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Capabilities of An Advanced Data Acquisition System For Mountainous Regions

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ABSTRACT

Capabilities of an advanced data acquisition system for hydrometeorological measurements in mountainous regions have been described. The system is capable of collecting data on hydrometeorological parameters through 12 analogue, 2 pulse and 8 digital input/output channels, with provision of expanding upto 192 channels using relay scanners/multiplexers. The system uses commercially available components, namely data-logger, portable computer, and telemetry device. Presently the system is in use for monitoring a few of the parameters like rainfall, soil suction, soil temperature and air temperature. Sensors for measurement of snow height, weight of accumulated snow, solar radiation, wind speed and direction, etc. can also be connected to the system. The instrument is programmable using a series of application-specific instructions to perform the measurement of sensor signals, mathematical computations, logic controls, data storage, and data output to peripheral devices. The data retrieval is possible on a portable computer either by direct connection to the data-logger or through wireless telemetry. A solar panel is provided for on-site charging of the batteries to ensure uninterrupted data collection.

INTRODUCTION

The study of quantity, quality and movement of available water in a basin or catchment needs a variety of hydrological and meteorological data. A list of some of the important parameters is given in Table 1. These are required for modelling, planning and management of water resources, water balance studies of a basin and hydrological forecasting.

Conventional techniques of data collection do not meet the demands of volume, accuracy, reliability and repeatability of the data needed in advanced modelling studies. Moreover, there are often chances of inadequate and unrealistic data especially from remote sites in mountainous regions. The use of automated data acquisition systems has enabled the measurement on continuous basis, and at the same time eliminated the chances of human errors in observation.

The paper discusses capabilities of a data acquisition system, which with proper selection of sensors, may be effectively used for automated data collection in mountainous regions.

SYSTEM SPECIFICATIONS AND DESIGN

The system discussed in the paper includes the features of the telemetered type automated hydrological observing stations (WMO, 1973) where the instrument measures and records the observations, and also transmits the data to a receiving station.

The Data Acquisition System (DAS) is based on a commercially available data-logger CR10 from Campbell Scientific, Inc., U.S.A. The CR10 combines a micro-computer, clock, multimeter, calibrator, scanner, timer, frequency counter, and controller in a compact, sealed, stainless steel package. A multitasking operating system allows simultaneous communication and measurement functions. The data-logger works on a power supply of 9.6-15VDC; it has a standard temperature range of -25 to 50^0C (-55 to 85^0C is optional), and a total weight of 0.9 kg. The data-logger has the following salient features :

(i) CPU is an 8-bit CMOS microprocessor (HITACHI 6303),

(ii) Data is stored in memory for transfer to a display, storage module, cassette, printer, modem, or directly to a computer. Standard memory allows internal storage of upto 29900 data values. With the use of external 'storage modules', upto 8x358,000 data values can be stored,

(iii) Twelve single-ended or six differential analog inputs with 13-bit resolution on five software selectable ranges ±2.5mV to ±2.5V; three switched excitation outputs; two pulse counting inputs; and eight digital I/O ports, selectable as binary input or output, are available. On these channels, it is possible to connect various combinations of sensors like rain/snow gauges, snow height sensors, evaporation recorders, soil/air temperature probes, tensiometers, soil moisture blocks, lysimeters, water-level sensors, pyranometers, anemometers, soil salinity probes, temperature/humidity probes, pH meters, etc.

(iv) The data-logger can be programmed to perform a variety of operations including measurement of sensor signals, some basic mathematical computations, control, data storage, and data output to peripheral devices. In addition, the user can manually initiate several operations such as data review and/or retrieval, the uploading and downloading of logger programmes, setting the logger clock, etc.

User-programmed real-time data processing is possible through standard, application-specific instructions available on-board in PROM. The data processing instructions include linearisation, algebraic and transcendental functions, engineering unit scaling, averaging, maximum/minimum, totalising, standard deviation, preparation of histograms, etc.

