# A TELEMETRY SYSTEM FOR AUTOMATIC ACQUISITION AND TRANSMISSION OF SNOW AND METEOROLOGICAL DATA AND ITS APPLICATION


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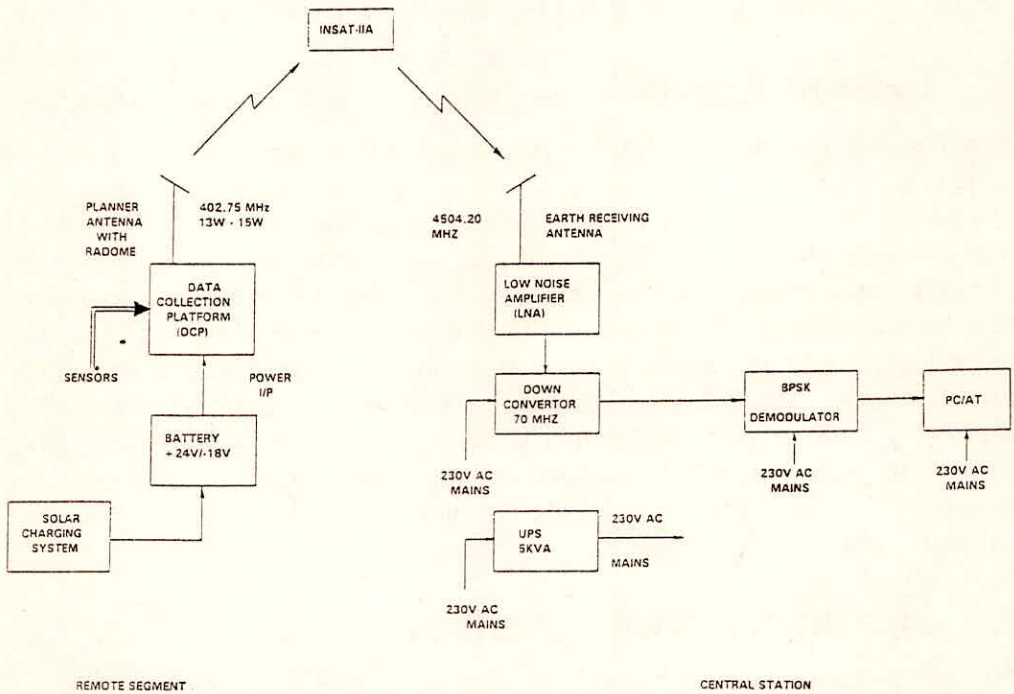
## 1. INTRODUCTION

Snow and meteorological data from inaccessible avalanche formation zones is a primary requirement for avalanche forecasting. For this purpose, development of a telemetry system for automatic collection and storage of hourly data, and its transmission to a central station through satellite link was undertaken by the Snow and Avalanche Study Establishment (SASE), Manali. This telemetry system can be used for snow-hydrology, by using some additional sensors and with slight modifications. This chapter describes various features of the SASE telemetry system and experience gained during the development process. The most important feature of the development is that all the electronic components are capable of operating upto –40°C and under extreme climatic conditions.

## 2. DESCRIPTION OF THE SYSTEM

The block diagram of the system is shown in Fig 1. It consists of three main segments, viz, remote segment, satellite segment and central station. At a remote station, a number of sensors are connccted to a Data Collection Platform (DCP) which is a microprocessor based data logger. After a predefined interval, outputs of the sensors are sampled. The analog outputs are converted into 12 bit digital signals before being stored, while the digital outputs are transmitted to the central station through the satellite link. The above functions are accomplished by a user-defined software in the EPROM of the CPU. A 12-Bit ADC is used for digital conversion of the analog data. This provides a resolution into 4095 steps. It results in fairly good accuracy of the measurement of different parameters. For example, in case of the temperature sensor, the accuracy is 0.024°C/bit (while with DCP and sensor together, the overall accuracy of temperature becomes 0.1°C). At the central station, data is received, demodulated and stored in a PC for further processing.




