MICROPROCESSOR APPLICATIONS IN THE NUCLEAR INDUSTRY

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ABSTRACT

Microprocessors in the nuclear industry, particularly at the Los Alamos Scientific Laboratory, have been and are being utilized in a wide variety of applications ranging from data acquisition and control for basic physics research to monitoring special nuclear material in long-term storage. Microprocessor systems have been developed to support weapons diagnostics measurements during underground weapons testing at the Nevada Test Site. Multiple single-component microcomputers are now controlling the measurement and recording of nuclear reactor operating power levels. The CMOS microprocessor data-acquisition instrumentation has operated on balloon flights to monitor power plant emissions. Target chamber mirror-positioning equipment for laser fusion facilities employs microprocessors.

INTRODUCTION

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Microprocessor systems have been developed to support weapons diagnostics measurements during underground weapons testing at the Nevada Test Site (NTS). Multiple single-component microcomputers are now controlling the measurement and recording of nuclear reactor operating power levels. The CMOS microprocessor data-acquisition instrumentation has operated on balloon flights to monitor power plant emissions. Target chamber mirror-positioning equipment for laser fusion facilities employs microprocessors.

The Electronics Division is an engineering science resource for all divisions at LASL. This capacity allows the Electronics Division Mini/Microcomputer Group to participate in the wide range of microprocessor applications. This discussion describes a sample of these applications.

TRANSIENT DATA RECORDING SYSTEM[1,2,3]

There is a continuing need for transient data recording systems at LASL. Such systems support experimental research efforts in the general areas of weapons development, laser research, fusion reactor research, and accelerator physics. Two instruments in particular are used extensively, the Tektronix R7912** scan converter transient digitizer and the Biomation Model 8100 transient recorder.

Two identical Intel 8008 microprocessor systems were developed for supporting two totally different experiments. The first system was to be used aboard an NC135 flying laboratory for the capture of electromagnetic simulator data from both ground-based and rocket-borne simulators.

The second system was to be used at NTS in support of weapons diagnostics measurements during underground weapons testing. The system was operated in an above-ground instrumentation van located fairly close to the shot site. This system was therefore to be subjected to the ground shock and probable loss of power as a result of this ground shock.

**Reference to a company or product name here or elsewhere in this report does not imply approval or exclusion of others that may be suitable.

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A critical requirement for the system was the ability to transfer (within 750 ms) data from volatile memories of the input devices into core memory to prevent loss of data in the event of power failure during ground shock.

The system for use at NTS also required the cathode-ray tube (CRT) display for set-up purposes. Because size, weight, and power consumption were of little importance, the magnetic tape recorder and the high-speed line printer were located in the instrumentation van. In addition, the system was interfaced to a microwave data link to allow transmission of data from the shot location to the cotrol point some 10 to 20 miles distant. As part of this requirement, it was also necessary to transmit a limited data block (335 words) prior to arrival of the ground shock wave.

The use of a microprocessor for data-acquisition system control proved to be practical for these applications. The feasibility of driving a variety of output devices was clearly demonstrated. The NTS system successfully transferred the required input data into permanent memory and transmitted the required data block by microwave link in approximately 650 ms, completing these tasks well ahead of the arrival of the ground shock wave. The programmability of these systems dramatically demonstrated the ease with which new input/output (I/O) devices could be interfaced to the system with no hardware changes required. Firmware changes were demonstrated to be straightforward and speedily accomplished.

NUCLEAR INSTRUMENTATION MODULE MICROCONTROLLER

As a result of the success of these Intel 8008 systems, additional systems based on the Intel 8080 microprocessor were developed prior to the availability of single-board microcontroller units. The following four applications utilized a nuclear instrumentation module (NIM) packaged design.

1. SPECTROMETER CONTROLLER[4]

X-ray spectrometry can prove useful in determining the molecular content of materials without the material under test sustaining any damage. The spectral lines given off by a particular element will be unique when examined by an experienced crystallographer. In order to perform a spectrographic analysis on a material, the spectrometer operator continuously scans the spectral lines to determine their coarse structure and location. Once the coarse structure and location of the spectral lines have been determined, a quantitative analysis is performed by step scanning over small angular increments and recording a pulse count proportional to the intensity of the spectral line at each such angle. The fine structure thus measured will reveal many interesting properties of the material under test.

