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DATA COLLECTION AND TRANSMISSION SYSTEM

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ABSTRACT

The report reviews the various systems of data collection and transmission in hydrology and hydrometeorology. Data on precipitation, evaporation temperature, humidity, wind velocity, sunshine hours, water level, discharge measurement, soil moisture etc. is required for use in weather and flood forecasting and efficient water management. Significant technological developments in the fields of tele-communication, computers and satellites are responsible for the automation of hydro-meteorological observation techniques.

Various systems for collection of hydrometeorlogical data can be classified into three basic groups i.e. manual, semi-automatic (man/machine mix) and automatic(computer controlled) observing station. In modern technology, point-to-point wireless communication, manually operated systems are being replaced by modern systems like telemetry through VHF/UHF/micro-wave or satellite.

During recent years, the need for data has extended to inaccessible areas where up to now no information has been available. Insistence on high quality information as well as rapid receipt of data (for real-time analysis) has resulted in drastic changes both in the methods of collection as well as transmission of data. Data collection systems are of basically two types-analog system and digital system. Analog systems encompass a wide hand-width of signal but have lower accuracy. Whereas digital systems are more accurate and are especially useful for multichannel recording systems. A variety of preliminary signal processing can also be performed on digital systems as the data is available in computer-compatible form. Some of the more commonly used hydrometeorological data transmitting systems are direct wire, telephone line, line-of-sight radio telemetry, radio relay, meteor-burst and satellite based system. The type of data transmission link to be used depends on the

distances involved between measuring stations and the receiving centre, and on the nature of the terrain. Depending upon the above requirements, various systems of data transmission have been recommended and their relative merits are outlined.

With the advent of microprocessors and micro-computers, data collection and transmission systems have undergone a remarkable improvement in terms of versatility and flexibility. Microprocessor-based systems are especially suitable for remote-field application which requires low-power, compact and flexible instrumentation. Flexibility is achieved by controlling the operations of the system through software.

1.0 INTRODUCTION

The need for collection of reliable hydrological and meteorological data like precipitation, evaporation, temperature, humidity, wind speed and direction, sunshine hours, water-level and flow measurements, soil moisture etc. need not be overemphasised. These parameters are required for use in weather and flood forecasting and efficient water management.

Various systems of hydrometeorological data-acquisition can be classified into three basic groups i.e.manual operating stations, semi-automatic(man/ machine mix) and automatic (computer-controlled) observing stations. Initially, hydrological observations were made from the individual manual stations only. Later on, when it was felt that the data collection especially from remote observation - points becomes difficult with manual stations, the concept of hydrological network of stations came up. The network may include some automatic and semi-automatic type of observing stations in addition to the usual manual stations, depending upon the need of the system.

Much of the information on the parameters mentioned above can be obtained by manual observation. Also if the quantity of data is small, a small staff can cope up with the time-consuming analysis of the observed data. Many networks depend on manual, in-situ observations by observers. This is a slow and laborious way of collecting data Consequently, there is often inadequate spatial information for those areas where observers are not readily available. Data from such networks are sufficient for simple general hydrological resource studies, but are of only limited value for project planning and operation. In most cases the data collection programme does not meet the requirements for timely preparation and issuing of hydrological forecasts and warnings or for synoptic monitoring.

The primary reason for changing to, or increasing the degree of, automation in a data collection network is the need to improve the quality, quantity and/or timely receipt of the data. This is of utmost importance in real-time hydrological forecasting systems. Also, in order to minimize the necessity for intervention in the measurement, recording and processing of the data, there is a need to develop and standardize on a complete hydrometeorological system, which incorporates all necessary and desirable facilities of an automated system.

The automation of data collection systems may reduce or eliminate most human observational errors. A distinct advantage in such systems is the continuous recording compared to the point measurements obtained by manual observations. One of the most obvious advantages of automation is the ability to obtain data from remote inaccessible locations.

