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EXPOSURE

vol.10 no.2 a newsletter for ocean technologists

Please Note: This Is The Last Issue Of The Newsletter.

Dear Reader:

After a little more than a decade, the publication of the EXPOSURE newsletter will end with this issue.

In 1971, the Office of Naval Research endorsed annual Ocean Technologists' meetings and the EXPOSURE newsletter project as vehicles to more effectively disseminate technology among persons developing instrumentation for use with ONR research programs. Twenty-eight attendees to the Ocean Technologists' meeting comprised the newsletter's first mail list. From this modest beginning, requests for the newsletter regularly increased nationally and internationally and, in 1977, the National Sea Grant Program, through participation in the United Nations' Working Committee for Training Education and Mutual Assistance of the Intergovernmental Oceanographic Commission, expanded the international circulation. Today, over 500 issues of the newsletter are mailed to persons and libraries at addresses in 89 countries around the world.

I feel the worldwide interest in EXPOSURE is a credit to the authors who have taken time to share some of their good works in the hundred or so articles submitted for publication. For their support and encouragement, I want to thank the authors, readers, and sponsoring agencies.

Sincerely,

R. Mesecar

Dr. Rod Mesecar, Editor

May 1982

Deployable Processor-Based Instrument Development

In the Instrument Section of the Ocean Engineering Department at the Woods Hole Oceanographic Institution we concentrate on the development of autonomous deployable instruments for oceanographic research. The availability of the low-power microprocessor has greatly increased the capability of our designs, but has changed our approach to the development of new instruments. This article describes an approach to the development of a microprocessor-based instrument and presents a case for choosing the Serial ASCII Instrumentation Loop (SAIL*) standard as a control and maintenance interface.

In the pre-processor days, instrument development usually began with the sensors and continued in a sequential manner to the data logger. Since 1977 we have used several approaches to developing microprocessor-based instruments. Recently we have converged on a technique which has served us well for several different systems and which we feel merits passing on to others in the oceanographic community. Rather than a sequential approach, it is a combination of both "top down" and "bottom up" design philosophies. These converge to provide a remarkably painless and rapid path for bringing a new design from concept to working prototype.

The instrument begins with a scientific and performance goal, and a designer's conviction that he can devise hardware to do the job. We find that the hardware comes into focus first, while the details of the software remain quite vague beyond a brief feasibility study and a minimal outline of the eventual processing required. (Perhaps this is because we all began as hardware designers!)

*Copies of the SAIL Standard are available from the Executive Secretary/UNOLS, School of Oceanography, University of Washington, Seattle, Washington 98195.

At this point we begin building the prototype system and, as soon as the power supplies are working, get the processor running. We use the RCA 1802 for our underwater equipment because of its low power consumption and simplicity. (A minimal system capable of talking to a terminal requires only three integrated circuits: the processor, memory latch-decode, and a ROM.) We begin with a simple 2k-byte monitor in ROM to communicate with a terminal using a software UART which allows us to load and examine memory, call subroutines, and do other basic chores. This monitor uses the CPU registers for most of its scratchpad needs and requires no RAM for its basic function.

After adding and testing the full-system memory (using a routine included with the monitor), we work outwards adding the interface components a subsystem at a time. We write a series of brief subroutines in RAM to exercise the new appendages as they are added. Some of these routines are temporary, while others are prototypes for the instrument's final program and are moved to the ROM for convenience.

We use Intel 2716 EPROMS with a fast transistor switch on their supply pin controlled by the chip select. Therefore they draw power only when read. The time-intensive routines of our final program are copied into CMOS RAM so the 2716 is perhaps the easiest PROM to program. We have often simply added the extra control circuitry necesssary to allow the prototype instrument to program these chips itself. It then becomes almost trivial to save routines debugged in RAM in the system ROM.

As the hardward begins to function, we begin to alternate between "top down" design, where we elaborate on the ultimate goal of the instrument to bring the details into focus, and "bottom up" design, where we write subroutines to handle the details of the processor's job. We link the routines together logically into larger routines eventually reaching a stage where a single subroutine call from the terminal can demonstrate a significant fraction of the instrument's goal. Finally we can concentrate on the inevitable sensor design problems and use the flexibility of the processor to set up appropriate tests and readouts.

Eventually we give the hardware a clean bill of health and set about the final stage of data processing and recording. Since the soft UART cannot function with interrupts active, we must abandon our simple monitor and switch to a more "application oriented" structure. By now, however, we have become addicted to the "handles" the monitor provides and are reluctant to set them aside to go to a more turn-key type of control. Our solution is to imbed the basic features of our monitor in the final control program used to communicate between the instrument and the outside world. Normally we use the friendlier high level control commands, but can always retreat to the level of our monitor for nitty-gritty modifications.

