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# Adaptive Learning Network (ALN) Hardware

## **Abstract**

Adaptronics, Inc. is currently developing a "smart" UT and EC interpretive instrument under funding by the Electric Power Research Institute (EPRI Contract Nu. RP1125). The instrument, denoted the "ALN 4000 Process Analysis Microcomputer", is a dual microprocessor microcomputer system.

## **Keywords**

Nondestructive Evaluation

## **Disciplines**

Materials Science and Engineering

## ADAPTIVE LEARNING NETWORK (ALN) HARDWARE

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### ABSTRACT

Adaptronics, Inc. is currently developing a "smart" UT and EC interpretive instrument under funding by the Electric Power Research Institute (EPRI Contract No. RP1125). The instrument, denoted the "ALN 4000 Process Analysis Microcomputer", is a dual microprocessor microcomputer system. The over all features of the ALN 4000 are:

- o Two Z80 microprocessor subsystems;
- o 30 MHz 8-bit A/D logic (ultrasonics);
- o 50 KHz 12-bit A/D logic (eddy current);
- o Adaptive Learning Network (ALN) implementation logic;
- o Tape cassette bulk memory capacity;
- o Miniprinter display;
- o Modem for remote digital data telephone transmission;
- o Conversational mode I/O with user;
- o Programmable;
- o Fully portable;
- o Operable in hostile environments (dust, heat, etc.).

The ALN 4000 breadboard is currently operational. The first field-portable prototypes will be available in the Fall of 1978.

### INTRODUCTION

The need for a real-time, portable computer system dedicated to NDE applications prompted the concept of the ALN 4000 Process Analysis Microcomputer smart instrument. New developments in semi-conductors and the advent of miniature peripherals made this concept feasible. The foundation of the instrument is a powerful dual computer system with several peripherals and dedicated NDE software. Several highly specialized boards to perform NDE functions and decrease execution times are also a part of the instrument.

The ALN 4000 is being designed to perform the function of NDE in as simple a manner as possible and with a minimum of equipment. In addition to the ALN 4000, only a transducer, a pulser-preamplifier and a receiver are necessary. When applicable, a positioning mechanism (scanner) for the transducer is included in the NDE system. Figure 1 shows a typical configuration. The instrument will control signal conversion, data acquisition, ALN processing, data storage and the scanner, where appropriate.

The instrument will be packaged in two cases, each approximately 8-3/4" H x 20" D x 17" W with custom-designed front panels. The weight of each case will be held to a maximum of 35 lbs. The

peripherals will consist of a hand-held Termiflex terminal serving as the control unit and key-board, a Digitec miniprinter for hard-copy display results, and a dual 3M mini-cassette system for mass storage. Alternatively, an off-line Computer Devices terminal may be used for more printing capability as well as providing a modem to transfer data to another computer system for ALN training or, perhaps, archival storage. There will be D/A (digital-to-analog) capability for oscilloscope display of waveforms (optional) and A/D (analog-to-digital) capability for digitizing RF signals from the transducer. Figure 2 shows the ALN 4000 as part of an NDE system in block diagram form.

The front panel of one of the cases (see Figure 3) will have all of the switches and status lights, the mini-printer and the cassettes. The other panel will be blank except for a power light. There will be only three switches, POWER, RESET and PAUSE; all other functions are controlled via the terminal. There will be three status lights to indicate the current operation: RUN, STANDBY, DIAGNOSTICS.

The instrument will also contain, where the application requires it, the hardware and software to control the scanning device. This will permit

automatic inspection and will increase the speed of the inspection as well as reduce the number of operations performed by the operator.

### OBJECTIVES

Flexibility of both the system hardware and software has been the major design consideration. The design reflects a desire to minimize the effort required to modify the instrument for different applications. The front end (data acquisition system) for ultrasonic applications, for example, can be programmed for different sampling rates (up to 20 MHz). To convert the instrument for use with eddy current applications, an A/U board and associated software will simply be replaced. Software changes are made as easily as changing a cassette. Data for specific applications can be entered via the keyboard, or prepared at an earlier date and stored on cassette.

