Carnegie-Mellon University

COMPUTATION CENTER

Hybrid Computation Laboratory

USERS MANUAL

ANALOG
EAI 680

USER MANUAL

OPERATION

EAI 680 Operational Characteristics

Carnegie-Mellon University
Hybrid Computation Laboratory
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1.0 PROBLEM PREPARATIONS

Time spent in preparation prior to actual computer running will greatly simplify debugging procedures and will help to produce more complete and meaningful results. The following procedure serves as a guide to problem preparation and will hopefully eliminate some of the problems encountered on the analog computer.

1.1 PROBLEM STATEMENT

The operator should attempt to state the problem and objectives precisely. With the problem defined the mathematical relations can be transformed to equations suitable for the analog computer as follows:

1) Express the problem as ordinary differential equations, transfer functions and/or algebraic equations.
2) Define the values for coefficients and initial conditions.
3) Note parameters to be valid.
4) Determine the estimated ranges of the variables.

1.2 BLOCK DIAGRAM

At this point a preliminary block diagram can be drawn. This diagram should be simple, ignoring scaling and actual values. It can be used to:

1) determine type and number of components needed,
2) if sufficient data is available to solve the problem,
3) isolate the parameters to be varied, and
4) simplify by eliminating redundant operations or components.

1.3 SCALING

Scaling the problem variables to machine variables can be accomplished by several different methods. The "Handbook of Analog Computation", referred

to in the introduction to this user manual, gives two methods of scaling, the advantages of each and a number of examples. A few points to keep in mind regardless of the scaling method employed are:

1) Amplifier outputs should take full advantage of the range 0.1 to 1.0 machine units to minimize the effect of inherent amplifier noise.
2) Poteniometer settings less than 0.1 lose a digit accuracy and should be avoided if possible.
3) Amplifier gains greater than 20 increase the effect of amplifier noise.
4) The problem should be time scaled within the bandwidth of the output device. Specifications are given in the individual device manuals.

The resulting scaled equations should be balanced, checked for the same relationships, and written explicitly to be used as a guide to patching.

1.4 COMPUTER DIAGRAM

A detailed computer diagram can now be drawn from the scaled equations. It should include amplifier gains, polarity, component numbers, and all other information pertinent to patching and running. A picture of the EAI 680 patch board included in the back of the Reference Handbook may simplify chosing the components to be used. The equipment available at the CMU Hybrid Lab is listed in the SYSTEM DESCRIPTION section of this manual. Standard symbols and patching instructions are given in Appendix 1 of the 680 Reference Handbook.

The potentiometer (Fig. 1) and amplifier (Fig. 2) assignment sheets are available to simplify bookkeeping. Assignment sheets for the logic

(Fig. 3) and the nonlinear components (Fig. 4) are also available. Further information and conventions used on assignment sheets are given in Appendix II of the 680 Reference Handbook.

1.5 STATIC CHECK

A static check can prevent needless frustration if performed prior to the computer run. It will:

1) Check patching,

2) Detect bad analog components, and

3) Find programming errors such as improper polarity, etc.

The 680 provides a Static Test (ST) mode permitting a static test with a minimun of effort and patching changes. A Test Reference available at the patch panel provides computer reference only during ST mode and is used to provide integrator outputs and other parameters for checking purposes.

The HYSAT program described in the hybrid HYSAT section of this manual facilitates using the PDP-9 to perform the static check.

FIGURE 1

CMU HYBRID COMPUTATION LABORATORY

EAI 680 POTENTIOMETER ASSIGNMENT SHEET (P00-P58)

PROBLEM_____ USAGE#_____ DATE_____

POT	PARAMETER EXPRESSION	CHECK SETTING	RUN SETTING
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
25			
26			
27			
28			

POT	PARAMETER EXPRESSION	CHECK SETTING	RUN SETTING
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
55			
56			
57			
58			

FIGURE 2

CMU HYBRID COMPUTATION LABORATORY
EAI 680 AMPLIFIER ASSIGNMENT SHEET (A00 - A58)

PROBLEM_____ USAGE#_____ DATE_____

AMP	USE	OUTPUT VARIABLE	CHECK DERIVATIVE	CHECK VALUE
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
25				
26				
27				

AMP	USE	OUTPUT VARIABLE	CHECK DERIVATIVE	CHECK VALUE
28				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
53				
55				
56				
58				

FIGURE 3

CMU HYBRID COMPUTATION LABORATORY

EAI 680 LOGIC ASSIGNMENT SHEET

PROBLEM_____ USAGE* _____ DATE _____

FF	OUTPUT	ENABLE	F/F	OUTPUT	ENABLE	F/F	OUTPUT	ENABLE
0A			1A			2A		
0B			1B			2B		
0C			1C			2C		
0D			1D			2D		
3A			4A			5A		
3B			4B			5B		
3C			4C			5C		
3D			4D			5D		