The following three categories of automated hydrological observing stations are defined (WMO, 1973) in the light of the overall functions of systems or stations:

(i) Automatic hydrological observing station at which instruments make and record the observations automatically,

(ii) Telemetering hydrological observing station, at which instruments make, but do not record, the observations automatically, and transmit them automatically to the receiving centre, and

(iii) Telemetering automatic hydrological observing station, at which instruments make and record the observations and transmit them automatically to the receiving centre.

In selecting the type of hydrological observation network proper consideration should also be given to the factors affecting choice of instruments and type of installation for the stations. Besides the relative price of the equipment and its availability, the factors which are important for consideration are climatic conditions, physiographic characteristics, available sources of power, accuracy requirements, proposed life of station, available maintenance facilities, transmission requirements and the eventual treatment (processing) of data.

2.0 REVIEW

During recent years, the demands of users of hydrological data have become more and more sophisticated so that the system where an observer makes manual measurements of rainfall, water-levels etc. and then mails the results to the analyst is becoming more and more obsolete. The need for data has extended to inaccessible areas where up to now no information has been available. In addition, the insistence on higher quality information e.g.for real-time forecasting has resulted in drastic changes both in the methods of measuring as well as the means of transmitting data.

2.1 Data Collecting Systems

Conceptually two types of data collection systems exist,(i) system in which data collection is done manually i.e.some phenomenon is measured by a human being for example, in non-recording type of raingauges, rainfall accumulates in a container and is measured manually with the help of a measuring flask,(ii) system in which data-collection is done automatically. These are further classified as mechanical and electrical type of systems in which the output of the system is in mechanical and electrical form respectively. For example, Syphon-type of raingauges give output in form of mechanically recorded charts whereas Automatic-telemetering type of raingauges give output in form of electrical pulses.

In recent years, data collection agencies have observed the following trends in instrumentation in order to achieve better management in terms of quality and quantity of data:

(a) Replacement of manual observations by automatic systems.

(b) Preference of electrical systems over mechanical systems.

(c) Refinement of existing systems by introducing more electronics with digital outputs and computer technology, and

(d) Use of microprocessor technology for the automated collection and telemetry of hydrologic data.

Any data collection system can be diagramatically represented as follows (figure 1)

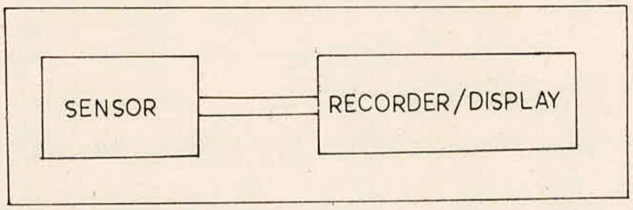


FIGURE 1 DATA COLLECTION SYSTEM

In number of systems the recorder/display device is an integral part of the sensor. However, it is generally possible to decouple them especially if continuous data collection is required. In a conventional computer environment, some phenomenon is measured by a human being. Those data are then manually converted to a machine-readable form (e.g.punched cards, or entered into a disk file). The machine-readable data are then read into the computer through an I/O (input/output) device connected to the I/O control unit. In an advanced system, the human being is eliminated by having the computer electronically detect the phenomenon and convert the reading into an electrical signal. The phenomenon may take several forms (e.g.mechanical, chemical,magnetic, optical) but must be converted to electricity to be compatible with the electronic computer; this conversion is done by a device called transducer.

Transducers may be seperated into two classes: active and passive. An active transducer is one which produces an electrical potential or voltage. A photo or solar cell is an example of an active transducer. A passive transducer produces an electrically measurable change, such as a change in resistance or capacitance. A strain gauge is an example of a passive transducer. Often, a passive transducer is combined with a voltage source to form a single unit, this, in effect, becomes an active transducer.

