INTRALAB MEMORANDUM

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FROM: J. Paradiso

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SUBJECT: SIGMA 5 CALCOMP PLOTTING PACKAGE

The attached document describes the operation and capability of the present Calcomp plot software residing in the Sigma 5. For those interested in running the programs this may be referenced as a users guide, while for those concerned with usage alone, this can serve to familiarize with options and various specifications which may be requested.

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SIGMA 5 CALCOMP PLOTTING PACKAGE

GENERAL DESCRIPTION

The Sigma Five System now possesses the capability of producing Calcomp plots from the following data sets:

C and A, Formatted Data, Dedicated Data

There is one "front end" data acquisition and conversion program written for each of the above, and they all refer to a common library of conventional Calcomp-Type routines.

CONTROL STRUCTURE

The control structures of the front end plotters are all basically similar in nature. After initiating a run, parameters and options are specified for one segment of the run, then indicies into the proper data set are entered. More segments may be started after one is finished by entering Keyed termination parameters, allowing another environment to be selected by specifying different options, etc. After finishing the final segment of the run, control is given to the Operating System, and the job is ended.

The card reader is the principal control device used in these programs, and the input deck required has the following structure:

(1) Load, Assign, and run commands

(2) Start Record, Stop Record, Record Skip Factor

(3) Option Specifications

(4) Title of run segment

(5) Indicies and Titles for each entry desired to be plotted

(6) "999" segment termination card

(7) "MORE"/"NO MORE" new segment/terminate run card

(8) Either start a new segment here, and go to 2, or include JCP cards

Each of these input steps will be described respectively in detail below:

(1) Conventional Format: refer to Sigma 5 RBM manuals. Also refer to the concluding sections of this document.

(2) This is one card, which initiates a run segment. Its format is: IB, IS, ISF where IB is the begin record, IS is the stop record, and ISF is the number of records to be skipped between each sampled point. The maximum number of points capable of being plotted is 2001. If the begin, stop times and skip factor are specified such that more than 2001 points will be sampled, the program adjusts the skip factor so that 2001 points or less are actually sampled.

(3) There are six options presently offered by our plotting system. More will be included when need arises. Each option requires at most two cards, one containing only a control character in column one specifying the particular option, followed by another, if needed, containing numerical information. These options may be specified in any amount and order (if no options are desired, none need be specified). The options currently offered are:

Control Character	Option Specified	Description
#	Tape	This option allows one to output the plot commands to tape (9TA81) in fixed length (200 byte) records, rather than directly to the plotter. After each plot is completed, a special indexing code is put on the tape so that every plot may be independently accessed. When a run is terminated, another code is put on tape specifying end-of-job. [A foreground program is available which reads and decodes these tapes, and dumps them to the plotter -- see ahead] This option is used when the speed of tape is preferred over the "plodding" plotter, resulting in a 90% reduction in background time. The tape created by this process can be later dumped to the plotter in foreground, freeing background for other jobs. This option is not re-set after each run segment and once specified, it holds until the run is complete. [Note-one 2,400 ft. tape will hold about 50 to 100 average full sized plots] No numerical input cards are required with this option!

? SUPRESS
END CODE

When dumping plots onto tape, it sometimes proves quite beneficial to include several runs [ie. plots from different data sets, different tests, etc.] on one tape. However, when the foreground dumping program (see ahead) process these tapes, it automatically halts plotting when it detects a special code placed on the tape at the conclusion of each run. Using this option however, you can suppress that end code, so that the foreground plotter will plot several runs without halting. (Just make sure that the last run on the tapes does have that end code, or the plotter may continue past the last plot and write gibberish). This option has no effect unless the tape (#) option is specified, it requires no numerical input cards, and it only needs to be specified once during a run.

% SIZE

By default, all plots produced occupy about 10 1/2 x 7 3/4 inches of paper, and the axes sizes correspond closely to those present on the plots already produced with the IBM 360. When this option is specified, however, the size of the plot may be changed. A numerical input card is necessary after this option speci-

fication, which contains a floating point number that multiplies the default plot size; .25 gives you 1/4 size, etc. DO NOT specify an entry greater than 1., as this will expand the plot, and, since plots now occupy most of the available area on the paper, this can cause the pen to jam against the edge of the plotter, hopelessly distorting the graph. This option resets to the default after each run segment, and it must be re-specified if desired. Smaller plots take less time to make and occupy less space on tape, so in some circumstances they may prove advantageous. Plots down to half size are quite legible.