Real-time operation is another important hardware and software design goal. The two hardware and software design efforts have proceeded simultaneously to achieve the maximum computational speeds. Multiplication, very slow in software, is performed much faster in hardware by means of a multiplier board using a high-speed multiplier chip. Similarly, an arithmetic processing unit (APU) chip has been interfaced to the ALN 4000 to provide a hardware implementation of functions such as the sin, cos, log, exp, etc. Assembly language is being used in the software to produce efficient programs, both in execution speeds and memory utilization.

Another objective is to provide an instrument that is reliable, requires minimum training, and is easy to operate.

### HARDWARE

The instrument design uses two microcomputer systems, each one to perform a separate function, but in parallel with each other. One system, called the controller, performs the supervisory functions, and the other system, called the signal processor, acquires waveforms and performs all analyses. Both systems use the Zilog Z80 microprocessor with a clock speed of 4 MHz. Communication between the two systems is achieved by means of a DMA (direct memory access) in conjunction with each computer, to provide direct memory access.

The various boards in each computer system are linked by means of a bus system. An industrial-quality bus, the Intel (Multibus) SBC bus, has been chosen.

Each computing system will contain a total of 64K bytes of memory consisting of 48K of RAM (random access memory) capable of reading and writing and 16K of EPROM (read only memory) with non-volatile read-only capability. The EPROM memory will be used to store the software that is pertinent to all applications. The controller computing system will have the input-output (I/O) capability and the signal processing system will have the data acquisition module.

Two special boards will provide the software support mentioned earlier, namely the high-speed multiplier board and the APU function which is

provided once in the controller system and four times in the signal processing system.

To summarize, there will be a total of thirteen boards in the ALN 4000. The controller will contain a CPU and DMA board, two memory boards of 32K each, one with a mix of 16K RAM and 16K EPROM, a board with one APU function and the D/A conversion logic, a multiplier board and an I/O board, for a total of six boards. The signal processor will contain an identical set of boards except that there will be four APU functions on a board and no D/A, there will be no I/O board, and will include two front-end boards for the data acquisition system for a total of seven boards.

### SOFTWARE

Three modes of operation are anticipated for the ALN 4000.

One is a data collection and digitization mode to store sufficient data to provide a data base necessary for ALN network training, for example. If a scanner is present, it may be controlled by the ALN 4000 in this mode to automate the collection procedure.

A second mode of operation is the off-line analysis to provide an inspector with the capability of selecting waveforms from the mass storage device and to perform signal processing operations as desired. The use of the off-line terminal in this mode will provide printing capability. A modem will permit data transferral to another computer. Use of an oscilloscope will provide a display of the waveforms.

The third mode is on-line analysis to be performed at the inspection site. This includes control of the scanning device, signal conversion and ALN processing to provide crack detection and sizing on-line. Figure 4 is a flow chart demonstrating the three modes of operation.

There will be no operating system of the type found in general computers. Instead, there will be an interactive program that queries the operator regarding desired actions and prompts with possible replies. The operator usually will have to respond only with a numerical value or with a single key stroke representing "yes" or "no" and "continue". The philosophy is to minimize operator errors and references to a User's Guide.

Self-diagnostic routines will be provided to increase system reliability. Each component of the instrument will be informed of any problems that may exist and, where possible, suggestions will be made to solve the problem; i.e., "place cassette in a specified drive", "check to see if a component is plugged in", etc. User system diagnostics will also be provided when appropriate.

The software modules that are applicable in any NDE system will be permanently resident in the ALN 4000. These will include supervisory programs, self-test diagnostics, I/O drivers, DMA routines and signal processing routines. Those routines and data that are application-specific will be stored on cassettes and will include the transducer scanning protocols, ALN structure and coefficients, and routines to drive and control the scanning

device.

### NDE APPLICATIONS

The ALN 4000 will be employed initially in UT and EC applications. The UT target areas are pipe crack detection and sizing, both in welds and heat-affected zones. The EC applications are currently detection and sizing of both hole, cracks in the TF-33 engine disk (Figs. 5 and 6)<sup>1</sup>, and detection, classification and sizing of defects in nuclear steam generator tubing.