In order to accomplish any of these functions, an external keyboard/display unit, which is an 8-character LCD and a 16-character keyboard, is connected to the data-logger. This unit is detachable, hand-held, synchronous terminal powered by the data-logger itself, and may be carried from station to station in a network of CR10 data-loggers. Other terminal devices which can be used to communicate with the data-logger include standard ASCII terminals, computers using communication software to function as a terminal emulator, and portable computers (many of them have built-in terminal emulator modes).

An 80C86-2 microprocessor based portable computer, model 1000XE having 20 MB HD and a 3 1/2", 1.44 MB FDD, from Toshiba Corporation, Japan is used to offload and store data from the data-logger. It has a backlit LCD screen with CGA for display, and serial as well as parallel ports for communication with external devices. The computer has a battery back-up facility so that it can be used during power failures.

In addition to offloading of the accumulated data with the use of the portable computer, a radio-telemetry system is also provided with the instrument for direct transmission of data to the base station. The transmission link is of the 'duplex' type. The RF transceiver works at a frequency of 458.575 MHz with an output power of 300-500 mW, effectively capable of covering a line-of-sight range of more than 10 Km without use of the repeaters.

A 12V,5Ah Lead-acid rechargeable battery-pack is used as the main battery for the field-unit of the instrument. A solar-panel, through a battery charge-regulator, is used to charge the main battery in the field. The data-logger is also provided by a standby 12V,2.5Ah Lead-acid rechargeable battery-pack, which is continuously charged through the main battery. The backup-battery saves the data, the program, and the clock in case of failure or discharge of the main battery. In the base-unit of the instrument, a 12V, 5Ah Lead-acid rechargeable battery-pack is used, and it is charged through the mains power-supply. The system has a low power consumption, and the main power consumption is at the time of data-transmission through telemetry. The maximum power drain of the CR10 and the keyboard/display unit is 35 mA, while that of the

Modem and Transceiver is 450 mA.

Harsh environments in field conditions require a rigid enclosure capable to protect the electronics during bad weather conditions. Strong stainless steel cabinets with international IP65 standard (splash, water, and dust-proof) are used for housing the electronics of the field and base-units.

Functional block diagram of the CR10-based Data Acquisition System is shown in Figure 1.

SOFTWARE CONTROL

For IBM compatible personal computers, a telecommunication software package 'PC208' is available in the DAS, which allows the operator to interrogate, to receive data or to change the program through a direct link, telephone line or RF link. A monitor mode allows real-time display of data-logger measurements.

The PC208 package supports telecommunications, programming, and data processing functions. With an appropriate communication link, it provides a two-way communication link between the data-logger and the PC. The package contains a terminal emulator programme (TERM), the editor (EDLOG), data split (SPLIT), and telecommunications (TELCOM). Each has a specific function and runs independently of others.

The editor (EDLOG) software allows the user to develop and document programs for the data-logger. Terminal emulator (TERM) software provides an efficient communication between the data-logger and a computer for real-time display of the data, and downloading/uploading of data-logger programs. Telecommunications (TELCOM) softwares ensures data retrieval from the data-logger over telephone, radio-telemetry, or hard-wire interfaces. The TELCOM also prepares a report on data error and communication quality during transfer of data from the data logger. This feature is useful in diagnosing the systems's performance at regular intervals.

The data split (SPLIT) software can process selected data from a data file or several data files and combine the data into a report file. The report file may be given a heading and labels for each column of data. SPLIT allows the user to output the report file to disk, printer or both. The report file is formatted to be compatible with popular spreadsheet programs.

Using the above mentioned softwares, a user can program the DAS in , for example, the following sequence :

1. Develop a logger program using EDLOG,
2. Program the data-logger using TERM,
3. Collect the data from the data-logger using TELCOM/TERM,
4. Check real-time measurements from the data-logger using TERM,
5. Generate a report of data collected, or analyse the data using SPLIT.

Finally, the data can be processed and stored/displayed in forms of graphs/charts through the use of "GRAPHER"/"LOTUS" software-packages.