The microprocessor system automatically controls three spectrometer systems. The modular microcomputer hardware was designed around the Intel 8080 central processing unit and is packaged using a modified NIM hardware system. This system consists of a microcontroller module based on the Intel 8080 chip, 32k bytes of read/write random access memory (RAM), a serial I/O module, and enough parallel I/O to operate the spectrometers. The microprocessor system is further controlled by a Wang 2200B calculator or a Texas Instruments ASR-733 terminal as desired by the operator.

The software used in the microcomputer system to operate the spectrometers was written entirely in PLM--a high-level algebraic language. The operating system schedules tasks by examining the task table continuously and executing any task that has been enabled.

The software operating system consists of timed tasks, interrupt-driven tasks, and table-driven tasks executing at three hardware priority levels.

The advantages of this system are that it allows one operator to run three or more spectrometers at one time while eliminating sources of error in the collected data that would be attributable to the operator. Mode-angle programmers can be purchased that will perform some of the functions of the spectrometer controller for one spectrometer. However, none of the units currently on the market have the flexibility of the spectrometer controller or control multiple spectrometers.

2. DATA INPUT CONTROL FOR NUMERICAL CONTOURING CONTROL[5]

An Intel 8080 microprocessor system has been developed for the Numerical Control

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Fabrication Group of the LASL Shops Department to enhance the input capability of a Mark Century numerical contouring control on an Excello 3-axis milling machine. The microprocessor system replaces the existing paper tape input medium with an equivalent endless magnetic tape input capability for jobs requiring large amounts of input data. This capability was established with the microprocessor controlling the Excello and an electronic data terminal that provides dual magnetic tape cassettes, a hard-copy printer, and ASCII interface with remote device control features. The microprocessor provides interactive operator control, and adaptive data rate control as a function of the magnitude of input data and Excello operation.

The microprocessor system has been added without modification to the controller so that the paper tape medium can be utilized for existing jobs.

The magnetic tape cassettes are reusable and represent an operational cost savings over the existing throw-away paper tape medium. The magnetic tape cassettes also reduce the handling requirements of paper tape for extremely large amounts of input numerical control data.

3. DATA ACQUISITION FOR USDA[3]

An Intel 8080 microprocessor system has been developed for the US Department of Agriculture. The system continually records the body temperature of diseased cattle. The transducer in a cow transmits a frequency proportional to the cow's temperature. The period of the frequency is digitized by a Hewlett-Packard (HP) 5300A counter. At specific time intervals the microprocessor system takes the HP data (4-bit parallel, 6-digit serial), checks it for validity, formats the data for reduction on large-scale processors, and records the formatted data on magnetic cassette medium.

4. ELECTRON BEAM WELDER DATA ACQUISITION[3]

Measurement and recording of an electron beam welder's operating parameters has been accomplished with one of the NIM microprocessor systems. The objective of this system is to provide quality control data for fabrication welds. The parameters from the electron beam welder are conditioned and converted to 12-bit parallel data. The microprocessor system then compares the data to specified operating limits, records the data on magnetic cassettes, and updates an operator control panel.

SINGLE-BOARD MICROCOMPUTER SYSTEMS

Design philosophy has changed with the microcomputers. A single-board microcomputer is defined herein as a microprocessor packaged on a single printed-circuit card containing all the functions required in a digital processing system. The following four systems represent single-board microcomputer applications.

1. MICROCOMPUTER-BASED PERSONNEL ACCESS CONTROL SYSTEM[6, 7]

An automated personnel access control system (PACS) utilizing a microcomputer is in use at LASL during nonstandard working hours. The PACS contains, at the point of access, all the elements necessary to (a) grant or deny entrance to the controlled area, (b) alert security personnel to abnormal conditions, (c) perform self-diagnostics, (d) allow modification of the data base containing names of persons authorized for access, and (e) video tape-record the access/egress transactions. In addition, the PACS transmits information on standard telephone lines to a printer, for hard-copy record of all transactions and abnormalities, and to a television monitor, each located in the central security station.