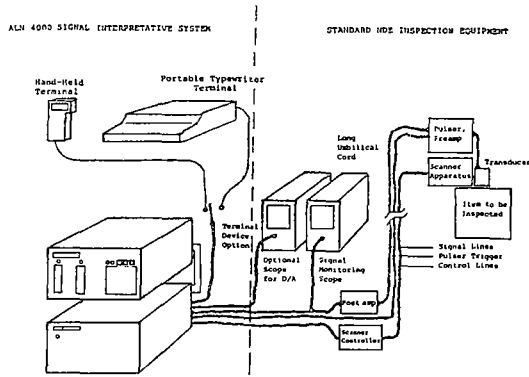


Fig. 1. Schematic of ALN 4000 NDE system interfaced to standard NDE inspection equipment

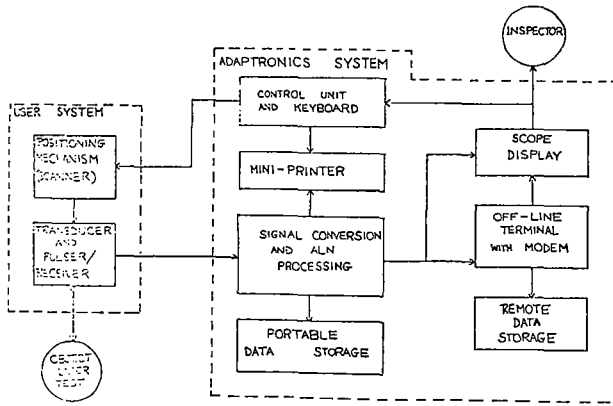


Fig. 2. Quantitative NDE system

<sup>1</sup>The engine disk eddy current application is sponsored by AFML under Contract No. F33615-77-C-5218.

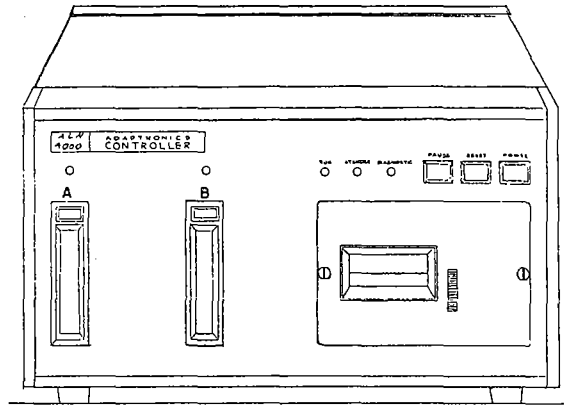


Fig. 3. Front panel layout of control unit of ALN 4000 showing tape cassettes, mini-printer, status lights and push button switches