2.1.1(a) Digital transducer system

Because modern computers are digital computers, the digital transducer is the easier kind to connect, but it is not without some pitfalls, first and foremost, the voltage levels of the digital signals must be compatible. Digital signals have 5 voltage ranges (figure 2): a range where the signal is treated as a logical "0", a range where the signal is treated as a logical "1", a transition range where the signal is meaningless, and two ranges where voltage will do harm to the circuitary. The transducer and the computer must agree on these ranges for proper functioning.

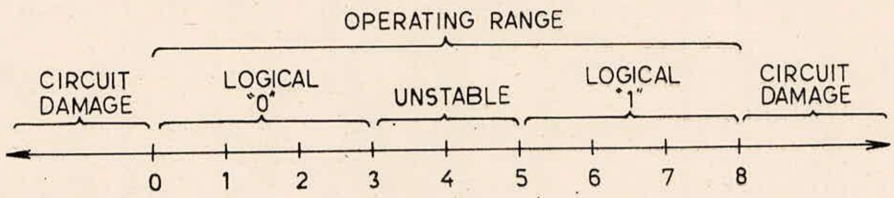


FIGURE - 2 ANATOMY OF DIGITAL SIGNAL

The second problem arises when multiple bits must be handled, which is the usual case. The bits may be transmitted one at a time, in sequence over a single wire. This is known as serial trasmission. Alternately, all bits may be transmitted simultaneously using as many wires as there are bits. This is known as parallel transmission. Here again, the digital transducer must use the same scheme as the computer.

There are two solution possibilities for the above. The first is to use one of the many industry computer interface standards, such as S-100 bus, S-50 bus, Centronix parallel port, Hewlett Packard GPIB, or the RS-232-C serial port. The second possibility lies in interface models which convert between standard interface configurations. These are readily available for most major protocols and are simply inserted into the transmission lines as shown in figure 3.

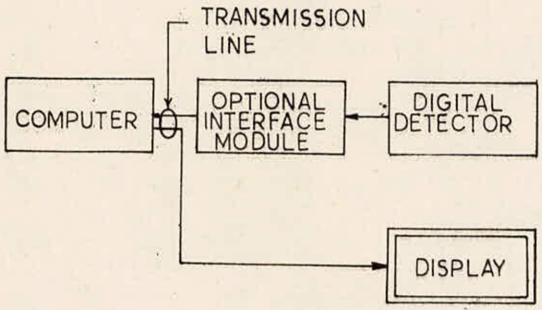


FIGURE 3- DIGITAL TRANSDUCER INPUT

2.1.1(b) Analog transducer system

Before an analog transducer can be connected to a computer, the signal it produces must be converted to a digital signal. This is achieved by using an 'analog to digital converter'(A/D converter), which is also placed in the transmission line as shown in figure. 4.

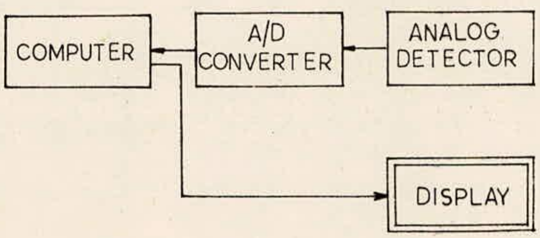


FIGURE 4 - ANALOG TRANSDUCER INPUT

The A/D converters are characterised by four factors-operating range. resolution,speed and stability. The first factor is the oerating range. If the transducer produces too large a voltage or the wrong polarity, it may injure the circuitary of A/D converter. Alternately, if the transducer does not produce enough voltage, it may be too small for the A/D converter to detect. Because there are an infinite number of analog values yet only a finite number of digital values, exact conversion to digital is impossible. The A/D converter transforms the continuous analog signal into a number of voltage ranges as shown in figure 5.