The PACS offers LASL an opportunity to reduce manpower costs while making work areas more available, thus encouraging use by employees. The criteria for granting access, traceability of penetration, access flow-rate limitations, selection of nonvolatile storage medium for data base and program, software design, and problems with detecting multiple person access are some the factors of the PACS design.

2. MICROCOMPUTER-CONTROLLED FAST SOLID-STATE CAMERA[8]

A fast solid-state camera has been designed to record diagnostic pictures of unpredictable high-speed events. The camera system was developed for the US Air Force Space and Missile Systems Organization at

Norton Air Force Base in California. The sensor is an array of silicon photodiodes that are read out in parallel. The system design features a variable framing rate to 100,000 frames/sec, continuous recording with asynchronous stop trigger, a solid-state memory holding 256 frames, and electronics having a dynamic range exceeding 2000:1. The image data are retained in a circular memory permitting the camera to run continuously until the event occurs. Immediately afterward the camera is shut down with a memory of 256 frames covering the event. The camera can be synchronized with similar cameras covering different aspects of the same scene. Operation of the camera is monitored and controlled by a microcomputer. The operator can select framing rate, image presentation on the CRT, and synchronization of multiple cameras.

The microcomputer provides interpretation of operator commands into an appropriate set of states on the timing and control logic interface and formatting of the memory data into a condensed readable display.

The microcomputer is an Intel SBC-80-204 printed-circuit card. This unit was selected because it is inexpensive, readily available, easily maintained, and supported by a great deal of software and diagnostic aids. The unit contains all of the memory, I/O, timers, and interrupts required to manage the fast solid-state camera.

3. EFFLUENT MONITORING FOR NUCLEAR SAFEGUARDS[9]

A microprocessor-based instrument operates a continuous surveillance on effluents from a nuclear facility. It receives and evaluates pulses from two NAI detectors and a set of single-channel analyzers. It has self-diagnosing capability so that it takes action not only when it recognizes excessive radioactivity but also when it ascertains some abnormal behaviour. Power failure procedure and automatic restart are provided. Operative constants such as alarm thresholds, times, and number of successive measurements are permanently stored in a read/write battery-operated C-MOS memory. The program allows automatic succession of phases in a peculiar way and has a feature for loading an auxiliary program into RAMs.

The instrument contains an Intel single-board computer, Type SBC 80/10, and operates autonomously without the need of any surveillance. It has self-diagnosing capability so that it can ascertain if both the effluent radioactivity is kept within the norm and its own operation is behaving correctly. An endless succession of measurement cycles interrupted by calibration procedures is performed. Times for each one of the measurements in a series as well as the interval between calibrations are selected by the operator during initialization.

The normal operation relies on the comparison of the measured values with prefixed limits, without taking any initiative if limits are not exceeded. In case of higher radioactivity or wrong behaviour, some actions are automatically initiated, and alarms are set up.

The operator is called only during alarm conditions, but during normal periods the instrument is operated 24 hr/day and no intervention is needed. Suitable warning to the building computer is given both in case of alarm or in case of local power failure.

4. LASER DAMAGE EXPERIMENTS[10]

Thermonuclear reactions, which are to be started by bombarding deuterium pellets with intense laser light, will require selection of optical systems that can transmit light of great energy densities. A data collection and analysis system to measure damage parameters of optical components has been designed, using a microcomputer as its central processing unit. Every time a pulsed, high-intensity laser is fired, data are collected from special instrumentation that leads to a report of energy density on the target and whether or not damage occurred. The software for the microcomputer was developed on a minicomputer with the transfer media being cassette tapes. The software consists of three tasks: a keyboard monitor and accounting program, an interrupt-driven routine to initialize the experiment for a laser shot, and an interrupt-driven routine to collect the data and calculate the report quantities.

The microcomputer system is based on the Digital Equipment Corporation microcomputer PDP-11/03 (LSI-11).

