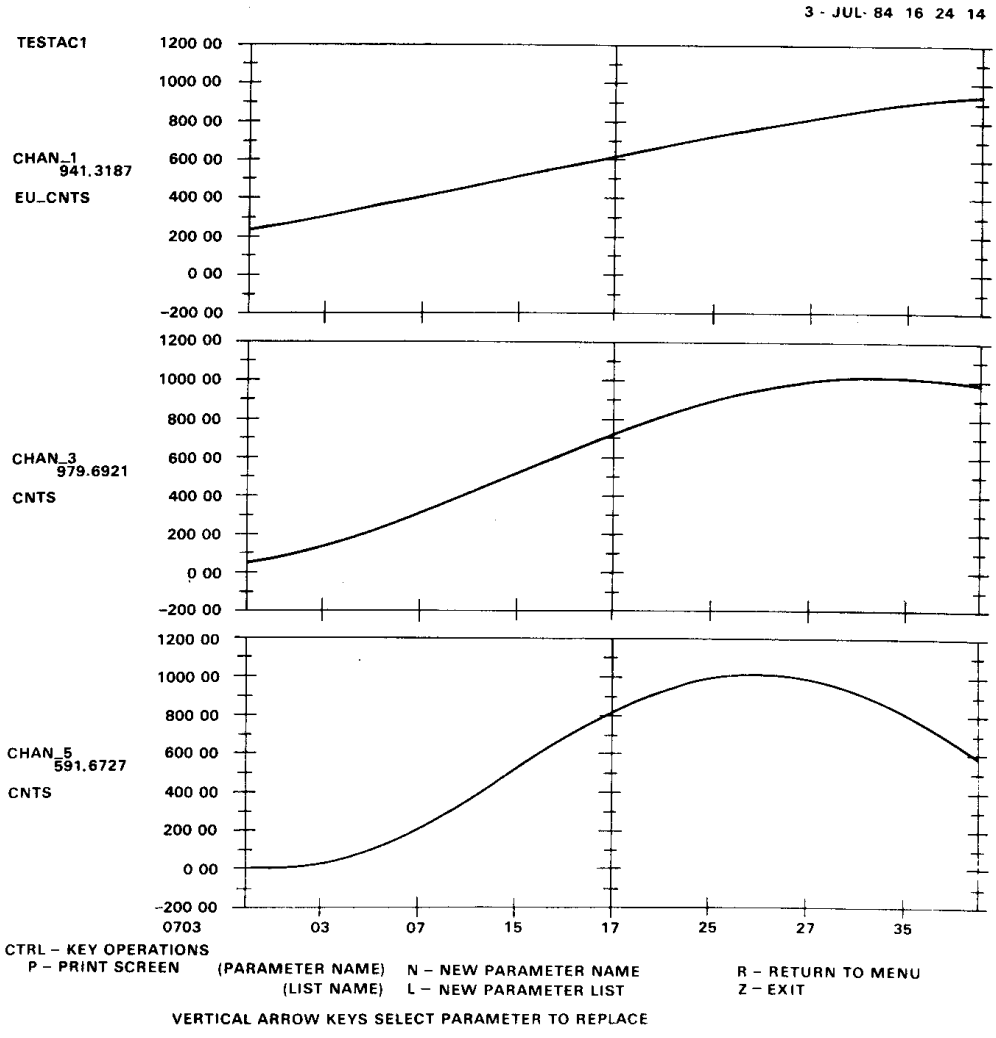

Figure 8 - ACQUISITION GRAPHIC DISPLAY

```
A N A L Y S I S   M E N U  - FDAPS                        24-APR-84 10:56:18

DISPLAY TITLE = FDAPS

DISPLAY INTERVAL  DISPLAY PARAMETERS
FROM:             1_____________
 000 00:44:59:000 2_____________
TO:               3_____________
 000 00:45:08:180 4_____________
                  5_____________ (Tabular Printout only)
                  6_____________ (Tabular Printout only)
                  7_____________ (Tabular Printout only)

SEARCH INTERVAL   SEARCH PARAMETERS  EVENT        VALUE          Found At:
FROM:             1_____________________________________________________
 000 00:44:59:000 2_____________________________________________________
TO:               3_____________________________________________________
 000 00:45:08:180 4_____________________________________________________
CTRL-Keys:
  P=Print screen     List name W=Write list file    G=Go to Analysis display
  B=Begin search     List name L=Recall list file
  T=Tabular print              U=Cancel operation   Z=Exit
(Enter HELP if you need instructions)
A16 INPUT:
```

Figure 9 - ANALYSIS ALPHA DISPLAY MENU

```
ANALYSIS OF TESTAC1                                      5-JUL-84 14:20:46

                CHAN1          CHAN2
   TIME         EUCNTS         EUCNTS
23:50:49:320     821.0000       512.0000
23:50:49:322     820.0000       512.0000
23:50:49:324     821.0000       512.0000
23:50:49:326     820.0000       512.0000
23:50:49:328     821.0000       512.0000
23:50:49:330     1023.000       512.0000
23:50:49:332     1023.000       512.0000
23:50:49:334     1023.000       512.0000
23:50:49:336     1023.000       512.0000
23:50:49:338     1023.000       511.0000
23:50:49:340     1023.000       512.0000
23:50:49:342     1023.000       512.0000


CTRL-Keys:
  P=Print screen                                          R=Return to menu
                                                          Z=Exit
Vertical ARROW KEYS start/stop scrolling   Number Keys 1-9 control scroll speed
```

