USER MANUAL

SYSTEM DESCRIPTION

Carnegie-Mellon University
Hybrid Computation Laboratory
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1.0 INTRODUCTION

The Carnegie-Mellon University Hybrid Computation Laboratory maintains a sophisticated hybrid computer as its primary computer system. This hybrid computer consists of a PDP-9 digital computer (Digital Equipment Corporation), an EAI 680 analog/logic computer (Electronic Associates, Inc.), and an EAI 693 hybrid interface (Electronic Associates, Inc.). The CMU hybrid lab also has available for use a Westinghouse GPS analog computer (vacuum-tube type repetitive operation analog computer).

The rest of this write-up presents an overall view of the hardware configuration and software complement of the hybrid computer.

2.0 HARDWARE

2.1 PDP-9 (DIGITAL)

The CMU hybrid computation laboratory PDP-9 digital computer configuration currently consists of the following equipment:

a.) PDP-9 digital computer with 1 μsec memory cycle time, real-time (60 cps) clock, 16K of 18-bit word core memory, and an extended arithmetic element.

b.) API option: 8 levels of automatic priority interrupts (4 hardware and 4 software levels).

c.) KSR35 teletype (console typewriter): 10 characters/second.

d.) High-speed paper tape I/O: 300 characters/second input and 50 characters/second output.

e.) Bulk storage I/O: 1 DECtape controller with 4 DECtape units-- fixed position reading and writing, 576 blocks of 256 18-bit words each per tape, 200 μsec/18-bit word transfer rate, 53 msec/block transfer rate (2.6 million bits/tape).

f.) Dataphone: in process of installation.

Detailed information concerning PDP-9 hardware is contained in DEC publication F-95, PDP-9 User's Handbook, January, 1968.

2.2 EAI 680 (ANALOG)

The EAI 680 is a 10 volt analog computer capable of computation in real time and compressed time up to 10,000 times real time. The 680 also has digital components for logic operations and control inputs to the analog components, and peripheral equipment for a wide range of output display.

The EAI 680 presently consists of the following equipment:

I. Analog computing elements
    a.) 30 combination amplifiers (may be used as integrators or summers)
    b.) 24 summing amplifiers
    c.) 24 inverters
    d.) 12 track-store amplifiers
    e.) 12 quarter-square multipliers
    f.) 8 variable diode function generators
    g.) 4 fixed diode function generators (LOG)
    h.) 4 fixed diode function generators (SIN/COS)
    i.) 100 servo-set potentiometers
    j.) 6 hand-set potentiometers
    k.) 16 comparators
    l.) 16 function relays
    m.) 16 D/A switches
    n.) 12 variable limiters
    o.) 12 zero limiters
    p.) 1 five-place digital voltmeter

II. Logic elements
    a.) 36 and gates
    b.) 6 4-bit general purpose registers
    c.) 6 monostable timers
    d.) 3 two-place BCD counters
    e.) 6 differentiators
    f.) control inputs for integrator time scales and modes, track-store modes, D/A switches, and function relays
    g.) comparator outputs

III. Peripheral display equipment
    a.) TEKTRONIX RM564 storage oscilloscope with a four-trace vertical amplifier
    b.) EAI 1110 X-Y plotter
    c.) 8-channel brush recorder with two event-marker channels
    d.) display scope with 8" x 10" display area and 4 distinct, simultaneous traces

Detailed information concerning EAI 680 hardware is contained in EAI publication #00800.2048-1, July, 1967.

2.3 EAI 693 (HYBRID INTERFACE)

The EAI 693 hybrid interface provides the data transfer and control operations between the EAI 680 and the PDP-9 necessary for hybrid computation. It provides the following capabilities:

a.) 15 channel, 30KC analog-to-digital converter (ADC).
b.) 4 digital-to-analog converters (DAC).
c.) 8 digital-to-analog multipliers (DAM).
d.) analog component selection and readout.
e.) potentiometer selection and servo-setting.
f.) analog and logic mode control.
g.) integrator time scale control.
h.) function relay control.
i.) comparator status readout.
j.) 16 digital-to-analog control lines.
k.) 8 analog-to-digital sense lines.
l.) 8 analog-to-digital general purpose interrupts.

3.0 SOFTWARE

3.1 DEC-SUPPLIED (PDP-9 STAND-ALONE)

All software described below is supplied and maintained by Digital Equipment Corporation. This software comprises the basic operating system for the PDP-9, stand-alone or hybrid.

a.) System Bootstrap: used to initial-load the Keyboard Monitor from the system tape.

b.) Keyboard Monitor (KM9): provides automatic storing, calling, loading, and executing of system and user programs; executes all I/O operations; provides error detection, error messages, and error recovery; provides for program pause and saving of the status of all relevant registers.

c.) Symbolic Editor (EDIT): provides the ability to create new symbolic text or to read old symbolic text from any input device, to examine and correct the text, and to write it on any output device.

d.) Library Update (UPDATE): provides the ability to create, examine, or alter library files on DECtape.

e.) Peripheral Interchange Program (PIP): facilitate the manipulation and transfer of data files from any input device to any output device.

f.) Fortran IV (F4): a two-pass compiler which accepts FORTRAN IV programs and produces relocatable object code acceptable to the Keyboard Monitor system.

g.) Macro-9 (MACRO-9): a two-pass machine language macro assembler which produces relocatable object code acceptable to the Keyboard Monitor system, or absolute object code acceptable for hardware read-in.

h.) Linking Loader: a relocatable loader which loads user programs into core, relocating and packing as necessary for efficient use of core storage.

3.2 HYBRID COMPUTATION LABORATORY

The software described below was developed and is maintained by the hybrid lab. Complete documentation of this software is contained in this user's manual.

a.) Hybrid Static Analog Test Program (HYSAT): provides the user with a standard facility for initial problem setup, static analog checkout, and potentiometer value save.

b.) linkage routines: a package of FORTRAN-callable functions and subroutines which provides the user access to all of the capabilities of the EAI 693 hybrid interface, as well as PDP-9 priority interrupt manipulations, console facilities, and the real-time clock.

c.) Continuous Systems Modeling Program (CSMP): provides a digital assist in the accurate simulation of dynamic systems modeled by ordinary differential and difference equations.