@ FILTER

This option specifies that the data is to be filtered using a conventional one stage digital filter before plotting takes place. A numerical input card is required, specifying the filter time constant <real no.> in minutes, and the filter skip factor <integer>, in records. The print skip factor (ISF, see pt. 1 above), and filter skip factor may be different, (if you desire to filter every 2 points, plot every 4, etc.) but, results may be unpredictable if the filter skip factor is not a multiple of the print

skip factor. If the filter skip factor is specified greater than the print skip factor, the program makes the filter skip factor equal to the print skip factor. Both the time constant and filter skip factor are printed in the upper left-hand corner of filtered plots. The filter option re-sets after each run segment, so it must be re-specified for each segment where filtering is desired.

MANUAL SCALING

The C and A and Dedicated Data programs scale data automatically by default. There are occasions which arise, however, when certain areas of the plot are viewed better under different scaling conditions, as automatic scaling can sometimes prove pretentious. This option overrides the scaling default, and enables the user to enter a numerical input card containing the maximum and minimum range values (Real numbers!! they may be specified on the card in any order). The plotting program then adjusts these values slightly so that the labels on the axes are properly rounded numbers. If the imposed scaling is too small, and would normally cause the graph to drift out of the plot boundry, a protection routine is brought into service which causes the

graph to saturate on the plot borders. Here again, this option re-sets to the default after each run segment, so it must be re-specified if desired. [Note: The Formatted Data plot program scales manually to +5.0, -4.0 volts by default. This option, when dealing with Formatted Data, allows one to set new values for manual scaling.]

* AUTOMATIC SCALING

This option is present only in the Formatted Data Plot program!! The manual scaling default described above is by-passed, and the program scales automatically when this option is specified. No numerical input cards are required! This option resets to the manual default after each run segment, so it must be re-specified if desired.

(4) The Title of the run segment is a 20 or less character block which is printed out on each plot in the segment. It is specified on a single card, left justified. (Lower case and scientific characters may be input by using the multi-punch on any card.)

(5) [Refer to the Queued I/O PDD for data set constructions. An indexing table which clarifies this section is contained at the end of this manual] Format of data set indexing and selec-

tion is different for each front end plotter, so they will be independently described:

a) C and A

Indexing into the C and A Table is primarily double precision. The three torque words are respectfully 1, 2, and 3, then the DP. index begins with 4, 5, and 6 pointing to WPIG 1, 2, and 3, etc. Indices 10, 11, and 12 are not used, but the numbering again proceeds normally with 13 pointing to the 1'st transition matrix entry and 114 pointing to the last entry in the Covarience Matrix diagonal. If necessary, the integers skipped in this data set may be accessed by specifying an index of 115 through 120. This is a single precision index, with 115 pointing to CNTRLWRD, and 120 pointing to CWPNTR. These integers are plotted as is, and no coversions are attempted. The index specified into the C and A Table is printed on the plot, and a message is printed whenever you access the State Vector estimate or standard deviation (covarience Matrix diagonal.) [A state vector index ranging 1→57 is also included]

The index is specified on a card along with a 16 character title describing the item selected, which is printed on the plot. Some Sample C and A index cards are:

1,TORQUE VECTOR#1

22,X RESIDUAL

b) Formatted Data

The formatted data table is accessed using two indices, one ranging 0 to 79 specifying the particular word in the table, and the other being a sub-index ranging 1 to 3, specifying the item desired in that word. The format of the indexing card is: INDEX, SUB-INDEX, TITLE where the title is a 16 character block printed on the plot. If the sub-index is specified greater than 3, all three items selected by the word index are plotted independently on 3 separate plots, with the specified title appearing on each. Both the word index and sub-index are also printed on every plot. Some sample indexing cards are:

```
65,1,SFIRJ1 20 VDC RN
74,3,TGG 3 20 VDC RTN
22,4,MTR PWR MON (Prints all 3)
```

