

## A LOW COST DATA LOGGING SYSTEM WITH SATELLITE TRANSMISSION CAPABILITIES

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### ABSTRACT

The concept of updating a shore based data bank by regular satellite transmissions of data collected at sea has important uses in programmes on the exploration and survey of sea bed mineral sites. In this context, the need arose to log data from a satellite navigator, deep sea echosounder, and a magnetometer on board a chartered research vessel. A novel data logger design was implemented with the extra option of transmitting logged data through the ships INMARSAT approved satellite terminal. The logger consists of an expandable 8 bit processor card (developed in-house), and a versatile high density tape recorder. The interrupt driven software for the logger was written in PLM 85 - a Higher Level Language. The results show that useful geophysical data collected at sea can be received on a shore computer at 2400 baud with a negligible error rate. Furthermore, this development shows that in-house construction of essential hardware/software components based on specific user needs reduces cost, increases reliability, and permits functional expansion as and when required by the user.

### INTRODUCTION

A typical institutional oceanographic cruise on the exploration and survey of sea bed mineral sites extends through a period of 45 days. During this time, large amounts of data are generated by three commonly used marine instruments e.g. satellite navigator, a magnetometer, and a deep sea echosounder. It therefore becomes necessary to acquire, store, retrieve, and even transmit this data-set to shore regularly. Following this need, a simple and effective data logger design was implemented taking into account the requirements of the user. The final design was influenced by the following considerations:-

1) The logger should accept incoming satellite fix data at any time, and be able to selectively sample magnetometer and echosounder data at a user defined interval. Furthermore, all data acquired by the logger should be stored on a high density tape storage device that does not require frequent tape cartridge changes.

2) The hardware design should be expandable to accommodate the data logging of other instruments, (e.g. gravimeter) and all software written for the logger should be in a Higher Level Language for easy modifications by the user and designer.

3) Raw data files transferred from the logger's tape medium should be processed on a desk top computer available on board, so that a reduced data set can be routed via a data modem to the ships satellite communications terminal.

4) The logger should have no front panel controls (which discourages user interaction), such that it performs only as a remote recording device.

The description of this work is organised into six separate sections. A brief description of the components of the complete data logging system is given in Section 2. The hardware details of the logger consisting of the 8085 single board processor and the microdrive tape recorder are given in Section 3. Section 4 outlines in order, the acquisition routines written for the logger, the data processing software on an HP9845 computer, and the communications software that enables data files to be transmitted through a satellite terminal to a shore based laboratory. A graphical representation of the data collected on a cruise is presented in Section 5 followed by concluding Section 6 that summarises this work.

### 2. SYSTEM DESCRIPTION

A block diagram of the complete system is shown in Figure 1. It consists of the ships system linked via satellite to the shore system. The ships system transmits selected data files which are received, stored and processed on the shore computer. A brief description of each system follows:

#### 2.1 Ships System

This system is made up of :

- \* Geological data logger.
- \* Satellite Navigator (SATNAV), magnetometer, and a narrow beam deep sea echosounder.
- \* An HP9845 computer interfaced to a 2400 baud rate data modem.
- \* An MX-211 satellite communications terminal (SATCOM).

