Extending and Expanding the Life of Older Current Meters

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Abstract - **The EG&G Model 610 VACM and Model 630 VMCM are standards for ocean current measurements. It is simple to add peripheral sensors to the data stream of the VACM by use of add-on CMOS circuitry. The firmware control of the VMCM makes it virtually impossible to add sampling of additional sensors. Most of the electronic components used in the VACM are obsolete or difficult to replace and the VMCM will soon follow suit. As a result, the USGS joined WHOI in the development of a PCMCIA data storage system to replace the cassette recording system in the VACM. Using the same PCMCIA recording package as the controller and recorder for the VMCM, a user-friendly VMCM is being designed. PCMCIA cards are rapidly becoming an industry standard with a wide range of storage capacities. By upgrading the VACM and VMCM to PCMCIA storage systems with a flexible microprocessor, they will continue to be viable instruments.**

I. VECTOR AVERAGING CURRENT METER (VACM)

A. Introduction

A new memory system based on the PCMCIA technology has been developed to replace the cassette tape drive recorder in the EG & G Model 610 VACM[1]. The cassette system was popular with manufacturers of oceanographic data loggers in the 1970s and 1980s. Over the years, the tape cassette system has proven to be a good storage medium. The driving forces behind upgrading to this new memory are the unavailability of replacement parts for the tape drives and the obsolescence of the tape readers that are becoming more difficult to repair. There are also inherent problems with the mechanical operation of a tape drive and the aging electronic circuitry for the head and motor driver circuits. The PCMCIA memory eliminates these failures. Another benefit of this replacement is the capability to sample a wide range of peripheral sensors under software control.

The new design was initiated at the Woods Hole Oceanographic Institution (WHOI) by the Sub-Surface Mooring Operations Group and was partially funded by a grant from the Keck Foundation. Having similar interests, the United States Geological Survey (USGS) Sediment Transport Instrumentation Group supplied matching funding for the completion of this project. Engineering design was performed by WHOI. This new system has been described in a paper presented at both the MTS 94 and OCEANS 94 conferences [1,2]. However, an overview of the system will be given here.

[1]Use of trade names are for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

B. Specifications

The system design was the result of research to find a system that would 1) use the power supplied by the existing 18 vdc 10 Amp-Hour (AH) battery stack in the VACM for the cassette recording system, 2) fit in the same space in the instrument rack as the cassette recorder, 3) retain compatibility with present instrument test sets, 4) not rely on batteries to maintain the memory, and 5) be a viable technology for years to come. In addition, researchers today have a requirement to measure other physical oceanographic parameters besides the current vectors and temperature provided by the VACM. These supplementary parameters can change from one field experiment to another. To accommodate this, the controller must provide user-friendly flexibility in sensor management, data recording and data processing.

C. Selection

An Onset Computer Corporation Tattletale 4A[1] (TT4A) is used as the controller. It runs under TTBASIC software which is a user-friendly programming language which is particularly important for people without extensive programming expertise. It has 16 I/O lines and an 8 channel, 12-bit analog-to-digital (A/D) converter. By adding a multiplexer in front of the frequency input channel, sampling of multiple peripheral sensors with frequency output signals can be done. The incorporation of the TT4A as the controller for the recorder upgrade opens the door for any VACM to sample a wide suite of external sensors. The user can add sensors to measure light transmission, pressure, fluorescence, optical backscatter, conductivity, and fast response temperature, all of which are under software control PCMCIA is used as the storage medium because it meets our power budget, size conditions, and requirement for a new, expanding technology. PCMCIA cards are reusable. Once data has been copied from the card, it can be reformatted and used again. FLASH cards are presently available with data capacities of up to 20 Mbytes of non-volatile storage. A FLASH EEPROM PCMCIA card is used instead of other types because it does not require a backup battery to retain data. This would preserve data indefinitely in the event the VACM was recovered after the life time of the main and backup batteries had expired. An added convenience of this technology is the simplicity for data transfer from the PCMCIA to a file on a personal computer (PC). A PC that is connected to either an external PCMCIA reader or an internal PCMCIA drive treats the PCMCIA card like another hard drive containing DOS files and data is simply copied from one disk to another. It takes about 40 seconds to transfer 2 Mbytes of data from a PCMCIA card to a file on a hard disk. By comparison, a 450' cassette tape holds about 1.6 Mbytes of data and takes 12 minutes to transfer that data using a cassette reader to a PC file. Once the PCMCIA data is on a hard disk, a program written in 'C' or BASIC can unpack it into a format useful for analysis. This is very convenient for instrument performance evaluation while still at sea.