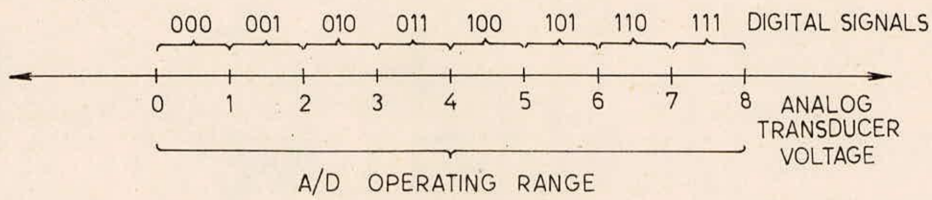


FIGURE 5- OPERATION OF A/D CONVERTER

The resolution is defined as the magnitude of the operating range divided by the number of voltage ranges, the smaller the result, the better the resolution. Because the operating range is set by the transducer, increased resolution is obtained by having more (or smaller) voltage ranges. The number of ranges is almost a power of 2, where the power also indicates the number of bits an A/D converter produces.

The third factor is stability. Because an A/D converter has an analog portion, the device is subject to changes in performance due to heat,electrical interference, power surges, and long-term changes in the electronic components. The changes, though quite small, can produce substantial changes in data values due to the distinct boundaries of the digital voltage ranges.

All electronic circuits require a finite time to operate, particularly analog circuits which contain resistor/capacitor time couplings. The A/D converter must respond to changes faster than sampling rate.

2.1.1(c) Brief review of hydrological, meteorological and related sensors (Panel Report, 1977):

A-Meteorological Sensors:-

(i) Precipitation measurement: For measurement of rain two types of instruments are available - non-recording and recording types. In India mainly two types of non-recording raingauges are used - metal raingauges and fibreglass reinforced plastic (REP) raingauges. Depending upon the period of measurement these may be classified as daily, weekly, monthly or totalizer gauges. In recording raingauges three types of instruments are in general use - weighing type, tilting bucket type and float type. Out of these, weighing type raingauges can be used for measuring all kinds of precipitation. Apart from rainfall intensity recorders there are more sophisticated rain gauges e.g. automatic telemetering type of raingauge in which a battery operated transmitter transmits from memory the total precipitation in coded form at preset intervals automatically and the informaation is received by a receiving station.

Radar permits observation of the location and movement of areas of precipitation and certain types of radar equipment can yield estimates of rainfall rates over areas within the range of the radar. For hydrometeorological purposes the effective radar range is usually 40-200 km depending upon the radar characteristics such as antenna, beam power output and receiver sensitivity. The measurement of the rate and amount of precipitation by radar is usually based upon the fact that a certain statistical relationship exists between the intensity of precipitation and the signal reflected from the rain drops which comprise the precipitation. Radar may be used for measuring precipitation over large areas including regions where the raingauges are sparsely distributed or where localised heavy rainfall occasionally occurs.

In addition, radar can integrate precipitation amounts over time and area by electronic or other means so that its application to hydrological purposes such as flood forecasting and dam control is also of great importance.

Measurement of snow is made either by snow gauges or by the depth of fresh snow deposited on the ground. Snow gauges - recording and non recording types are used to measure the snow - catches. Snow poles, snow pillows and snow samplers are used mainly during expeditions to mountainous regions and glaciers. For systematic measurement of snow cover, alongwith proper account of density variation, nucleonic snow gauging is done using gamma ray absorption tool e.g. a G.M. counter. Aerial surveys are also done to determine water content using principle of natural soil radioactivity

(ii) Evaporation measurement

Measurement of evaporation is done using atmometers (from small sized wet surface) and pan or tank evaporimeters(from water-filled receptacles). Other methods are indirect in nature and do not utilize any independent instrument.

(iii) Evaporatranspiration measurement

The evapotranspiration from soil is usually measured by using lysimeters. Two types of lysimeters are classified on basis of their working principles-gravimetric and volumetric types of lysimeters. Floating type evapotranspirometers are also used for measuring evapotranspiration.