c) Dedicated Data

The dedicated data word index ranges 1→25. Value 3 points to Pump Pressure Sum, 4, 5, and 6 to Wheel Power Sums, 7 to OLDMAT, and 8 to fluid temperature. The 80 word Formatted Data Table is then skipped, and Index 9 points to the TOD, 10 to the SF attitude word, etc. When plotting attitude data, a sub index must be specified, pointing to the item (31 and 32 speed) in the selected word. If that index is greater than 2, both speeds are output on two separate plots. If the

specified sub-index is negative, the attitude error is calculated and another card is input containing a real number specifying the rate used. When selected, messages are printed on the plot showing Attitude type (phi or Theta), speed, Error flag, and rate (if calculated). An index is also printed on the plot, but this index includes the formatted data Table, and ranges 1→105. The format of the indexing card is: INDEX, TITLE SUBINDEX, [Sub-index begins in column 20, and is followed by a comma]

The sub-index need not be specified if attitude data is not selected. If a sub index greater than two is included with any item other than attitude data, two plots of the selected item are produced. The title, of course, is 16 characters long, and appears on the plot. Some sample indexing cards follow:

```
3,PUMP PRESSURE
11,31 SPEED PHI ATT 1,
12,PHI ATT, WORD#2 3, (Plots both speeds)
14,THETA ATT. #1 ERR -3,(Calculates error for
                         both speeds)
15.5                    (Rate card)
17,DC MATRIX #1 3,      (Makes two plots
                         of the same item)
```

In any data set, as many indexing cards as desired can be included in a run segment.

(6) This is one card with the number "999" left justified. Its only purpose is to inform the program that the current run segment has ended, and no more indexing cards are to be read.

(7) This is one card specifying whether to terminate the run and input a JCP card, or to start a new segment, and input a Begin, Stop, Skip Factor card and Re-initialize. If this card bears the word "MORE", left justified, a new segment is initiated, but if it contains anything else, the run ends, and control is handed to the JCP.

(8) If the above card was "MORE", Skip back to item (2) above, if not, a JCP card (probably! FIN) goes here.

FORMAT, FEATURES and FACTORS

Each program calculates the actual maximum, the average, and the standard deviation over the presented domain (unaffected by any scaling conditions). This data is printed at the bottom of every plot. A plot number is also included on the plots, this refers to the sequential order of plots within a run segment. All plots also print the Time of Day (Hour, minute, month, day, year) taken from the computer clock when the plot was made. The begin and stop records are not printed, but the horizontal axis is labeled in MPC minutes, which results from record number. The record skip factor (ISF) is not printed, but small circular marks are made on the graph after every 200 points are plotted, so, observing the

density of these marks, the amount of points skipped is easily estimated. When plotting attitude data, the validity flag is always checked, and if it is not set, the pen is lifted and the "bad" points are not plotted. If, for some reason, there are no valid points found within the specified domain, the message "NO VALID POINTS" is printed and the next item is plotted.

In C and A and Dedicated Data, several different conversions are applied to the data in order to plot in engineering units. The units themselves are printed on the axes (as labels) wherever possible. All items in Formatted Data are converted to and plotted in VOLTS.

PLOTTING IN FOREGROUND

Because our plotter is painfully slow (8 minutes per plot, average), and since whenever background is used to plot the computer is effectively monopolized, a scheme of foreground plotting has been developed. The tape option mentioned earlier can be specified, allowing up to 100 plots to be set up on a magnetic tape within an hour, saving 95% of computer time. A foreground dumper named "PLTDMP" can then be run, which decodes the tape and dumps incremental commands to the plotter. Background jobs can be entered while this program is engaged, and it can run simultaneously with AIRSHLOD.

In order to operate this program, key in the teletype: "RUN PLTDMP". A four-digit or less number is then requested specifying the number of plots to dump from tape. If a number larger than the

amount of plots residing on the tape is input, the program will plot until a termination code is detected, which is placed on the tape at the completion of a run. Next, another number is requested, specifying the number of plots to skip on the tape. If this number is zero, plotting begins wherever the tape is currently placed. The program will then start plotting, and continue until either an I/O error is detected (at which time an appropriate message will be typed), or until it completes all plots. When the program finishes plotting it releases itself.

NOTES ON RUNNING IN BACKGROUND

In order to run a background load module, you must first copy it into the OV file in the BT area using RADEIT, and then execute with a !ROV command.