GATE	OUTPUT	GATE	OUTPUT	GATE	OUTPUT	GATE	OUTPUT	GATE	OUTPUT	GATE	OUTPUT
0A		0D		1A		1D		2A		2D	
0B		0E		1B		1E		2B		2E	
0C		0F		1C		1F		2C		2F	
3A		3D		4A		4D		5A		5D	
3B		3E		4B		4E		5B		5E	
3C		3F		4C		4F		5C		5F	

MONO	FUNCTION	SETTING	DIFF	FUNCTION	PB	FUNCTION
00			00		0	
01			01		1	
02			02		2	
40			40		3	
41			41		4	
42			42		5	

COUNTER	FUNCTION	T W	U/D	INTERVAL	FUNCTION	SETTING		
1				A				
3				B				
5				C				

FIGURE 4

CMU HYBRID COMPUTATION LABORATORY

EAI 680 NONLINEAR COMPONENT ASSIGNMENT SHEET (MULTIPLIERS, DFG's, LIMITERS, AND HAND SET POTS)

PROBLEM_____ USAGE#_____ DATE_____

HAND POT	PARAMETER EXPRESSION	CHECK SETTING	RUN SETTING
2			
7			
12			

HAND POT	PARAMETER EXPRESSION	CHECK SETTING	RUN SETTING
17			
22			
27			

LIMITER	AMP	LIMITIED VARIABLE	CHECK SETTINGS +	CHECK SETTINGS −	RUN SETTINGS +	RUN SETTINGS −
1						
11						
21						
31						
41						
51						
61						
71						
81						
91						
101						
111						

VDFG	USE	OUTPUT VARIABLE	CHECK VALUE
32			
42			
62			
72			

VDFG	USE	OUTPUT VARIABLE	CHECK VALUE
37			
47			
67			
77			

MULT	USE	MULT	USE	MULT	USE	MULT	USE	FDFG	TYPE	USE	FDFG	TYPE	USE	FDFG	TYPE	USE
3		18		33		48		32			47			72		
8		23		38		53		37			62			77		
13		28		43		58		42			67					

2.0 PATCHING

The EAI 680 patch boards will be available at the hybrid lab before the scheduled time to permit off-line patching. The taped sections of the patch board indicate that components are missing due to maintenance or non-availability. Patch directly from the computer diagram, marking out lines as they have been patched. When patching is complete, recheck or have a partner recheck for errors. A few points to remember are:

1) Check bottle plugs for proper function of the component (see Appendix 1*).
2) Outputs of D/A switches must be patched to a summing function of an amplifier and normally give a gain of ten (see Chapter 13.3*).
3) Pot inputs are normally connected to amplifier output in the same tray (see Chapter 8.1*).
4) Handset pots lettered as Q on the patch board are not easily distinguished from normal servo set pots (see Chapter 8.2*).
5) Never patch a pot directly into a multiplier or function generator.

*EAI 680 Reference Handbook

3.0 ANALOG COMPUTER OPERATION

Organization is the key to obtaining good results on the analog computer. After thorough preparation and a static check, a carefully planned approach to the problem should begin. The following is an outline for a planned running procedure.

3.1 COMPLETED PREPARATION

Before running a problem on the 680, the user should have:

1) the original equation of the problem,
2) the preliminary block diagram,
3) scaled table and equations,
4) detailed circuit diagram,
5) potentiometer, amplifier, logic, and non-linear assignment sheets,
6) a schedule of operations indicating operating plan, and
7) problem log to record all actions and results while running.

3.2 START UP

1) Insert patch panel into 680 patch bay and press engage button.
2) Set all potentiometers using servo pot system (see Chapter 4, Reference Handbook).
3) Set all limiters and (or) diode function generators.
4) Perform static check calculated previously, measuring all amplifier outputs and integrator derivatives.

After the static check is successfully completed, a test solution or a dynamic check should be recorded for comparison with future test runs.

If patching changes are to be made while on line, read the cautions in division 4 of this write-up.

4.0 CAUTIONS AND HINTS

4.1 CAUTIONS

1) Patching amplifier output to another amplifier output will cause overload and result in amplifier damage.
2) Patch from cold to hot; i.e., input to output and input to reference.
3) Patching computer reference directly into a function relay is dangerous since an inadvertant short will weld the relay contacts together.
4) Prolonged overloads reduce the life of amplifiers and should thus be avoided.
5) A potentiometer that fails to set properly will drive continously or until the clear (CL) button is pushed. If allowed to drive damage to the servo motor and/or servo power supply will result.

4.2 HINTS

1) Overloading of all amplifiers indicates patch panel is not engaged.
2) The digital voltmeter (DVM) will not convert if the digital computer I/O switch (located behind the logic component display door) is on. In this case, a pushbutton to the left and below the DVM will give convert commands to the DVM as long as it is depressed.
3) The 6 handset pots, prefixed by a Q, are not clearly marked on the patch panel and may inadvertantly be used as a servo pot.
4) A D/A switch must be patched to a summing junction of an amplifier.
5) Patching a pot into a multiplier or function generator causes errors due to their non-linear input impedance.
6) The indicator in the Q4 potentiometer position lights whenever the 680 console is selected by the PDP-9.