(iv) Measurement of solar radiation

Pyrheliometer measures the intensity of direct solar radiation at normal incidence. Measurement of solar radiation received from the whole hemisphere suitable for the measurement of the total or sky radiation is done by using pyranometers. Pyrgeometer measures net atmospheric radiation on a horizontal upward facing black surface at the ambient air temperature. Net pyrradiometer is an instrument for measuring the net flux of downward and upward total (solar terrestrial surface and atmospheric) radiation i.e. net flux of all radiations. Other instruments for solar radiation measurements are-Bellani spherical pyranometer, bimetallic pyrenographs and photocell illuminometers.

(v) Measurement of relative humidity

Though there are many methods, direct and indirect, for measuring air humidity the methods which are in general use for meteorological work fall into the following classes:

(a) thermodynamic method utilizing Psychrometers,

(b) method using change in dimensions of hydroscopic substances(hair hygrometers) and

(c) electrical methods-using-dew point recorder with a dewcel sensor, relative humidity recorder with a polymer thin film capacitor sensor and lithium chloride hygristor or carbon hygristor for upper air measurements.

Recently airborne hygrometers have been developed for humidity measurements.

(vi) Measurement of soil moisture

The available instruments and methods for determining soil moisture are classified into two fundamental groups. The first group comprises methods based on the determination of moisture in samples of soil withdrawn from the soil layer. The second group includes methods that take the measurement in-situ, with the aid of an instrument permanently or temperarily set within the given horizon of the soil. The recent development of equipment has been directed primarily towards instruments that continuously measure changes in moisture content at a single sampling point.

Gravimetric methods, the only direct method of measuring soil moisture, involves collection of soil samples and weighing the sample before and after drying. The loss of weight equals moisture content of the sample. Hand augers, soil-sampling tube, core barrel or drive sampler and piston sampler are the simpler instruments for soil-moisture sampling. Tensiometers work on the principle of measurement of tension developed because of movement of water in the soil. Inspite of some limitations in the use of tensiometers, these are useful instruments for soil-moisture measurements. An indirect method for measurement of soil moisture involves the measurement of change in electrical resistance with change in moisture content of the soil. The resistance is measured with an a.c.bridge (usually 1000 Hz). Soil density determinations, for correlation to the moisture content in unsaturated zones, are done using three different types of soil density probes:

(a) Single Hole Gamma Absorption Probe(SHGAP)

(b) Double Hole Gamma Absorption Probe(DHGAP)

(c) Single Hole Gamma Scatterning Probe(SHGSP)

Neutron soil moisture gauges utilizing a fast neutron source like Am-Be and a slow neutron detector like BF3 proportional counter are used for measuring soil moisture content in the unsaturated zone.

B - Hydrological (Surface water) Sensors :—

(i) Measurement of water-stage

Conventional instrument for measurement of stage of river is a stream-gauge. For continuous measurements, automatic water level recorders are used for transmitting the water level readings to a remote station by electrical devices or by pneumatic pressure. Various hydrological organisations use non-recording in-situ indicating type gauges or in-situ recording type gauges or remote recording type gauges depending upon the site requirement and the frequency of data required. Non-recording in-situ indicating type instruments include vertical and inclined staff Gauges, weight type chain gauges, Float gauges and Electrical Gauges. Diaphram type Pneumatic Gauges, Electric Long Distance Gauges, step by step transmission system and Induction Type Gauges are grouped as non recording remote indicating type gauges. In-situ type recording gauges include float type water-level recorders.

(ii) Measurement of velocity

Propeller type and cup type rotating currentmeters are widely used for measurement of velocity. A new method using currentmeter has been developed by U.S.Geological Survey for gauging large rivers and is called Moving Boat method, where the currentmeter fitted with direction sensing vane is fixed to the motor boat for measurement of velocity and vane angle. In this method the data are collected at each observation point while the observer is aboard a boat i.e.rapidly traversing the cross-section. The acoustic measurement of velocity of flow uses the following three techniques.

(a) transit time measurement

(b) correlation techniques and

(c) doppler effects

Electromagnetic type of currentmeters are also being increasingly used for velocity measurements. In cases where stream-velocities are too high or if the stream is carrying heavy drifts, branches of trees and other wash materials, currentmeters can not be used and then surface floats and optical currentmeters are employed. One of the instrument utilizing nuclear methods is Deep Water Isotope Current Analyser(DWICA) which is used to locate currents caused by seepages in reservoirs and canals.