LASER MIRROR-POSITION DISPLAY[11]

Within the past year at LASL, a high-energy carbon dioxide laser facility has become operational and is being used to conduct research in laser-induced fusion. Named Helios, this facility is the most powerful gas laser in the world. It is comprised of four dual-beam carbon dioxide power amplifiers and associated preamplifiers that can generate eight high-energy laser beams at the 10.6-μm wavelength. These beams are directed and focused by mirrors onto deuterium-tritium-filled targets specially fabricated for fusion experiments. At full output the laser is capable of generating more than 10 kJ of energy with a pulse duration of less than 1 ns. Present experiments are aimed at providing high plasma densities from target shots.

The Helios facility employs 16 mirrors within a target chamber to direct 8 laser beams onto a target. Each mirror mount contains three stepping motors that drive lead screws to move the mirror. A motor controller has been fabricated that steps the motors to control mirror-position relative to the target. To augment this equipment, a mirror position display system has been designed containing memory to store the 48 stepping-motor postions. Motor motion is sensed by 48 incremental optical encoders coupled to the drive shafts. Outputs from the encoder tracks are multiplexed to an 8085 microprocessor, which is programmed to address the mirror mount being moved, and transmit step information to the display chassis located in the control room. Data transmission is accomplished by an 8251 USART and a fiber-optic data link.

Processing and display of the encoder data is accomplished by the mirror-position display chassis in the control room. This unit contains an 8085 microprocessor and 2716 EPROM. A 5101 RAM with standby battery power stores the position of 48 stepping motors. Scratch-pad memory is provided by an 8155 RAM. Two 8251 USARTs communicate with the target chamber circuits and the target chamber circuits and the facility computer.

The programmed control algorithms provide means for storing and updating motor position data, for communicating with the target chamber and the facility computer, for generating the front-panel display, and monitoring the front-panel switches. For a selected mirror mount, motor-position data are processed and displayed in either absolute motor steps, and focus, tilt, and rotate position. Programs were written in assembly language and translated by a cross assembler, which produced necessary outputs for an EPROM programmer.

LOW-POWER APPLICATIONS

The availability of a relatively complete family of CMOS, LSI, and MSI chips (including microprocessors) has made possible the in situ preprocessing of data prior to recording. Such preprocessing makes it possible to do significant data compression with little or no loss in data content and results in a large reduction in the volume of data actually recorded.

A fully portable battery-powered microprocessor adaptive data-acquisition system (MADAS) capable of performing a reasonable comprehensive real-time analysis of data, providing a first-order compression of the significant data, and recording this preprocessed data on a self-contained cassette tape has been developed at LASL.

The entire system is packaged in a deep-drawn aluminum military enclosure that provides adequate environmental protection for most applications. The suitcase contains, in addition to the microcomputer, the tape cassette deck, 20-day battery pack, analog-to-digital (A/D) converter(s), precision time-of-day clock, and spare card slots for signal conditioning.

The microprocessor for these systems is the RCA CMOS 1802. This system was used for the following three applications.

1. SEISMIC EVENT DETECTION[12]

The seismological application utilizes a dynamic threshold detection scheme followed by subsequent frequency analysis to determine what data are valid and should be recorded. The MADAS is continuously digitizing the data at a 100 sample/sec rate, storing the data in RAM buffer memory. A dynamic noise band is continually computed, based on the previous 128 data samples. If a sample value exceeds two times this dynamic noise band, the computer recognizes that an event may have occurred. The data buffer from a point in time (arbitrary interval) preceding this possible event detection point is saved. The computer now enters into a quasi-frequency analysis portion of the program, which requires that a certain number of sign changes (zero crossings) must occur within a given time interval. If this criteria is

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met, the computer has picked the event as a probable real event, and starts outputting raw data to the cassette tape recorder form memory. Simultaneously, of course, data acquisition continues, and now the computer is analyzing the currently digitized data to determine the end of the event. The end-of-event algorithm uses the pre-event noise band as a test threshold, and declares an end to the event when no threshold crossings occur for an arbitrary time, usually 16 sec. Obviously, this technique requires a large buffer memory to store event data until it can be read out to the recorder. For a typical event duration of say 5 min, a data buffer of some 32k bytes is required. It is apparent that earthquake swarms or closely spaced events can swamp this system because 64k is the maximum memory capability of the MADAS system. In this event, MADAS could be programmed to activate other real-time recorders to cover such an occurrence.