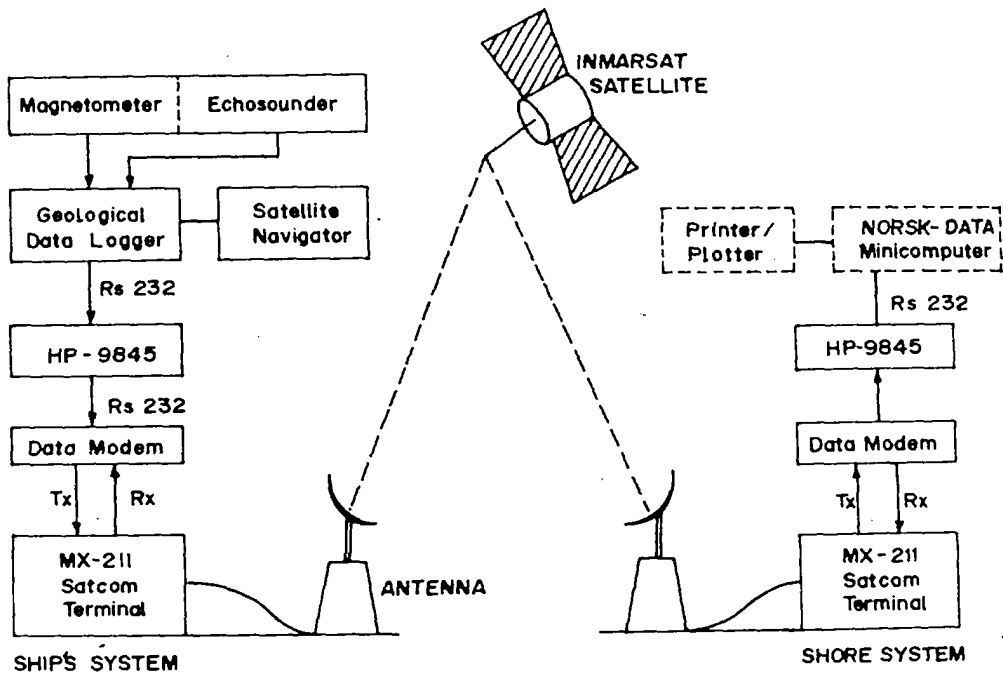


Figure 1. Block Diagram of the Complete System

The data logger is interfaced to the SATNAV by an RS-232C serial link set to 600 baud. The 5 digit Binary Coded Decimal (BCD) outputs of the magnetometer and echosounder are directly connected to the input/output (I/O) ports of the logger. These outputs are sampled by the logger on a real time clock interrupt once every 10 seconds.

The magnetometer updates its output (units:gammas) once every 6 secs (typically) whilst the echosounder output is updated once every 8 secs at a typical depth of 5000 meters.

The HP9845 computer having upto 1.6 Mbytes of user memory accepts serial data at 2400 baud from the Microdrive tape recorder on the logger. Under software control, recorded data from the logger can be down-loaded to this computer for sorting and storage in a reduced data format. The data modem which is also serially interfaced to the HP9845 was switched configured for 4-wire full duplex operation with the SATCOM terminal.

The MX-211 satellite terminal is a standard ships earth station conforming to INMARSAT (International Maritime Satellite Organisation) requirements. The communication modes possible on this terminal include telex, voice, medium speed data, and slow scan television. The use of an optional data interface card on the terminal provides the use of the data mode.

## 2.2 Shore System

The basic configuration of this system as shown in Figure 1 consists of the SATCOM-DATA MODEM-HP9845 combination which is a duplicate of the ships system. Currently, low volume data sets can be directly stored on the high density tape drives of the HP9845. The dotted blocks in Figure 1 represent future additions to this system which would allow data to be routed to a NORISK DATA super minicomputer for the control and maintenance of a shore based data bank on survey cruises.

## 3. HARDWARE DESCRIPTION OF THE LOGGER

A functional block diagram of the data logger electronics is shown in Figure 2. The logger consists of a single board computer (SBC) (Ref 1) and a tape transport which uses data cartridges to store data.

The SBC uses an Intel 8085 microprocessor running at 6.144 MHz. There is on board provision for 6 K EPROM and 2 K RAM. On-board decoding logic provides two RS-232 serial ports (Intel 8251), two parallel I/O ports (Intel 8255), a real time clock chip (MM 58167A) and six extra decoded outputs for future expansion to other memory and I/O devices. As shown in Figure 2, the RST 7.5 interrupt on the CPU connects directly to the RxRDY output on the 8251