Figure 10 - ANALYSIS ALPHA DISPLAY

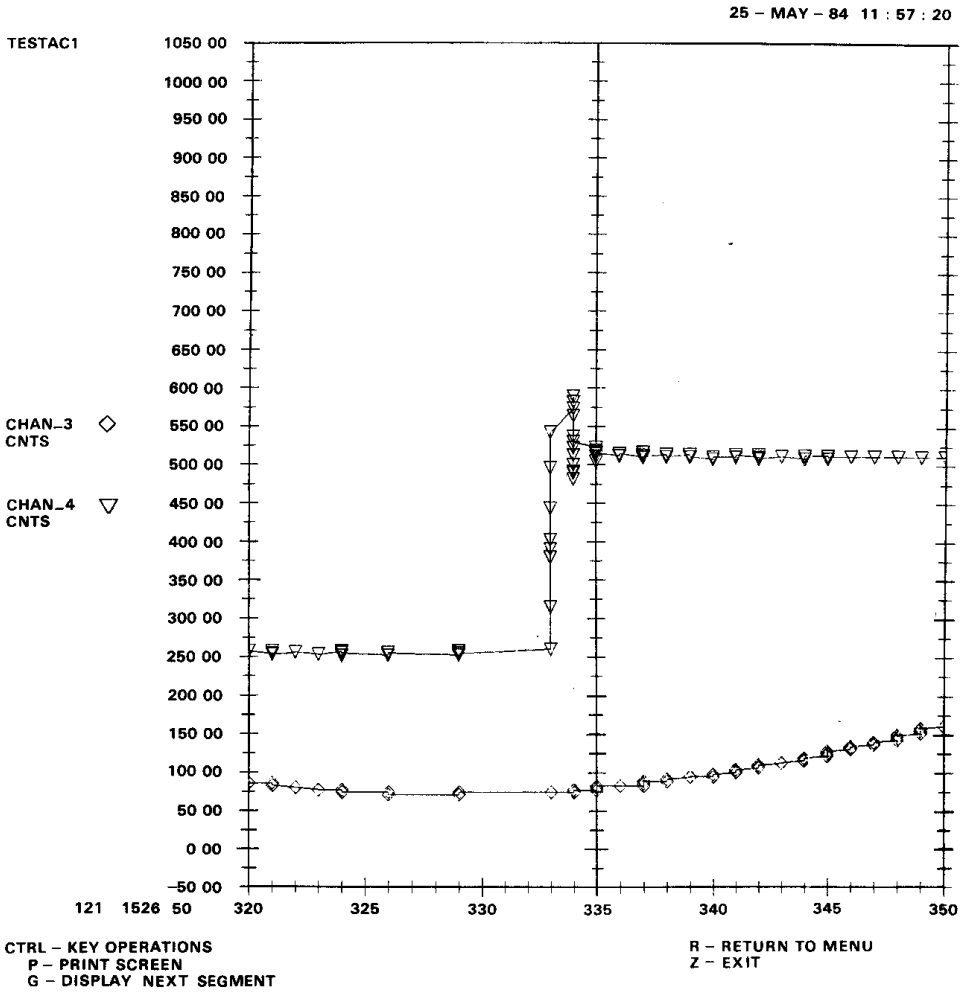

Figure 11 - ANALYSIS GRAPHIC DISPLAY

```
AUTOTROUBLE (AUTO.COM)                AUTOTROUBLE          5-JUL-1984 08:20:53
+-------------------------------------------------------------------------------+
|    SIMULATED STREAM TESTS             |    715 #1 DIAGNOSTICS                 |
|         OPTIONS: /NOBIT,/LOOP         |      16. MEMORY TEST                  |
|       1. SIMULATED PCM                |      17. ALL OTHER TESTS              |
|       2. SIMULATED SRAM               |                                       |
|       3. SIMULATED PAVETACK           |    715 #2 DIAGNOSTICS                 |
|       4. SIMULATED MARK II #1         |      18. MEMORY TEST                  |
|       5. SIMULATED MARK II #2         |      19. ALL OTHER TESTS              |
|       6. SIMULATED MARK II #3         |                                       |
|       7. SIMULATED MARK II #4         |    715 #3 DIAGNOSTICS                 |
|       8. SIMULATED 1553 MUX BUS 1     |      20. MEMORY TEST                  |
|       9. SIMULATED 1553 MUX BUS 2     |      21. ALL OTHER TESTS              |
|      10. SIMULATED FM MUX 1           |                                       |
|      11. SIMULATED FM MUX 2           |  +------------------------------------|
|      12. SIMULATED FM MUX 3           |    DISK ASSIGNMENTS                   |
|      13. SIMULATED MULTI-STREAMS      |      22. ASSIGN DATA DISKS            |
|      14. ALL SIMULATION TESTS         |  +------------------------------------|
|    ANALOG STREAM TESTS                |                                       |
|         OPTION: /ACQONLY              |       EX. EXIT TO VMS                 |
|      15. ANALOG TAPE                  |       LO. LOGOFF AUTOTROUBLE          |
+-------------------------------------------------------------------------------+

ENTER MENU ITEM NBR:
```

Figure 12 - AUTOTROUBLE SHOOTING MENU