2. SPECTROGRAPHIC-EVENT DETECTION[12]

The portable spectrograph application also utilizes a dynamic threshold detection scheme followed by subsequent frequency analysis to determine what data are valid and should be recorded.

Spectrographic analysis results in count peaks corresponding to a possible relative concentration of a given material. The event detection analysis program then must not only detect count peaks in excess of some computed average background count but must also match the spacing of these detected peaks to determine if the suspected material is actually present. In the LASL application, several spectra comparisons must be made to determine which, if any, of the suspected materials is present. The match spectra are stored in look-up tables, and a possible match is declared when more than half of the detected peaks match with the look-up spectrum. Once a match has been declared, an identifier message is output to the LCD display. This unit is used in a van-mounted application and, hence, is always manned during operation.

3. BALLOON-MOUNTED SYSTEM FOR EMISSION MONITORING

A MADAS system has been developed for a power plant stack emission-monitoring application for a program being conducted by Sandia Laboratories and the University of Denver. This system has been mounted in a large balloon gondola and used for several experiments measuring power plant emissions. Development of this application is continuing with the possibility of incorporating altitude control into the microprocessor system.

SINGLE-COMPONENT MICROCOMPUTER APPLICATIONS

The availability of single-component microcomputers has encouraged many applications in the nuclear industry. A single-component microcomputer is defined as a single physical package, most commonly a dual-in-line (DIP), which contains a microprocessor complete with at least some RAM, some read-only memory (ROM), and I/O capability. One objective of the low-end microcomputer is to be self-contained in regard to the computer hardware/software requirement. Several single-component microcomputers are now commercially available.

The Intel 8048 and the Mostek 3870 are examples of low-end single-component microcomputers, which contain ROM program memory. The Intel 8048 is a member of the ASM-48 single-component microcomputer family, which includes the following nine versions of the basic architecture: 8048, 8748, 8035, 8041, 8741, 8049, 8039, 8021, and 8022.

The Intel 8048 is totally self-sufficient 8-bit parallel computer fabricated on a single silicon chip using N-channel silicon gate MOS process. The microcomputer contains 1024 8-bit bytes of program memory, 64 8-bit bytes of RAM data memory (working registers), 27 I/O lines, and an 8-bit timer/counter in addition to on-chip oscillator and clock circuit. The 8048 is designed to be an efficient controller as well as an arithmetic processor. The microcomputer has extensive bit-handling capability as well as facilities for both binary and BCD arithmetic. Efficient use of program memory results from an instruction set consisting mostly of single byte instructions and no instructions over two bytes in length.

Features of the microcomputer include a single +5-V supply, 2 5-μsec cycle time (all instructions one or two cycles), and a single-level interrupt system. Of specific concern for high-volume applications is the interchangeable 8048 ROM version with the 8748 EPROM version, which can be easily reprogrammed throughout the development and prototype debugging. A repertoire of over 90 instructions makes the single-chip 8748 equal in performance to most multichip NMOS microcprocessors available.

The Intel 9748 provided flexibility in program development because of its feature of ultra-violet (uv) light erasable/programmable ROM EPROM program memory. The EPROM feature allows simple and quick turnaround for physically altering the microcomputer software. Typical erasure time with a high-intensity uv light is approximately 19 min. Experience has shown the programming time to be in the order of 2 min. The EPROM capability eliminates the need for extremely high volume necessary for ROM cost with ROM mask preparation, and the technical risk of a single-bit error requiring a recycle of mask preparation.

The following five applications have utilized a single-component microcomputer.