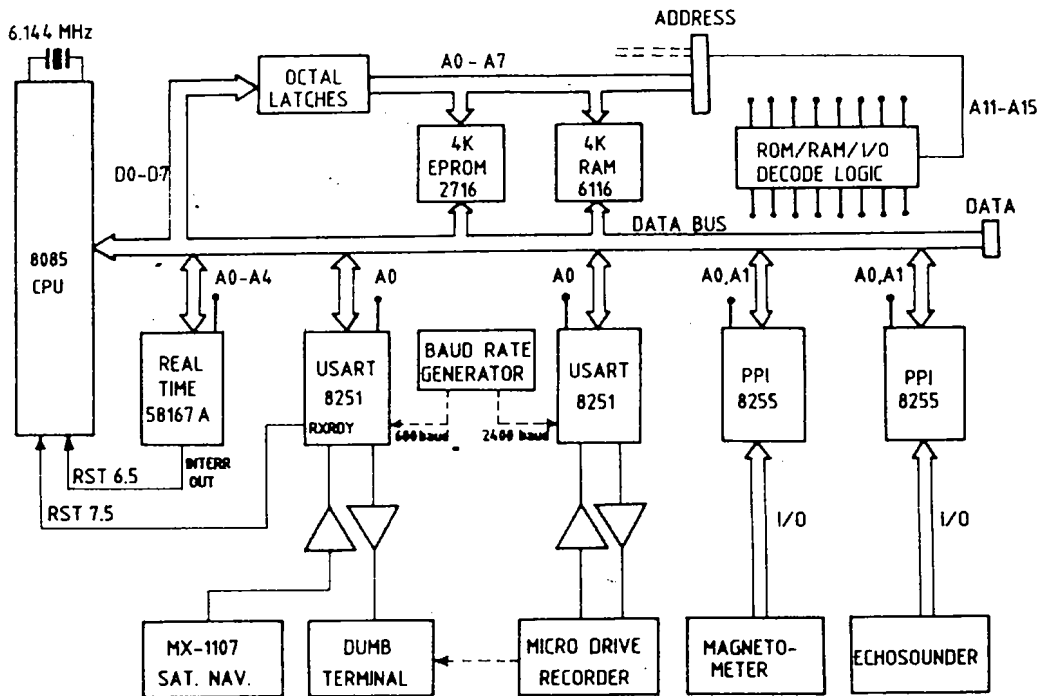


Figure 2. S. B. C. 8085 Board of the Data Logger

USART which receives satellite navigator data; the RST 6.5 interrupt connects to the interrupt output of the real time clock. The parallel I/O ports on the SBC interface directly to the TTL compatible BCD lines from the magnetometer and echosounder. One of the serial ports on the SBC is used in the control of the tape transport. The microdrive tape transport is capable of reading and writing data to tape at a density of 1600 bpi on two tracks of a standard DC-100 tape cartridge. The tape storage capacity of 1.344 Mbytes makes it possible to record approximately 8 days of data assuming that the SATNAV interrupts the logger every 10 mins., and the magnetometer and echosounder ports are sampled every 10 secs.

#### 4. SOFTWARE DESCRIPTION

This section briefly describes the software routines written for the total system described in section 2. These routines are :-

- \* Acquisition routines in PL/M-85 for the SBC of the data logger
- \* Processing programs written in HP-BASIC that enable post processing of logged data
- \* Communications programs (also in HP-BASIC) that enable the transmission and reception of data files using the satellite terminals.

#### 4.1 Acquisition routines

A flow diagram of the main PL/M program is shown in Figure 4. The program allocates a 1024 byte buffer area (partitioned into two separate 512 byte half buffers) for storing data from external devices. The satellite navigator interrupt procedure is activated on the reception of an incoming character belonging to the 266 byte satellite message block. Similarly, interrupt routines for the magnetometer and echosounder deposit sampled data into two 6 byte memory locations on receiving a real time clock interrupt. The background loop of the program copies a full 512 byte buffer to tape by checking the status of the half buffer flag. The second half buffer can be used to store data during a tape copy process. In this way, no data is missed by the logger. All data is stored on tape in ASCII code. In order to simplify data processing, each data type is identified by a tag.