D. Recorder Subsystem

The mechanical design of the system is dictated by the size constraint previously mentioned. Thus, the system design consists of stacked printed circuit boards. The block diagram of the interface circuitry is shown in Fig. 1.

The TT4A is mounted on its own printed circuit board with input/output lines available on 0.1" in-line pin alignment. This card is the foundation of the stack.

The PCMCIA card mount is located on the upper card of the stack and is identified as the L-Board. This printed circuit board also contains the electronics for the interface between the TT4A and the PCMCIA drive.

A VACM Interface printed circuit board interfaces the TT4A to the VACM. It is placed between the L-Board and the TT4A printed circuit board and provides the interconnection between the three boards. The VACM electronics provides ground, power, an interrupt, serial data, and clock shift signals to the recording package.

E. Power Requirements

This system is normally in a dormant state. When an interrupt ("data request signal") is generated by the VACM, it "wakes up"the TT4A which in turn powers up the L-Board, loads the address for the incoming data, writes the data and then powers down. The power budget based on a one year deployment of a standard VACM at a 7.5 minute record interval is 4.464 AH based on the following:

1 year = 70,080 records = 1.1 Mbytes
(8 records/Hr x 24 Hrs x 365 days)

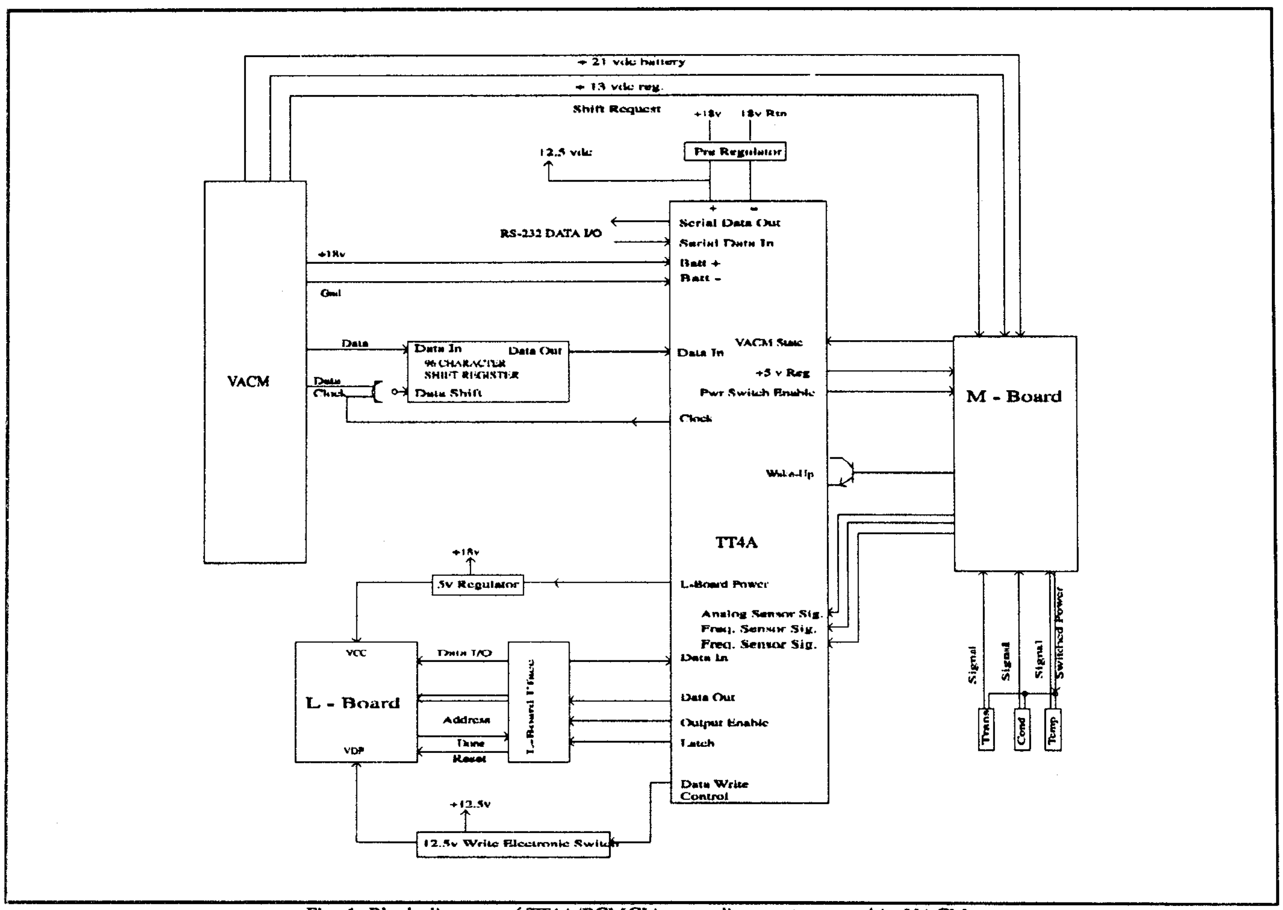

Fig. 1. Block diagram of TT4A/PCMCIA recording system used in VACM.

Power Requirements for each record:

Data write:	0.050 A for 1.4 s	1.36 AH
VACM hold off and data load		0.22 AH
Standby current:	200 uA x 8760 hours	1.75 AH