*. ig. 1 Block Diagram of the Telemetry System*

Since the DCP is an unattended, battery-powered equipment, it must consume minimum power. This has been ensured by using CMOS ICs. The operational role of SASE demands data collection from inaccessible regions of the Western and Central Himalayas. This prompted the selection of satellite based communication, as against meteor-burst or VHF communication. Contrary to the general telemetry approach of remote data collection through interrogation by the central station, automatic transmission of data from remote station at fixed hours was preferred. This resulted in lesser power consumption and reduced weight. A brief description of each segment of the system is given in the following paragraphs.

## 3. REMOTE SEGMENT

Remote segment consists of Sensors, Data Collection Platform (DCP) and Power Supply Unit.

3.1 **Sensors:** In addition to normal meteorological sensors, Precipitation Detection and Sunshine Detection sensors have also been provided. These sensors are designed to operate upto –40°C. The total power consumption of all the sensors is less than 2 watts in the normal mode of operation. The brief of the sensors is given in Table 1.

**Table 1**

| Sn | Name | Range | Output | Operating Principle |
|---|---|---|---|---|
| 1. | Ambient Temp. | +50 to –50°C | Analog | PT-100 Platinum Resistance as temperature transducer. |
| 2. | Relative Humidity | 0 t0 100% RH | Analog | Thin film capacitor as sensing element. |
| 3. | Wind Speed | 50 mps | Digital | Opto-electronic sensor -3 cup anemometer. |
| 4. | Wind Direction | 0 to 460° | Analog | Potentiometer type. |
| 5. | Albedometer | 0 to 100% | Analog | Consists of 72 junctions of thermocouples of copper constantan junctions. |
| 6. | Pyranometer | 0 to 150m W/cm$^2$ | Analog | Consists of 72 junctions of thermocouples of copperconstantan junctions. |
| 7. | Precipitation Detection | — | Digital | Change of state of relative events |
| 8. | Sunshine Duration | — | Analog | Thermobimetallic strips are used for contact closure in presence of sunshine |

3.2 **Data Collection Platform (DCP):** Data collection platform is a rugged remote-end equipment housed in a NEMA-IV enclosure suitable for a harsh environment. In can support upto 19 channels. In order to check its proper functioning, three known voltages and health of batteries are monitored regularly at the earth station. It consists of the following subsystems:

3.3 **Data Acquisition System (DAS):** It is the heart of the DCP and is built around a 80C85 microprocessor. In normal mode of operation, data from various snow and meteorological sensors is acquired by DAS every one minute (4 sec in case of wind speed sensor), processed at the end of every hour and stored in the Data Storage Unit (DSU) alongwith time, data and station identification. The data is then formatted and sent to the RF transmitting system. In case of power shortage, the DAS automatically switches over to an alternate mode of operation in which data is acquired every hour and stored. No transmission takes place in this mode. After the required level of power is regained by the battery bank through solar charging, it automatically switches back to the normal mode of operation.

3.4 **Data Storage Unit (DSU):** It is a RAM module having battery back-up. Its memory capacity is 512 KB, sufficient for storing data upto six months. The equipment is generally not accessible for five to six months during winter.

3.5 **RF Transmitting System:** It consists of an RF box and a radome covered, low-weight cross-polarized, planner antenna. The RF box receives formatted data from DAS, modulates the same and transmits it to the satellite. A fail-safe circuit automatically switches off the RF power if transmission continues for more than the required period. The need for less weight suggested the use of the planner antenna. Radome has been provided to protect the antenna from snow accumulation.

3.6 **Power Supply Unit (PSU):** The power supply unit consists of two battery banks, viz, 24V/100AH and 18V/50AH. These battery banks are charged by an array of solar panels. The battery banks are so designed that the remote staion can operate for seven continuous no-sunshine days.

## 4. SATELLITE SEGMENT

The Data Collection System (DCS) transponder of INSAT-IIA is being used as the satellite segment. DCP transmits uplink signal at 402.75 MHz, and INSAT-IIA relays the downlink signal at 4504.20 MHz.