SENSORS

At present, the following sensors with electrical output are connected to the data-logger as a typical application :

i.	Tipping bucket raingauge resolution : 0.2 mm/tip	1 No.
ii.	Tensiometers range : < 650 mbar	3 Nos.
iii.	Soil temperature probe	1 No.
iv.	Air temperature probe	1 No.
v.	Snow depth/water-level sensor range : 0.6-10 m	1 No.

Besides these sensors, a resistance of 1 ohm is connected in series with the solar-panel to measure the charging current from the panel. Three measurement channels of the data-logger have been utilized to measure the battery voltage, the charging current, and the panel temperature inside the field-unit. These parameters are useful in monitoring the proper functioning of the instrument, in detection of any malfunctioning of the battery or of the solar-panel, and to decide how often to transmit the data in case of discharge of the battery.

Presently the snow depth/ water-level sensor is installed at a certain height from the ground surface, and the height monitored for testing of the sensor. With the available capacity of the number of measurement channels, few more sensors can be connected to the data-logger.

EXPANSION CAPABILITIES

The CR10 data-logger offers a sufficiently large range of input channels for any hydrological study. Twelve analog channels, two pulse input channels, and eight digital input/output lines are available with the standard unit of the data-logger. Various transducers e.g. PRTs, pressure transducers, load cells, strain gauges, switching devices, etc. can be used to measure different hydrological parameters. As a result, it is possible to use a combination of rain/snow gauges, acoustic snow height sensor, soil/air temperature probes, tensiometers, soil moisture blocks, lysimeters, water level sensors, pyranometers, anemometers, soil salinity probes, pH meters, etc. sensors for measurement of hydrometeorological parameters with the DAS.

With the use of 'relay scanners', the analog channels can be expanded upto 192. The data-logger has a provision of connecting various output devices e.g. keyboard-display unit, data storage module, cassette, printer, computer, modems for telephone/radio/ satellite telemetry, chart recorders (using analog output MUX) through its communication ports. A number of CR10 based remote stations may be used to transmit the measured data to a base station through a telemetry network with or without use of the repeater stations, depending on the terrain conditions. With use of additional hardware with the PC at the base station, the system can be used to collect data in unattended mode.

CONCLUSIONS

Capabilities of a microprocessor-based data acquisition system (DAS) are discussed for automated collection of hydrometeorological data in mountainous regions. The discussion is based on the configuration of an instrument which was installed at the premises of the National Institute of Hydrology, Roorkee, India. The installed system uses a radio-telemetry link to transfer the data from the field-unit to a nearby base-station. The system being portable, light weight and easier to handle and operate, is considered to be suitable for use in the mountainous regions. The low power consumption and wide operatational temperature range of the data-logger qualifies its suitability for use in remote areas.

With the reported features of the system uninterrupted data collection may be ensured on a long term basis. The additional advantage with the system as reported here is that it can provide timely reporting and an early detection of faults/malfunctioning at the remote sites, which is especially useful in the mountainous regions.

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TABLE I

IMPORTANT HYDRO-METEOROLOGICAL PARAMETERS

1. METEOROLOGICAL
   a. Precipitation —— i. rainfall
      ii. snowfall
   b. Evapotranspiration
   c. Relative humidity
   d. Air temperature
   e. Wind speed & direction
   f. Atmospheric pressure
   g. Sunshine duration
   h. Solar radiation

2. HYDROLOGICAL
   a. Discharge
   b. Stage
   c. Runoff
   d. Water level
   e. Aquifer parameters
   f. Soil moisture
   g. Infiltration
   h. Bed load
   i. Suspended sediments
   j. Soil/water conductivity
   k. pH
   l. Dissolved oxygen (DO)
   m. Soil/water temperature
   n. Turbidity
   o. Dissolved solids
   p. Biological & microbiological contents
   q. Chemical contents