#### 4.2 Processing routines

Three main functions are performed conveniently by this set of programs. These are :

- 1) Logged data from the tape drive on the logger is down loaded to the HP9845
- 2) A sorting routine picks out latitude, longitude and GMT from the satellite message, and sorts out magnetometer and echosounder by

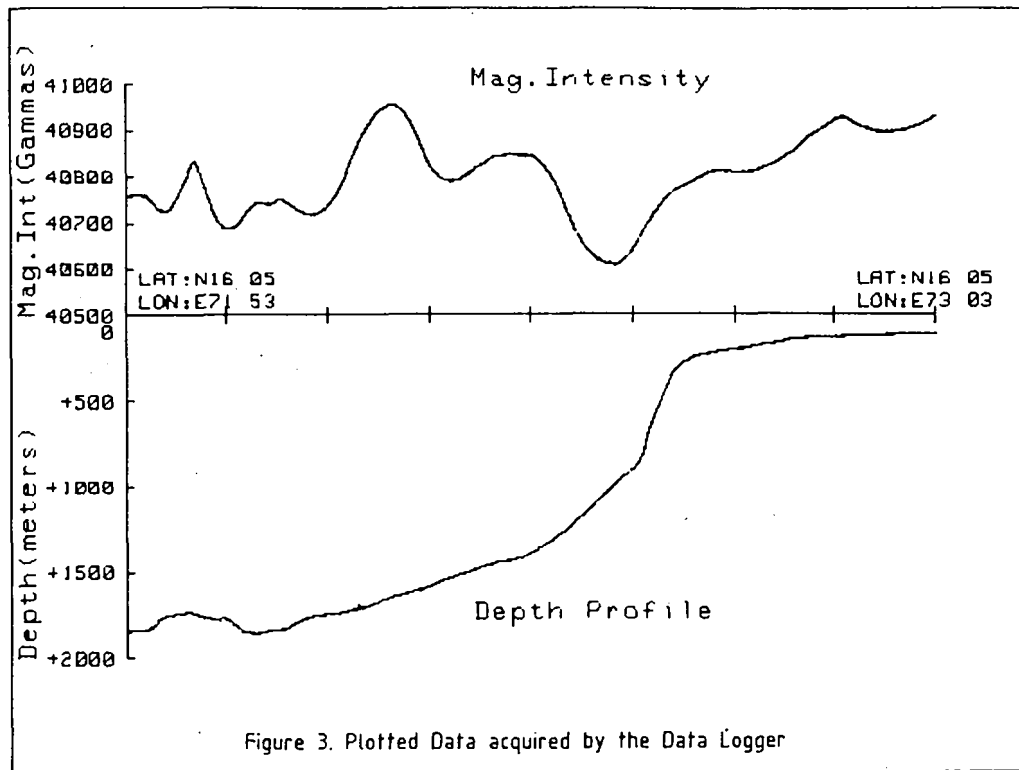


Figure 3. Plotted Data acquired by the Data Logger

their tags. Sorted data is stored in a file prepared in a format suitable for satellite transmission.

3) Graphical plots of sorted data over survey lines can be obtained for the convenience of geophysicists on board the ship.

#### 4.3 Communication routines

The transmission of a selected data file begins by signalling the shore computer through a sign-on message. Each record of the data file is sent as a stream of ASCII characters terminated by a CR-LF (carriage return-line feed) sequence. On checking end of the file status, the ships transmission terminates by sending the shore system an end message.

The reception program on the shore computer works on a character interrupt basis. The CPU fetches each character into a 320 byte circular buffer. Each record is stored in memory and displayed on the CRT screen. The reception of start and end strings sent by the ships system are monitored in a background loop. Received data is stored as a file in the same format in which it was transmitted.