The power required for a 1 year deployment is 3.33 AH. With the present battery capacity of 10 AH, 3.36 Mbytes of data from a standard VACM can be recorded. This data capacity can be reached by simply using a 4 Mbyte PCMCIA card allowing a 3-year deployment.

F. Data Recording

The data is written on the PCMCIA cards as MS-DOS files and can therefore be read directly by a PCMCIA card reader such as those built into the latest notebook computers. The data for a standard VACM is stored in Hexadecimal as it appears from the UART;

AAAAAA EEEEEE NNNNNN RRRRRR CC VV TTTT MMMMMM KK

A=PCMCIA address (not stored, but displayed), E=East component, N=North Component, R=Rotor, C=Compass, V=Vane, T=Time, M=Internal Thermistor, K=Checksum.

G. Peripheral Sensors and Expanded Data Format

A fourth card (M-board) added in the center of the printed circuit board stack contains the various signal conditioning circuits required for the external sensors. Fig. 2 shows an exploded view of the four card system. Using the VACM "mid-interval clock pulse", the TT4A is awakened, power is applied to the sensors and the data sampled and stored. Analog signals are routed to the various A/D channels. Frequency signals are multiplexed and sampled using the built-in TTBASIC 'PERIOD' command.

A typical extended data format adds Conductivity, External Temperature Cell, Light Transmission, and Fluorescence to the standard VACM parameters.

AAAAAA EEEEEE NNNNNN RRRRRR CC VV TTTT MMMMMM SSSSSS XXXXXX LLLLLL FFFFFF KK

A = PCMCIA address (not stored, but displayed), E = East component, N = North Component, R = Rotor, C = Compass, V = Vane, T = Time, M = Internal Thermistor, S = Conductivity, X = External Temperature Sensor, L = Light Transmission, F = Fluorescence, and K = Checksum.

