A Remote Monitoring System For Water Quality Parameters

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Introduction. The Waterways Experiment Station (WES) assists the Corps field offices by conducting research and developing new methods and equipment for their use. Much of the development work is concerned with data acquisition and storage utilizing modern, electronic equipment. The information is provided to the field offices through published reports, conferences, and/or demonstrations. Once adopted by the district, WES acts as a consultant to insure continuous and effective utilization of the equipment.

An example of this is a remote data acquisition and storage system which is being developed by the Instrumentation Services Division of WES at the request of the WES Hydraulics Laboratory. The system will acquire, process, and record wave data at remote sites. Use of the system is not restricted to waves. Water quality parameters could be monitored and stored in increments of appropriate units.

Background. The Streambank Erosion Control Evaluation and Demonstration Act of 1974 states, in part, "The Waterways Experiment Station will conduct laboratory and field studies . . . to define the causes and mechanisms of streambank erosion, . . . ". Wave attack is recognized as a major contributor to streambank damage at many locations. For this reason, wave action data are an essential part of field observations. Districts responsible for collecting the wave data have requested development of a remote wave monitoring system.

As stated previously, the system could be adapted to almost any water quality parameter by changing the sensor unit and the software. It will be simpler, however, to discuss progress in terms of the wave data system actually being developed.

The system is designed to detect the heights and periods of waves generated by navigation traffic and/or wind in U. S. rivers and streams. Figure 1 shows typical wave and stream velocity data recorded during a study conducted on the Ohio River. The microprocessor will group the waves in a matrix of period versus amplitude. A typical printout is shown in Figure 2. The input data was simulated to check the storage capability of the system.

Microprocessor. The microprocessor is used to control and process the data collected. The system utilizes state-of-the-art low-power components. The entire system - sensor, processing unit, and cassette recorder, shown in Figure 3 - uses less than 10 watts of power and is designed to function unattended. In the field, the unit is powered by automotive batteries which may be charged by solar cells. The unit can store (in the present data format) 35 days worth of data on a Texas Instrument 733 compatible cassette tape using a low-power Memodyne recorder. The use of the Texas Instrument format allows the cassette to be printed locally on any Silent 733 terminal or to be transmitted over telephone lines to a remote computer. Therefore, a person may gather up the cassettes and transmit them from a terminal in a hotel room to another Silent 733 in the home office for simultaneous printout and immediate action, or the cassettes may be mailed (or transmitted) to the sponsor for further processing on a computer. Time of day is recorded so that data from different locations may be synchronized for comparison.

This system (as does any computer-based system) consists of hardware and software. The term hardware pertains to the

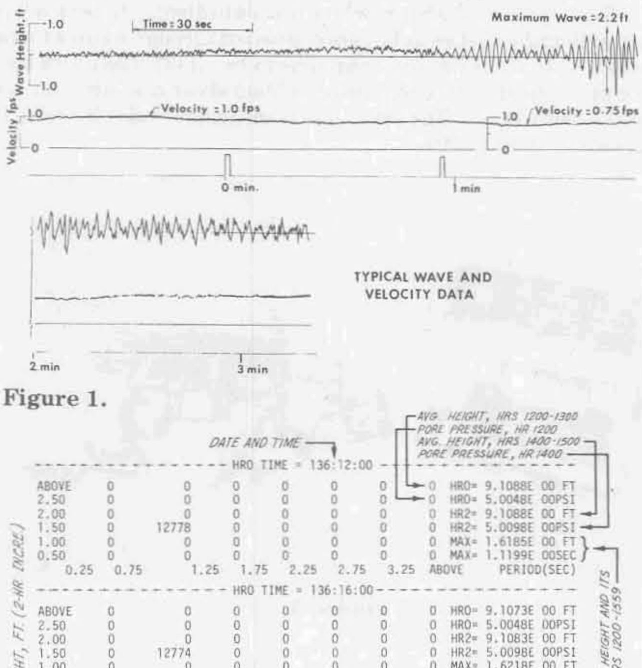
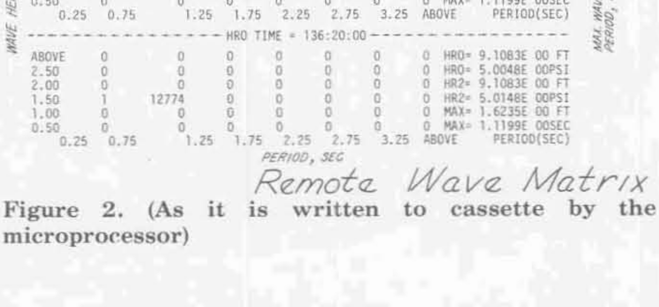


Figure 1.



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2.00     0        0     0     0     0     0     0  HR2= 9.1088E 00 FT
1.50     0    12778     0     0     0     0     0  HR2= 5.0098E 00PSI
1.00     0        0     0     0     0     0     0  MAX= 1.6185E 00 FT
0.50     0        0     0     0     0     0     0  MAX= 1.1199E 00SEC
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2.00     0        0     0     0     0     0     0  HR2= 9.1083E 00 FT
1.50     0    12774     0     0     0     0     0  HR2= 5.0098E 00PSI
1.00     0        0     0     0     0     0     0  MAX= 1.6218E 00 FT
0.50     0        0     0     0     0     0     0  MAX= 1.1199E 00SEC
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2.00     0        0     0     0     0     0     0  HR2= 9.1083E 00 FT
1.50     1    12774     0     0     0     0     0  HR2= 5.0148E 00PSI
1.00     0        0     0     0     0     0     0  MAX= 1.6235E 00 FT
0.50     0        0     0     0     0     0     0  MAX= 1.1199E 00SEC
    0.25   0.75     1.25  1.75  2.25  2.75  3.25  ABOVE    PERIOD(SEC)
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Figure 2. (As it is written to cassette by the microprocessor)

physical components of the system (such as the microprocessor and the cassette recorder), whereas, the term software pertains to the programs which the microprocessor executes.