#### 5. RESULTS

The geological data logger has been put into successful operation on several oceanographic

cruises of the Institute's Research Vessel Sagar Kanya. Graphical plots of magnetic intensity and depth profiles are shown in Figure 3 over a survey line. More sophisticated plots can be drawn by plotting such data on a Mercator Map grid.

#### 6. CONCLUSIONS

This paper has described a complete data logging system capable of transmitting data logged on a research vessel to a shore computer. The central component in this system is the geological data logger whose design was largely determined by user inputs. Apart from its low cost, the logger performs nearly all functions of a costly commercial data logging system. The philosophy of optimising the use of equipment available on most modern research vessels is justified and has enhanced the essential function of the simple data logger described here.

The major limitations of the present system are:

- 1) Low volume data sets can be transmitted to shore at a limited baud rate (2400).
- 2) The cost factor involved in satellite based transmission prevents widespread usage specially in research vessels.

The usefulness of this system will be further enhanced by incorporating a few minor modifications:

- 1) Tape storage on the logger can be increased by a factor of 4 from its present capacity by writing data on both tracks of the tape and by fitting an extra tape drive mechanism.
- 2) The communications software can be improved by more stringent handshaking protocols between the ship and shore system. Data in a tightly compressed data format will increase the information content of data files. Error checking of data content would then be essential.
- 3) The addition of an extra serial port on the SBC of the logger with software changes will permit the data logging of a gravimeter - another important tool in geophysical exploration.

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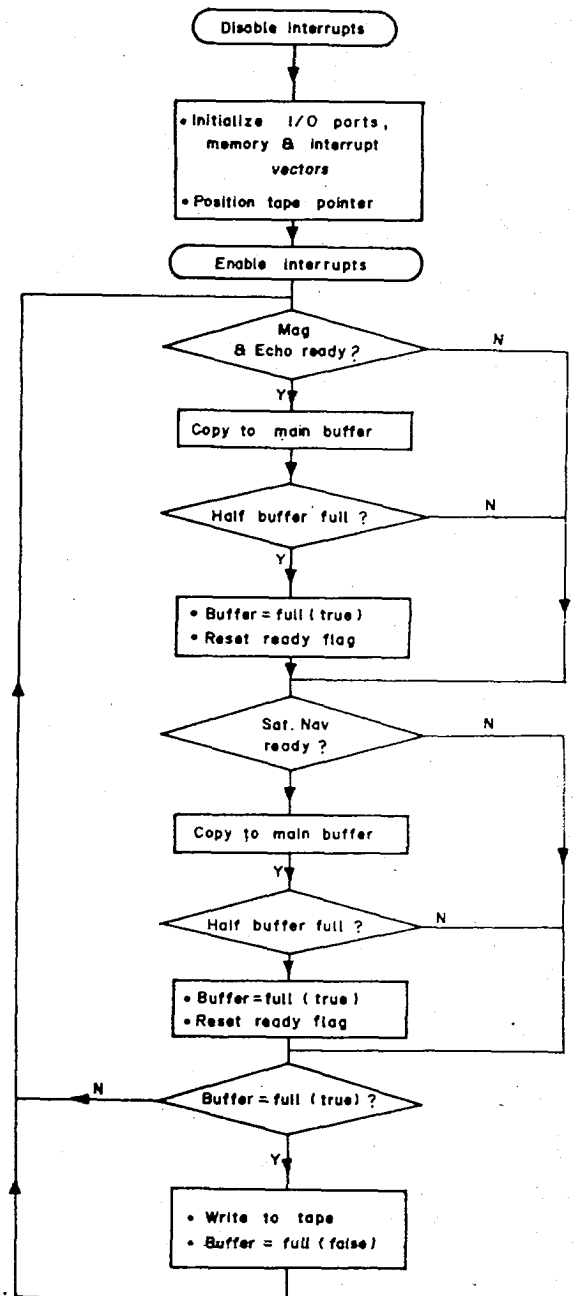


Figure 4. PL/M Flow Diagram of the Data Logger