1. SHELF-MONITOR SYSTEM FOR SPECIAL NUCLEAR MATERIAL REAL-TIME INVENTORY[13, 14]

Special nuclear material in long-term storage in a vault is an attractive target for a diverter. A shelf-monitor system has been designed that will enable constant surveillance of this material using a variety of sensors. A single-component microcomputer collects data from a Geiger-Muller (GM) tube that monitors gamma emissions and from a scale that monitors the total weight of the container and contents. A network of the microcomputer shelf monitors reports the acquired data to a minicomputer for analysis, alarm if necessary, and storage. The objective of this research program has been to develop a reliable, inexpensive monitor network and associated data processing equipment capable of real-time monitoring.

2. REACTOR POWER MONITOR[15]

The reactor power monitor is a portable, low-power data collection instrument built for the International Atomic Energy Agency (IAEA). It is being used to measure and record the hourly integrated operating thermal power level of a nuclear reactor in order to detect unannounced plutonium production.

The monitor consists of a ^{3}He proportional neutron detector (two tubes, 1-in. diam by 17-in. length, 4 atm), control electronics based on two Intel 8748 microprocessors and a write-only cassette tape drive. The detector is shielded by cadmium and 1-1/4 in. of polyethylene to provide sensitivity only in the direction of the reactor. The instrument is packaged in a zero aluminum suitcase that is bolted to the biological shield so that nothing can be placed between it and the reactor.

The unit is powered from 120-Vac, 60-Hz line current provided by the plant operator. It also contains about 8 hr of battery back-up to cover power interruptions. All of the control electronics, with the exception of the two processors, are implemented in CMOS to obtain low power consumption. The CMOS version of the 8748 (87C48) will be used when it becomes available, reducing power consumption even more.

A major goal in the design of this instrument was simplicity of installation and operation. A 10-sec neutron counter and display are included to aid in initial placement. Using this, the IAEA inspector chooses an area along the biological shield and then bolts the case in place. After connecting power, he inserts a blank cassette and sets in the date, time, and operating level. The case is then locked and requires no further attention. After 3 months the inspector retruns to retrieve the cassette. At this point he has the option of performing a terminal or strip-chart dump, resetting the time, recalibrating the instrument, or just replacing the tape without disturbing the operation.

3. MICROCOMPUTER-BASED PORTABLE RADIATION INSTRUMENT[16]

None of the commercially available survey instruments can correctly measure the pulsed neutron dose rate in cases where the detector resolving time would result in significant count losses. In the early 1970s Fermi National Accelerator Laboratory developed a portable instrument, the Albatross III, that uses silver activation to integrate neutron flux information. The activated silver beta decays at a rate slow enough to be counted by a GM tube detector, yet fast enough to follow changes in the neutron flux within several minutes.

Pulsed neutron dose equivalent rate instruments are needed at LASL, and although the detector configuration and operational features of Albatross III seemed appropriate, the complexity and lengthy calibration procedure of its analog circuitry were unattractive. Albatross IV is an updated version of Albatross III with completely redesigned electronics and added operational features that make it more versatile and easier to calibrate.

In this application, a single-component microcomputer replaces the analog weighting and averaging circuitry. The result is a simpler, more versatile, and less expensive instrument that is easier to calibrate and that can measure neutron dose equivalent rates of 1 to 300 mrem/hr from neutron pulses of any duration.

Nine Albatross IVs are currently being used to monitor neutron-dose equivalent rates in various experimental areas at the LASL Weapons Neutron Research Facility. The facility uses an 800-MeV proton beam of 1 to 120 pulses/sec with pulse widths of 1 to 500,000 ns. Information obtained from these units is sent to the central console, where the proton beam is prevented from entering the facility if the radiation levels exceed 10 mrem/h. Two additional Albatross IVs are used as portable units to perform radiation surveys at the facility.

The digital electronics and microcomputer of the Albatross IV provide ease and reliability of calibration as well as versatility in determining radiation dose equivalent rates from pulsed neutrons. The opportunity to use the 15-sec averaging time, which permits observation of the radiation variation in real time during beam tuning, and then to switch to a 4-min averaging time to obtain a more precise reading, is most useful.