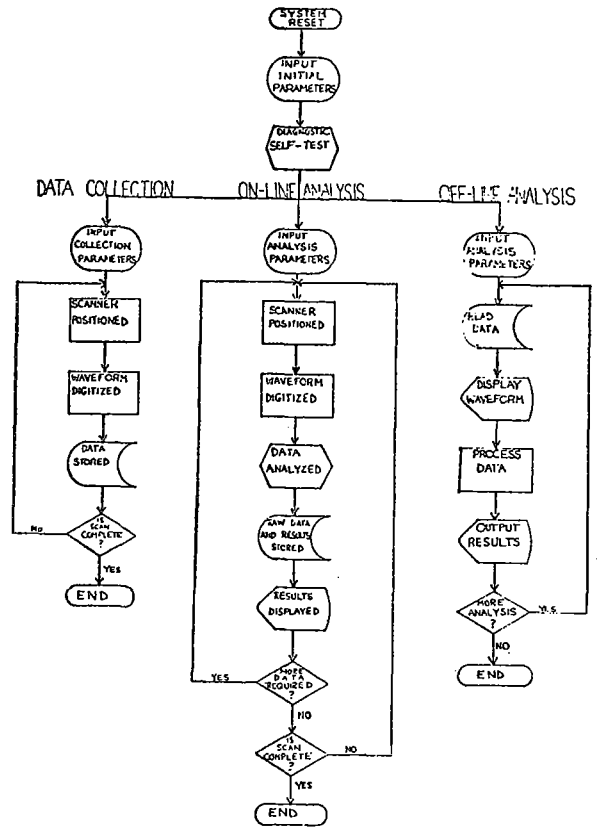


Fig. 4. Three modes of operation for ALN 4000

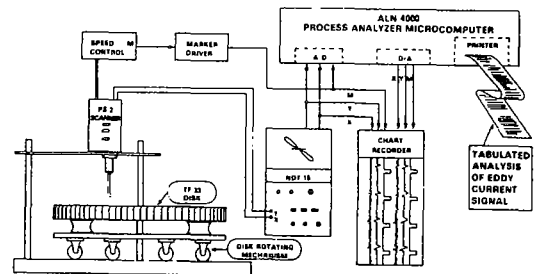


Fig. 5. Eddy current data collection and analysis system

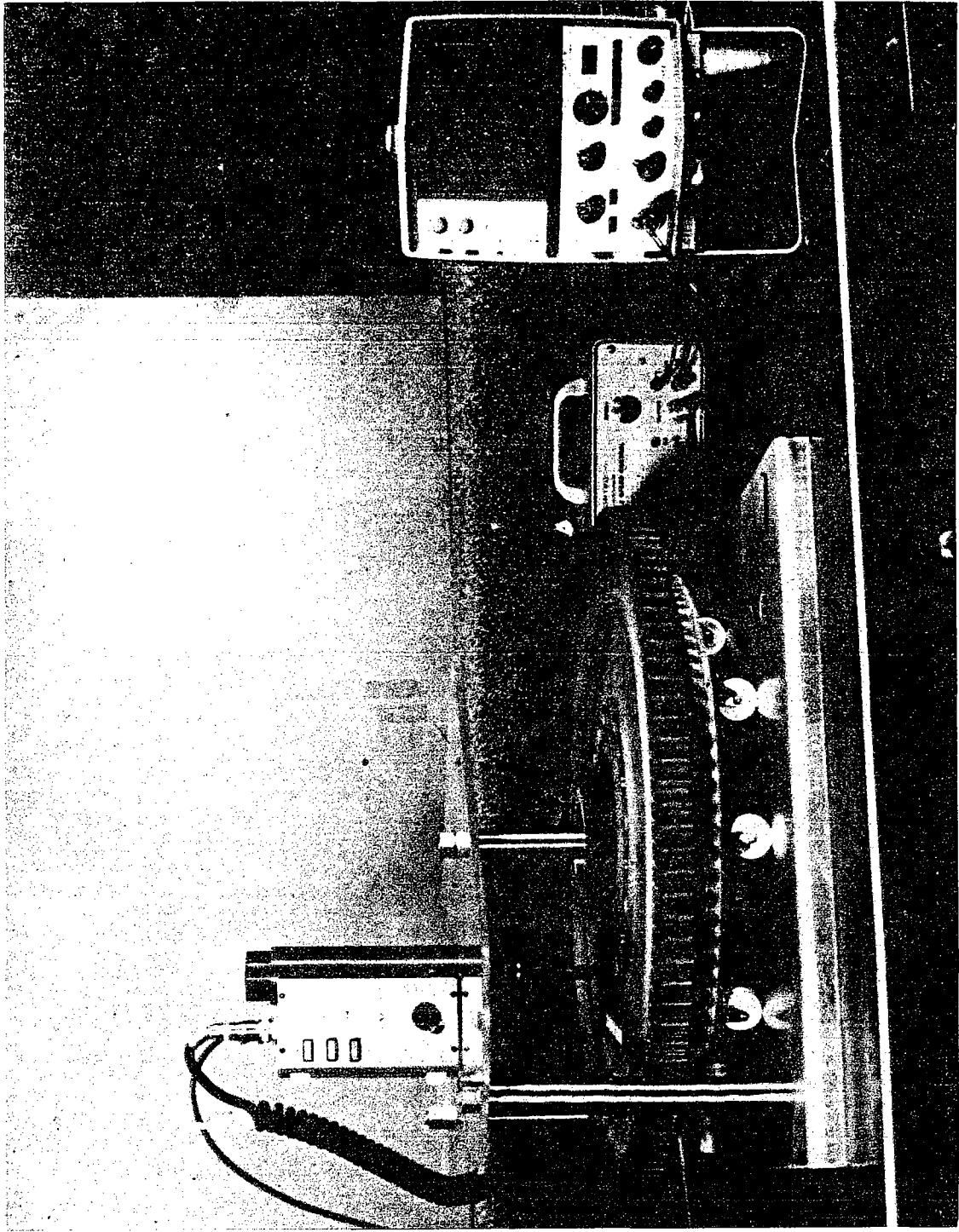


Fig. 6. TF-33 engine disk with eddy current scanner and eddy scope