In an attempt to simplify and standardize the design of the external test equipment, we have chosen the SAIL interface, even though the instrument is usually intended to be deployed autonomously, not as a component of a group of hard-wire-connected sensors for which SAIL was originally intended. We have found SAIL to be an excellent choice for several reasons. First, SAIL only requires two wires through the end cap where connections are costly and inconvenient. Second, the external test equipment can be anything from

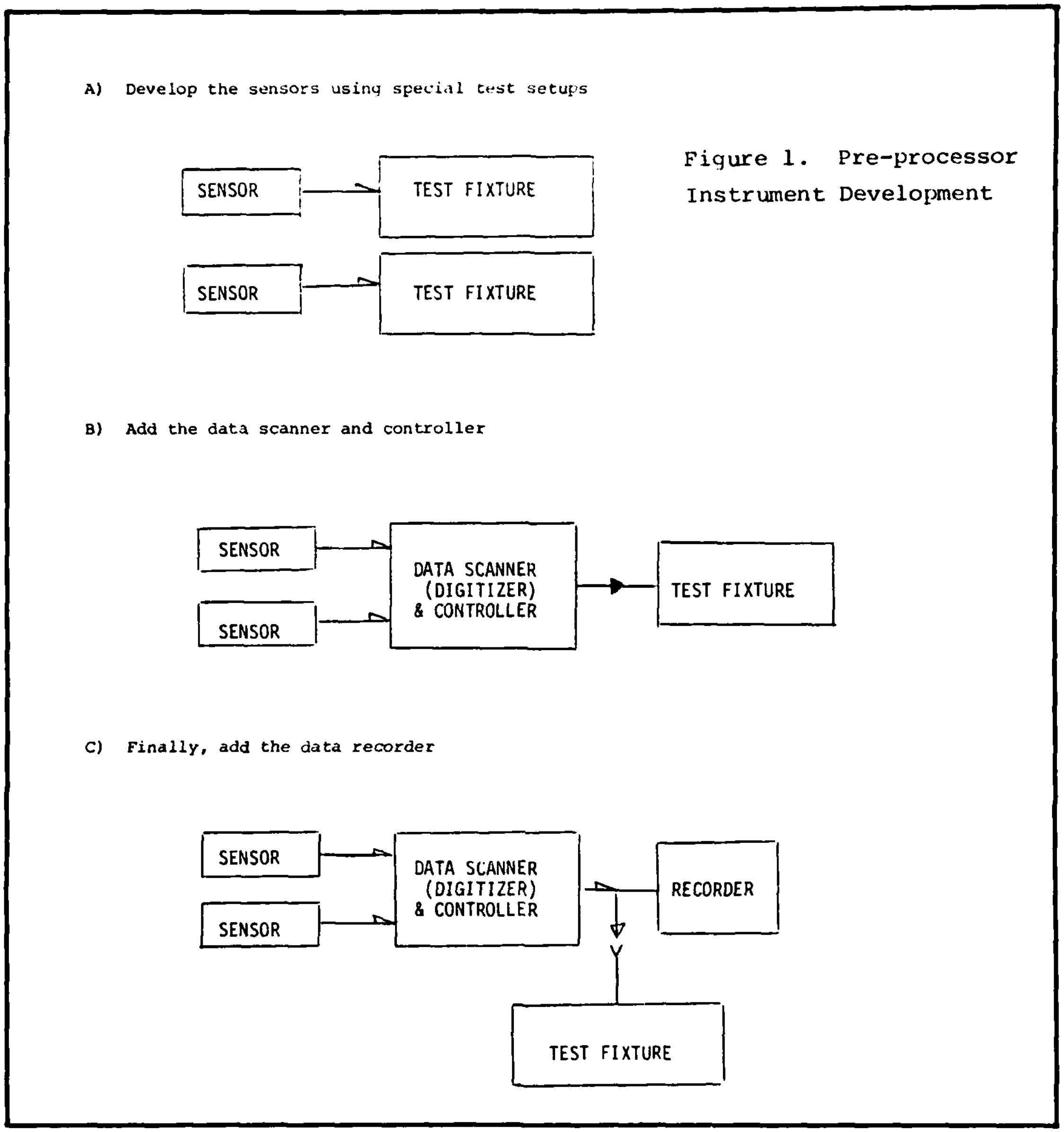


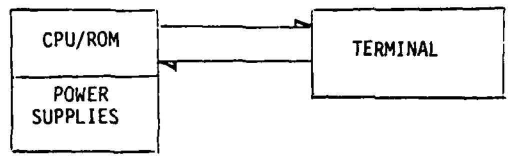
Figure 1. Pre-processor Instrument Development

a simple portable terminal to a minicomputer. The variety of small computers on the market with a serial interface is truly mind boggling; hence the shrinking research dollar can go a long way. (Also, in a pinch, a terminal is about the easiest thing to scrounge!) Third, since SAIL is true addressed bus protocol, several instruments can be looped together and controlled from a single terminal.