Not every sensor will be used on each deployment. Although this format could be viewed as a waste of data storage space, PCMCIA is available in various storage sizes up to 20 Mbytes. Thus, data storage size is no longer the tradeoff it once was. Based on the use of a 4 Mbyte PCMCIA card and a 7.5 minute record interval, the VACM with all these sensors can be deployed for 2 years. On the other hand, the demands on data processing to cope with many unique packed data formats is nearly eliminated by maintaining a standardized data format.

II. VECTOR MEASURING CURRENT METER (VMCM)

A. Introduction

Once this new recording package was under development, we explored ways to incorporate it into the EG&G VMCM. The University of Southern California has replaced the tape cassette system with an Onset Computer Tattletale 6 (TT6) which uses a hard disk as the storage medium. They utilized the same technique for adding peripheral sensors as we were doing for the VACM. The smallest hard drive available from Onset for the TT6 is 120 Mbyte and we did not require that amount of data capacity. In addition, the Technology Applications Group, Hydraulics Laboratory Facility at Scripps Institute of Oceanography (SIO) has designed a current meter around the Weller-Davis current sensor using low-power microprocessors for the sensor electronics module and the data storage module. This design incorporated only an additional conductivity measurement. The convenience of changes to that design is directly related to the expertise in the architecture and specific assembly language of the microprocessors. The SIO design also includes a KVH 101-4 compass, a 14-bit thermistor measurement and a removable sting assembly. WHOI redesigned the mechanical configuration of the sting, the sting hub shaft and bearings, rotor boards and load cage as part of their on-going effort to improve the EG&G design. WHOI also replaced the original SAIL penetrator with a more rugged penetrator.

The design of an upgraded version of the VMCM is underway. This design incorporates the features of the current meter designs and revisions previously described which best suit USGS requirements. This work is guided by the philosophy that the use of commercially available, proven modular sub-systems and sensors and similar software/firmware recording packages produce a high degree of data recovery .

B. Mechanical

With our present inventory of EG&G VMCMs, it seems prudent to incorporate the electronics in the same pressure housing. All of the USGS instruments have been upgraded to the sting, hub and propeller shaft mechanical designs developed by WHOI. In addition, the SAIL penetrator designed by WHOI is used. By retaining the current pressure housing, no changes are required by our present load cages. These load cages have been redesigned by the USGS to mount a Sea Bird SEACAT-16 and two Sea Tech 25 cm transmissometers. The SIO removable sting design was attractive. It was designed to facilitate the at-sea turnaround of the VMCM. A biologically-fouled sting could be replaced and the stored data down-loaded without opening the pressure housing. At the present time, typical USGS deployments do not call for this capability and therefore will not be incorporated into this design. However, the modular design permits any sting assembly using Micro Switch SS2[1] or equivalent magneto-resistive sensors to be used.

C. Basic VMCM electronics

The USGS VMCM design will be centered around the VMCM electronics package available from SIO that provides North and East vectors, propeller counts, compass and thermistor data via a RS-232 link at 1 minute intervals. These 1 minute blocks of data will be averaged over a software controlled time interval by the TT4A and stored. The compass and thermistor interface circuits are included. The electronics are incorporated on three printed circuit boardsT. he recent WHOI design for the rotor boards in the propeller hubs will be used. A block diagram of the VMCM is shown in Fig. 3.

D. Peripheral Sensors

The same M-board as used in the VACM recording package redesign will be used for peripheral sensor signal conditioning in this VMCM design. Modifications to the TT4A's software routines will be similar to the ones incorporated into the standard VACM routines. Connections for the peripheral sensors will be made through a 10-pin penetrator similar to the WHOI design for the SAIL penetrator. It will be installed in the upper end cap in place of the plug for the optional pressure transducer. For every VMCM deployed by the USGS at the present time, a Sea-Bird SEACAT and a transmissometer are mounted to the VMCM load cage to satisfy the requirements levied by USGS scientific personnel. By incorporating these and other additional measurements into the VMCM, all the data can be collected using one timebase.

E. Recording System

This VMCM design uses the same TT4A/PCMCIA recording package developed for the VACM. The USGS multi-parameter data format (similar to the expanded VACM format) includes standard VMCM parameters and foreseeable peripheral sensors.