Hardware. The hardware portion is built around two printed circuit boards:

a. A commercially available microprocessor development board.

b. A Waterways Experiment Station designed and constructed Input and Output (I/O) board.

The commercially available unit was modified by the vendor, Quay Corporation, to use lower than normal power components for this application. It features an extremely fast and powerful 8-bit microprocessor, the Z80A. This processor is the largest power consumer of the system but was selected because of the tremendous flexibility and mathematical capability it allows on site. The board can accommodate a large amount of memory storage (14 kilobytes of read-only memory (ROM) and 65 kilobytes of random-access memory (RAM). The board contains a Universal Assychronous Receiver Transmitter (UART) and Z80 Parallel Input-Output (PIO) chips to provide connection to a Silent 733 terminal and the WES board. There are four clock/timers on the board which may be used for various timing applications such as data sampling interval and time of day. The WES board provides the interface between the microprocessor and a wide range of hardware devices. It allows for up to 64 differential (128 single-ended) analog inputs such as wave gages, pressure gages, temperature gages, and velocity meters. This gives the system a great deal of versatility in that it is general enough to be used for a wide range of remote data collection and processing applications. The WES board also has three analog outputs which can be used to set control parameters or position limited-range gages. There is an 8-digit liquid crystal diode (LCD) display on the board which is used to display time of day (a set of thumbwheel switches are connected through a cable to the board to allow initial power-up time to be input). The board also contains the interface to connect a Memodyne cassette recorder to the Quay board. The price, less transducers and solar cells, is approximately $3,000.

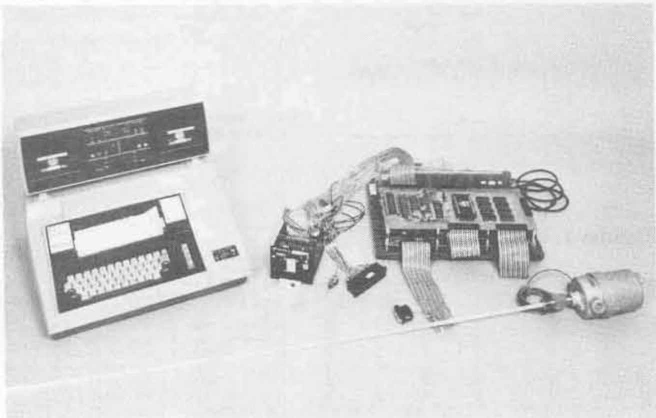

Figure 3.

Software. Several software utility packages have been written to allow modular program development. There is a math package which allows software fixed and floating point operations of the type a simple calculator would do. There is a time of day package for keeping time. There are software packages for analog-to-digital and digital-to-analog conversions. There is a liquid crystal display driver package and a thumbwheel switch driver package. In the unlikely event (since batteries are the energy source) of a power failure, there is a routine to automatically restore order and renew data acquisition and processing upon power restoration.

Data processing is accomplished in software using algorithms which fit the application. The data is subjected to a digital low pass filter prior to the algorithm implementation. The best algorithm for wave height analysis: first derivative, second derivative, zero crossing, or fast Fourier analysis has yet to be determined. However, an interim working program has been tested.

Other Systems. Similar systems are being used on other projects where AC power is available and additional software and hardware is available for these applications. Floating point hardware has been incorporated utilizing the Advanced Micro Devices 9511 chip. A complete Silent 733 driver package for reading and writing to or from the terminal's twin cassette tapes and typing at 120 characters per second has been developed. Faster analog-to-digital converters than the one used on this project (70 microseconds conversion time) have been utilized on other projects.

Future systems may include components which are just now becoming available. One of these may be the MC68000 16-bit microprocessor which can directly address 8,000,000 bytes of memory. Another may be the Winchester disc drive which can store up to 47,000,000 bytes of data.

Other Uses. The microprocessor can be used as an alarm system, i.e., to signal or display an alarm on site or a remote location when the data has exceeded preset limits.

Status. The system shown in Figure 3 has been laboratory tested with three different sensors. During these tests, difficulty was experienced in what the system recorded as a wave. Considerable effort is now underway to (a) define the wave form desired and (b) determine the best algorithm for programming to obtain this information. After this has been accomplished in the laboratory, the system will be evaluated in the field. If the results are satisfactory, the system will be utilized by a number of Corps districts in monitoring waves.

When the system has been debugged, a reliable tool for acquiring and converting remote analog data will be available to the Corps. The system will provide a means for acquiring wave data, in a form suitable for analysis, both quickly and reliably.

The information presented herein, unless otherwise noted, was obtained from research conducted at the U. S. Army Engineer Waterways Experiment Station in activities under the Streambank Erosion Control Evaluation and Demonstration Act of 1974 (Public Law 93-251, Section 32). Permission was granted by the Chief of Engineers to publish this information.