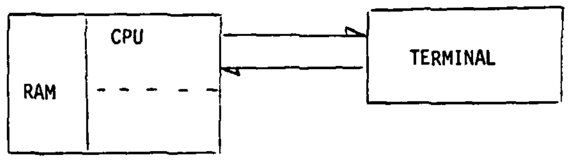
Back in the Stone Age, to check out an instrument involved opening the case and hooking on an elaborate test jig that could only be loved by its mother, going through a detailed sequence easily forgotten, cleaning the O-rings and sealing the package up again. Now we have the terminal continually hooked to all the instruments in the group of interest. It takes only a moment to look at the case (where the SAIL address is written in large,

Figure 2. Processor-Based Instrument Development

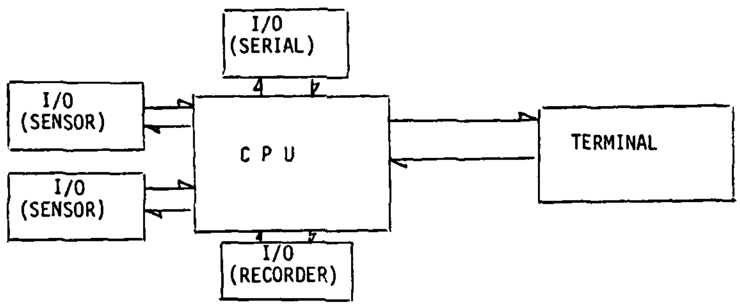
A) Start with CPU talking to a terminal



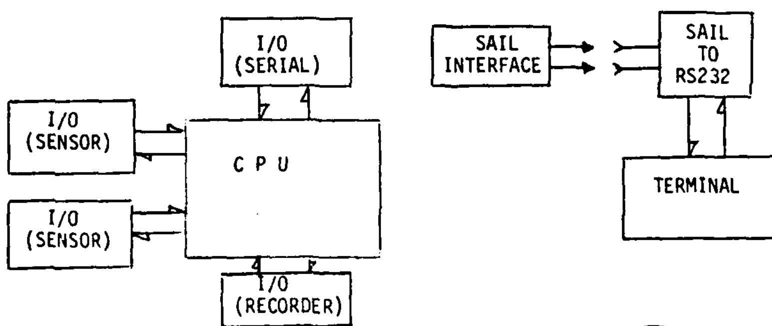
B) Add and test system memory



C) Add and test I/O a group at a time and eventually test entire instrument



D) Finally, switch to final program and use SAIL interface for further development



friendly letters in case you have forgotten it), address the instrument, type "HELP" to find out how to invoke the self-test, run the test and go to the next in line.

Now that we are SAIL addicts, twisted pairs run everywhere 'round the laboratory, and no longer do we shiver over a scope in the coldroom just to see if something is still working. There are currently seven families of instruments designed at Woods Hole which utilize SAIL as the control and test interface. These include the autonomous listening station for float tracking; its successor, the Tillier listening station; the receivers and sound sources for the ocean acoustic tomography experiment (plus a system clock); the pop-up profiler; and, most recently, the laser Doppler velocimeter. In addition, the Pegasus free-drop current meter built at the University of Rhode Island uses our SAIL driver program. It is routinely deployed up to twenty times at sea without once having to have its case opened. Members of the acoustics group in the Ocean Engineering department are so addicted to using SAIL for their instrumentation that they are designing an acoustic modem to allow communication with a moored instrument's SAIL port after deployment. Within the next few months we will be using the SAIL protocol to communicate between separate sensors on a mooring.

The SAIL standard is admittedly limited, but we believe the simplicity of "getting aboard" overrides its limitations. We expect to use SAIL in most processor-based instruments in the future and recommend it to the ocean-instrument community as the interface of choice for control, testing, and maintenance for autonomous deployable instruments.

FOR FURTHER INFORMATION, CONTACT:

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Mr. Bradley studied Engineering Physics at Cornell University and received his Bachelors degree in 1966 and Masters in 1967. He continued his graduate studies in the Ocean Engineering Department of Massachusetts Institute of Technology where he received his Ph.D. in 1973. After working at M.I.T. for one year, he came to the Instrument Section of the Ocean Engineering Department at Woods Hole Oceanographic Institution. Since then, Al has worked on several projects including the SOFAR floats and listening stations for the POLYMODE program, the sound sources for the ocean tomography experiment and the pop-up profiler. Al was recently promoted to Research Specialist and considers himself an instrument designer.

EXPOSURE

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