A typical multi-parameter data format adds conductivity, an external temperature cell, light transmission and fluorescence to the standard VMCM parameters.

III. CONCLUSION

In today's economy, it seems imperative that operational centers concentrate on upgrading present inventory in a modular fashion rather than purchasing whole new instrumentation systems that often fall short of the flexible measurement platforms with high data capacities required by most researchers today.

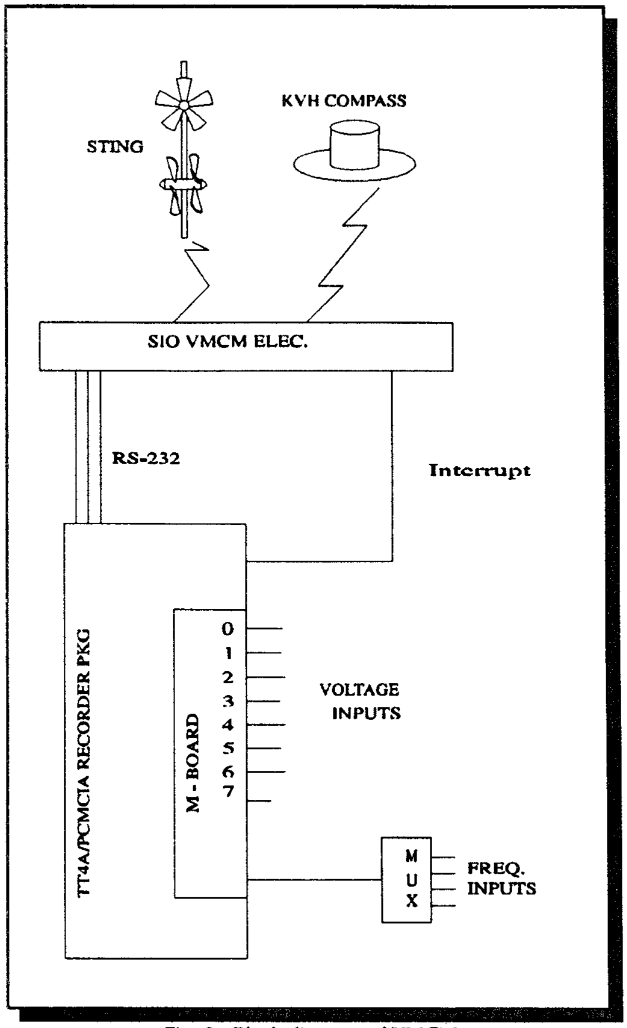

Fig. 3. Block diagram of VMCM.

PCMCIA storage provides operational oceanographic instrumentation centers with a great opportunity to prolong the life of their older current meters while providing access to additional sensors. The TT4A-PCMCIA replacement of a cassette recording system is viable and economical.

The USGS has a relatively small instrument pool of VACMs (30) and VMCMs (10). Economics preclude the purchase in quantity of replacement instruments in any given year. In addition, it is extremely difficult to find a commercially available current meter that has the flexibility to sample multiple types of peripheral sensors and the data capacity that this upgrade provides. However, this low cost upgrade extends the useful life of these current meters into the next century. The capability and flexibility of sampling multiple peripheral sensors is an additional bonus. Often WHOI and USGS borrow instruments from each other to support large field experiments. Currently, the peripheral sensor requirements needed by each group is quite different. By simply changing the software program loaded into the TT4A, the difference between USGS and WHOI instrumentation is transparent.

REFERENCES

[1] Strahle, W. J., Worrilow, S. E., Fucile, P. D. and Martini, M. A., 1994, New Recording Package for VACM Provides Sensor Flexibility. *Proc. IEEE OCEANS '94 Conf.* vol I, pp391-396.

[2] Strahle, W. J., Worrilow, S. E., Fucile, P. D. and Martini, M. A., 1994, New Recording Package for VACM Provides Sensor Flexibility. *Proc. MTS '94 Conf.* pp152-158.