### 4.1 Central Station

Downlink signal from the satellite transponder is received by a three-meter parabolic dish antenna. The received signal is amplified by a low noise amplifier (LNA) mounted on the antenna, downconverted to 70 MHz IF, demodulated and finally given to a processing unit. The processing unit converts raw data into engineering units and using dedicated software prepares daily reports of responding DCPs and gives details of stations which have not communicated with the central station on a particular day.

### 4.2 Data Transmission: Random Time Multiple Access

Each DCP transmits in self-timed pseudo-random manner in its prescribed time slot within the hour before the next observation is taken. All the DCPs are grouped into five transmission windows, each of 10 minutes duration. The remaining one window of 10 minutes duration is used for data processing at the central station. Each transmission window consists of three time slots of three minutes each. In normal case, every DCP pseudo-randomly transmits its hourly data in a burst of 88 milliseconds within a time slot of three minutes. This is repeated in all three time slots of a window. This is done to obviate the loss of data due to communication errors and collisions of messages.

The above mentioned data transmission procedure is suitable for 422 bit format in conventional DCPs with a capability to transmit 10 data points. In SASE DCPs as many as 20 data points are required to be transmitted in the final stage. In addition, provision for message code and additional health monitoring codes is also there. Thus, the total number of bits excceds 422, while a maximum of 422-bit data format is permissible for DCS transponder of the INSAT. Hence, in order to transmit all data points, a DCP transmits half of the data points in one time slot, and the remaining in a different time slot, under different identification code, maintaining 422-bit format. This arrangement has been implemented through software.

## 5. EXPERIENCE DURING THE DEVELOPMENT PROCESS

### 5.1 Data Collection Platform

In January 1992, two DCPs were installed at field team locations (where minimum temperature goes upto –15°C) for winter trials. During the trials, the DCPs functioned satisfactorily for collection, storage and processing of data. Due to non-availability of a stable satellite (INSAT-IB was available at that time), the data from remote stations could be received for a limited period only. In February 1993, three more DCPs were installed at field team locations at relatively higher altitudes (where minimum temperature goes upto –25°C) for winter trials. The main problems faced during the trails, their probable causes and remedial actions taken are given in Table 2.

### 5.2 Sensors

The performance of Ambient Temperature, Relative Humidity and Wind Speed sensors was erratic during the field trials. The problems were mainly due to malfunctioning of some electronics components. They have been hardened and replaced and the sensors have been tested in the laboratory for operations upto –40°C. The same will be tested in the field during the winter of 1994–95.

**Table 2**

| Nature of problem | Probable cause | Remedial action taken |
|---|---|---|
| Failure of Power supply card. | Excess voltage from solar panels. | Charge controllers were provided. |
| ADC card failure | Reason could not be ascertained. | Card was repaired. |
| Variation of RF transmitting power | Due to variation in output of power amplifier | Power amplifier was changed |
| Frequent failure of RF box | TCXO failure | TCXO was replaced |
| Corruption of stored data | Unwanted memory write during data retrieval | Write protect switch was provided |

## 6. APPLICATION

SASE telemetry system can be used for automatic collection and transmission of snow-meteorological, hydrological, soil conservation, pollution control data from remote locations. For this purpose suitable sensors will be required to be integrated with a DCP. Slight modifications in the DCP circuit may also be required. The sampling interval, processing etc can be changed as per the user's requirements by modifying the software in the EPROM of the CPU in the DCP. The hourly data which is presently being received at Manali may be transmitted on real time basis to the user agencies through micro-wave link/electronic mail employed by the user.

## 7. CONCLUDING REMARKS

SASE already has five remote stations and a central earth station. Since March 1993, near-real time data from remote locations are being received through satellite link. It is planned to install five more remote stations in the ensuing winter at new field team locations. Inspite of some problems the system has worked satisfactorily. A lot of efforts are being put in to improve the system and make it foolproof. Four more sensors for snow surface temperature, snow depth, snow particle count and pressure have been planned to be developed. With this, the system will be able to cover almost all the snow-meterological parameters.

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