The following is a sample deck, loading C and A plots onto tape:

```
!JOB 4108, PARADISO
!RADEDIT
!COPY (FILE,D7,CXACALC),(FILE,BT,OV)
!ROV
10,1500,2 (Plot every other record, 10 thru
           1500)
#          (Selects tape option)
@          (Selects filter option)
30.0, 1    (30 min. time const., filter every
           point)
TST#360, DISC CAL#5   (Title of segment)
2,TORQUE WRD#2        (Indexing cards)
6,WPIG#3
```

```
999                 (Terminator)
MORE                (begins another segment)
1500,2000,1         (Plot every record, 1500
                     thru 2000)
RUN#2          (Title of next segment - No
                options declared)
24,Z RESIDUAL       ( Indexing cards)
999                 (Run Terminator)
NO MORE             (Job Terminator)
!FIN                (JCP card)
```

It is possible to redefine the read DCB's in the front end programs so that they will pick up data from other disk files which may have been created using previous D8 save tapes. If the data has been dumped into a file called X9 in the BT area, you will need a card:

```
!ASS (F:4,BT,X9)   For C and A data
!ASS (F:7,BT,X9)   For dedicated and formatted
                   data
```

These cards are placed immediately before the !ROV card.

NOTE: It is now possible to read data in any format, convert and re-format it, and then store it on disk in conventional "data set" form. The Calcomp routing can then be called to read and plot these files, making it possible to employ our present front end plotting library to plot any type of data from any source (tape, cards, other disk files, etc.). Software to perform this format conversion has already been developed, and it is a simple matter to adapt it for any type of input data.

FILES IN PLOTTING LIBRARY

Purpose	Title (Source)	Title (binary)	Title (load module)	Rad Area
C and A front end	CAPLOT [F]	ROMCAPT	CXACALC	D7
Formatted Data front end	FORPLOT [F]	ROMFDPT	FORMCALC	D7
Dedicated Data front end	DEDPLOT [F]	ROMDDPT	DEDCALC	D7
Scaling	CCSCALE [F]	ROMSCALE	———	D7
Scaling check	CCCHECK [F]	ROMCHECK	———	D7
Array Plotting	CCLINE [F]	ROMLINE	———	D7
Axis drawing	CCAXIS [F]	ROMAXIS	———	D7
Tod read	CCTIME [AP]	ROMTIME	———	D7
Symbol/Number Plotter	CCSYMB [AP]	ROMSYMB	———	D7
Plot Driver	CCPLOT [AP]	ROMPLOT	———	D7
Foreground Dumper	DUMPER [AP]	ROMDUMP	PLTDMP	D7, DF

NOTE: [F] = Fortran Source [AP]= Assembly Source

DATA SET INDEXING

1) C and A: Data set #4

Item	Index
Torque Command Words	1→3
SFIR Head Rate (WPIG)	4→6
Platform Rate (WPIP)	7→9
C and A Control Word	115
CWPNTR	↓ 120
Transition Matrix	13→21
Measurement Residual	22→24
State Vector	25→81
Covarience Matrix Diagonal	82→114

2) Formatted Data: Data set #7

Item	Index	Sub-Index
SFIR-J1 Minor Loop Null Mon SFIR-J2 Minor Loop Null Mon SFIR-J3 Minor Loop Null Mon	0	1 2 3
SFIR-J1 Servo Lag Output Mon SFIR-J2 Servo Lag Output Mon SFIR-J3 Servo Lag Output Mon	1	1 2 3
	↓	
Valve 1B Position Mon Valve 2B Position Mon Valve 3B Position Mon	79	1 2 3

3) Dedicated Data: Data set #7

Item	Index	Sub-Index (if applicable)
MPC at 1 Min.	1	———
ID.=7	2	———
Pump Pressure Sum	3	———
Wheel Power Sums	4→6	———
OLDMAT	7	———
Fluid Temperature	8	———
	80 Word Formatted Data Table is skipped	
Time Of Day	9	———
Super-Fine Attitude Word	10	1=31 speed, 2=32 speed
Ø Attitude angles	11→13	1=31 speed, 2=32 speed
Θ Attitude angles	14→16	1=31 speed, 2=32 speed
Attitude Direction Cosine Matrix	17→25	———