4. EXHAUST-STACK ENVIRONMENTAL MEASUREMENTS[17]

The exhaust-stack particulate sampler microcomputer-controlled data acquisition, calculation, and display system has been developed to provide the operator with continouous sampling information as particulate samples are taken. Data inputs to the microcomputer system are provided by sensors measuring temperatures, pressures, humidity, and velocity of a stack flow stream. The microcomputer system incorporates a single-component microcomputer, a number-oriented microprocessor, a single-chip 16-channel A/D converter, a programmable keyboard/display interface, and liquid crystal displays. The scientific calculation capability and associated display have been incorporated to perform and display the results of 28 complex equations. These results allow the operator to maintain proper sampler probe temperatures, to maintain proper flow through the sampler probe, and to make sampler probe positional changes when necessary.

The data-acquisition system consists of three equipment packages that operate on 115-Vac, 60-Hz power. The microcomputer electronics, keyboard, displays, and signal-conditioning electronics are packaged in an aluminum carrying case. The probe and probe temperature control electronics are packaged in a seond aluminum carrying case. The third module consists of a vacuum pump and associated cabling.

The scientific calculating capability is established with a number-oriented microprocessor sequenced by a single-component microcomputer. A MOS/LSI number-oriented microprocessor provides the scientific calculating capability with reverse Polish notation data format. Input data sequencing, computation processing, intermediate result storage, and display of the results are controlled by a single-component microcomputer. The analog input signals are processed by a complete data-acquisition system on a complementary metal-oxide semicondoctor chip.

This microcomputer application has been mutually developed by LASL Health Research Division (Industrial Hygene Group--Aerosol Studies Section) and the Electronics Division (Microcomputer/Minicomputer Systems Group). The system application is related to an Environmental Protection Agency task to "evaluate and improve the present method-5 emission-control standards."

5. INTELLIGENT DATA-ACQUISITION INSTRUMENTATION FOR SPECIAL NUCLEAR MATERIAL ASSAY[18, 19]

The Detection, Surveillance, Verification, and Recovery Group of the LASL Energy Division/Nuclear Safeguards Programs is now utilizing intelligent data-acquisition instrumentation for assay data analysis of special nuclear material. The microcomputer-based instrumentation module has firmware for as many as 12 user-selected functions.

The data acquisition and analysis are enabled by the incorporation of a number-

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orinted (number-crunching) microprocessor sequenced by a single-component microcomputer.

The microprocessor calculations are performed employing scientific notation with reverse Polish notation for data and key-level language instruction input.

The hardware/software implementation of the microcomputer and microprocessor was performed by the Electronics Division Mini/Microprocessor Systems Group. The scalar hardware was designed by the Energy Division.

Microcomputer firmware establishes the capability for the user to select the display of scalar data or the computation of several selected functions. The microcomputer obtains the selected function from the input thumbwheel switch located on the module front panel. The switch also allows the user to self-test the display and to cause the microcomputer to execute instrumentation self-diagnostics.

SUMMARY

Microprocessors in the nuclear industry, particularly at LASL, have been and are being utilized in a wide variety of applications varying from data acquisition and control for basic physics research to monitoring special nuclear material in long-term storage. Microprocessor systems have been developed to support weapons diagnostics measurements during underground weapons testing at NTS. Multiple single-component microcomputers are now controlling the measurement and recording of nuclear reactor operating power levels. The CMOS microprocessor data-acquisition instrumentation has operated on balloon flights to monitor power plant emissions. Target chamber mirror positioning equipment for laser fusion facilities employs microprocessors.

The Electronics Division is an engineering science resource for all divisions of LASL. This capacity allows the Electronics Division Mini/Microcomputer Systems Group to participate in the wide range of microprocessor applications.

The hardware/software/firmware is developed in a microprocessor development lab consisting of microprocessor development systems with incircuit emulators, logic analyzers, and conventional test equipment. Future applications appear to be in-line with the previously discussed systems. The sophistication of the single-component microcomputers continues to enable new applications of adding intelligence to and increasing the accuracy of nuclear instrumentation.

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