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

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Abstract *This paper describes various features of the SASE telemetry system, sensors and data collection platform and experience gained during development process. This telemetry system is versatile and can be used in other fields with additional sensors or with slight modifications.*

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 Snow and Avalanche Study Establishment (SASE), Manali. The most important feature of the development is that all the electronic components are capable of operating up to -40°C and under extreme climate conditions.

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 the remote station, a number of sensors are connected 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 registered in a 10-bit counter. At end of every hour, this data is processed, stored locally and transmitted to the central station through the satellite link. The above functions are accomplished by a user-defined software in the EPROM of CPU. A 2-bit ADC (Analog to Digital Converter) is used for digital conversion of the analog data. This provides a resolution into 4095 steps. It results in fairly good accuracy of measurement of different parameters. For example, in the case of 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 central station, data is received, demodulated and stored in a PC for further processing.

Since DCP is an unattended, battery-powered equipment, it must consume minimum power. This was ensured by using CMOS ICs. The operational role of

SASE demands data collection from inaccessible regions of Western and Central Himalayas. This prompted the selection of satellite based communication, as against meteor-burst or VHF communication. Contrary to general telemetry approach of remote data collection through interrogation by central station, automatic transmission of data from remote station at fixed hours was preferred. This resulted in lesser power consumption and reduced weight. Brief description of each segment of the system is given in the following paragraphs.

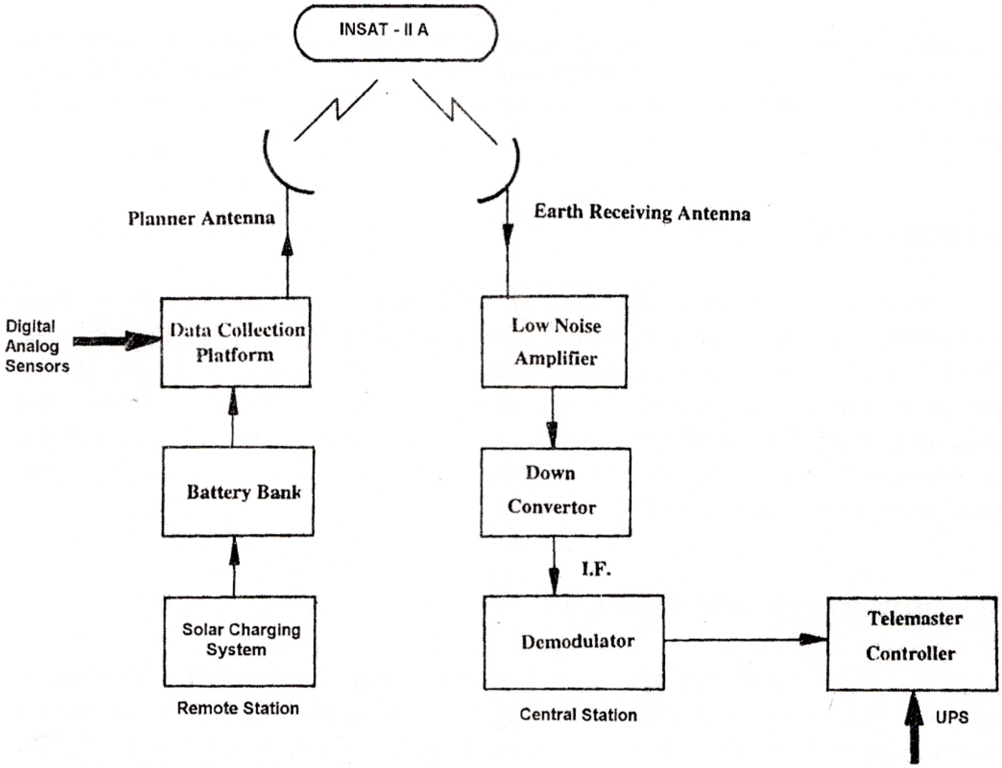

Fig. 1 Block diagram of telemetry system.