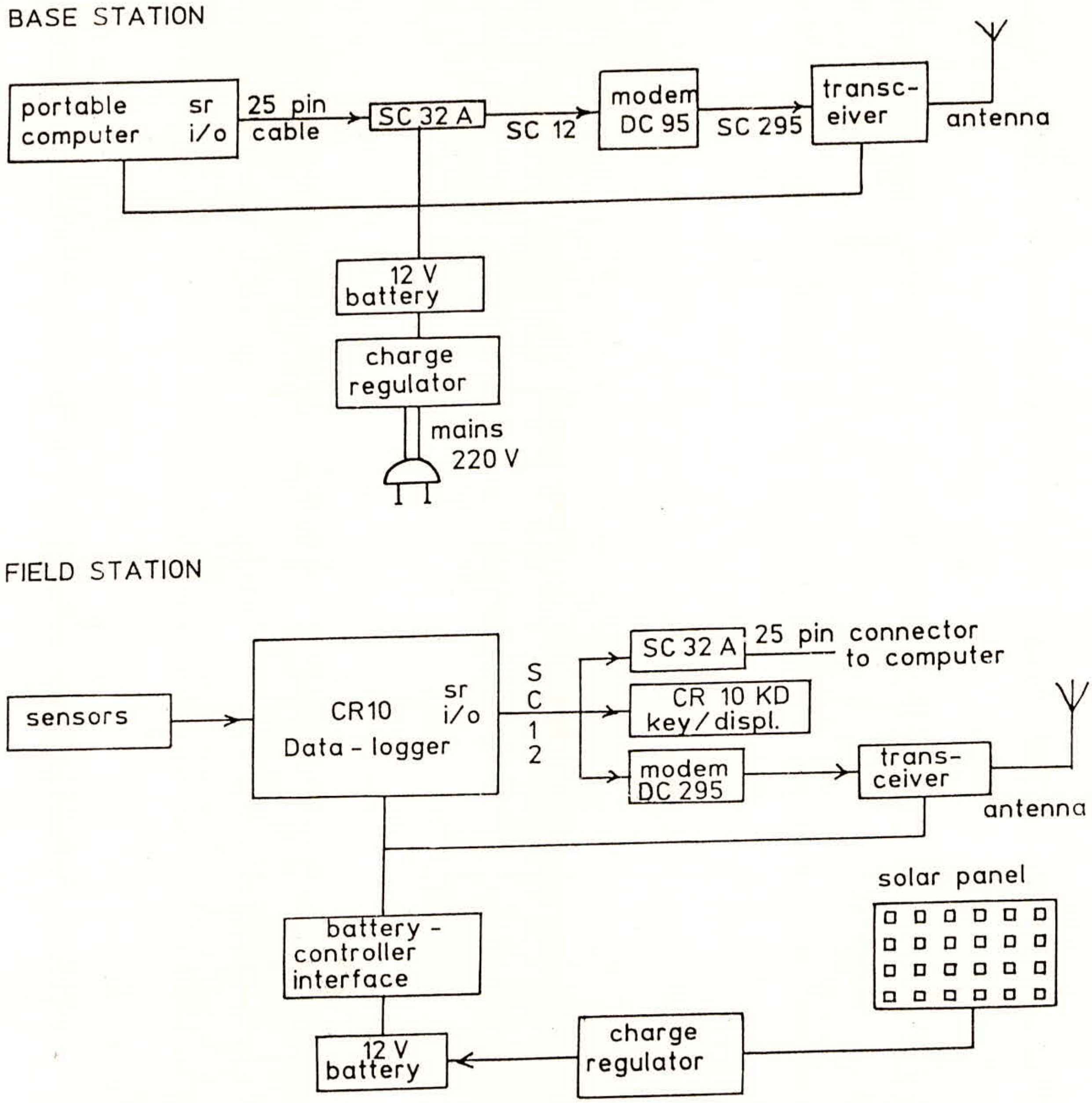

Figure 1. Functional Block-diagram of the CR10-based Data Acquisition System