Remote Segment

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

Sensors

In addition to normal meteorological sensors, Precipitation Detection and Sunshine Detection Sensors have also been provided. These sensors are designed to operate up to -40°C. The total power consumption of all the sensors is less than 2 W in normal mode of operation. A brief description of the sensors is given in Table 1.

Table 1 Brief description of the sensors

Sr. No.	Name	Range	Output	Operating Principle
1.	Ambient temp	+50 to –50°C	Analog	PT-100 Platinum resistance temperature transducer
2.	Relative humidity	0 to 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 con-stantan junctions
6.	Pyranometer	0 to 150m	Analog	Consists of 72 junctions of thermocouples of copper
7.	Precipitation detection	-	Digital	Change of state of relay
8.	Sunshine duration	-	Analog	Thermo bimetallic strips are used for contact closure in presence of sunshine

Data Collection Platform (DCP)

DCP is a rugged remote-end equipment housed in a NEMA-IV enclosure suitable for harsh environment. It can support up to 19 channels. In order to check its paper functioning, three known voltages and health of batteries are monitored regularly at the earth station. It consists of the subsystems described below.

Data Acquisition System (DAS) It is the heart of DCP and is built around a 80C85 microprocessor. In the normal mode of operation, data from various snow and meteorological sensors is acquired by DAS every one minute (4 s in the case of wind speed sensor), processed at the end of every hour and stored in a Data Storage Unit (DSU) along with time, date 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.

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

RF Transmitting System It consists of an RF box and a radome-covered, low-weight cross-polarized, planar antenna. 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 planar antenna. Radome was provided to protect the antenna from snow accumulation.

Power Supply Unit

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 station can operate for seven continuous no-sunshine days.

Satellite Segment

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

Central Station

Downlink signal from satellite transponder is received by a three-metre parabolic dish antenna. The received signal is amplified by a low-noise amplifier (LNA) mounted at the antenna, downconverted to 70MHz IF, demodulated and finally given to a processing unit. The processing unit converts raw data into engineering units using a dedicated software. LNA, downconverter and demodulator have 1:1 redundancy. The software prepares daily reports of responding DCPs and gives details of stations which have not communicated with the central station on a particular day.

Data Transmission: Random Time Multiple Access

Each DCP transmits in self-timed pseudo-random manner in its prescribed time slot within an hour before the next observation is taken. All the DCPs are grouped into five transmission windows, each of 10 min duration. The remaining one window of 10 min duration is used for data processing at the central station. Each group can accommodate a maximum of 80 DCPs, taking channel capacity to 400 DCPs. Each transmission window consists of three time slots of 3 min each. In normal case, every DCP pseudo-randomly transmits its hourly data in a burst of 88 ms within a time slot of 3 min. This is repeated in all the 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 data 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, total number of bits exceeds 422, while a maximum of 422-bit data format is permissible for DCP 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 was implemented through software.

EXPERIENCE DURING DEVELOPMENT PROCESS

Data Collection Platform

In January 1992, two DCPs were installed at field team locations (where minimum temperature goes down to -15°C) for winter trails. During the trials, the DCPs functioned satisfactorily for collection, storage, and processing of data. Owing 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 of relatively higher altitudes (where minimum temperature goes down to -25°C) for winter trials. The main problems faced during the trials, their probable causes and remedial actions taken are given in Table 2.

Table 2 Problems of DCPs, causes and remedial measures

Nature of problem	Cause of problem	Remedial action taken
Failure of power supply card	Excess voltage from solar panels	Charge controllers provided
ADC card failure	Reasons could not be certained	Card 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

Sensors

The performance of sensors for ambient temperature, relative humidity and wind speed sensors was erratic during the field trials. The problems were mainly due to malfunctioning of some electronic components. They were hardened and replaced and the sensors were tested in laboratory for operation up to -40°C.

APPLICATION

The 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. A slight modification in the DCP circuit may also be required. The sampling interval, processing, etc. can be changed as per the user's requirement by modifying the software in the EPROM of CPU in DCP. The hourly data being received at Manali may be transmitted on real time basis to the user agencies through microwave link/electronic mail employed by the user.

CONCLUDING REMARKS

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

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