(iii) Instruments for depth measurement

For depth measurements Wading Rod, Sounding Rod, Log Line, Real Line and Cranes, Rack and Pinion arrangement and Echo-sounder are used all over the world. The choice of the instrument depends upon the depth and velocity to be negotiated. Apart from these conventional type of instruments, better equipment include Mounting Brackets, Mobili Winch,Brackets, Torpedo Counter Weight, Hydrologist Winch, Winch cranes, Double Drum Winch, Light Weight cranes, with rotating jib, cable way Installation etc. Echo sounders are normally used for depth measurement in oceanographic surveys.

(iv) Instruments for measurement of sediment load

Measurement of transported sediment may be classified as suspended and bed load measurement. The suspended sediment load samplers may be grouped as Vertical Pipe type, Bottle type, Instantaneous Horizontal type, Depth/Point/Time Integrating type samplers. Recent developments include pumping samplers for automatic operation and apparatus for continuous monitoring of suspended sediment concentrations based on photo-electric turbidity and radio-isotope measurements.

C - Hydrological (Ground Water) Sensors

(i) Measurement of ground water level

Direct measurement of ground water levels in observation wells can be undertaken either by manually operated or by automatic recording instruments. The most common method of manual measurements is by suspending a weighted line (a steel tape etc.) from a defined point at the surface known as measuring point. Pneumatic gauges are also used for measuring water levels, electrical contact methods involve the lowering of one or more electrodes to water level, contact with the water closes the circuit and is indicated by warning light, audible buzzer or meter. The water level can also be measured by some principle using electrochemical effect of two dissimilar metals immersed in water and by detecting the current flow so generated by in the microammeter. A float linked to a counter weight by a cable over a pulley can indicate the level change in a well by indicating the rise or fall of the counter weight, measured with respect to a fixed mark on the cable. A less common acoustic method of indicating water level employs a hollow cylinder at the end of a tape which when allowed to fall gives a whistling or plopping sound on touching the water level.

(ii) Geophysical instruments for ground water exploration and exploitation

Geophysical instruments used in ground water expolration and exploitation are quite varied. They may be classified into three categories:

(a) Instruments for aerial survey,

(b) Instruments for ground surveys,

(c) Instruments for portable logging.

Sensors used in aerial surveys include various remote sensing instruments for photography in the infrared, visible and ultraviolet bands, imagery in the above and microwave band and measurement of some physical parameters of the ground like temperature, electrical conductivity, radio activity, intensity of magnetic field, reflectance of EM waves and so on. Ground water prospecting by geophysical methods is mainly done by the resistivity method, the seismic method and the magnetic method. Other methods like the electromagnetic, the induced polarization method and the gravity method are less commonly used. D.C.resistivity meter, A.C.resistivity meter and Meggar are the instruments used for resistivity measurements. Hammer seismograph, 6 or 12 channel Engineering Seismograph and Multichannel Signal Enhancement Seismographs are being used for refraction and reflection seismic surveys. Recently seismographs with signal processing and printing/display facilities have been developed. In the magnetic method, flux gate Magnetometer, Torsion Magnetometer are used for detecting faults, dykes, silts etc. Recently microprocessor-based automatic data storage and signal processing magnetometers have been developed relieving the task of repetitive manual data handling. Borehole logging instruments are mainly classified under two groups-nuclear and radioactive logging. Borehole logging unit comprises of various logs including Natural Gamma, Gamma-Gamma, Neutron-Neutron, Neutron Activation and Pulsed Neutron type.

(iii) Measurement of wells discharge

There are mainly 3 types of instruments that are used for discharge measurement.

(a) Orifice plate type

(b) Relating vane type

(c) Borewell flowmeter sonde.

(iv) Instruments for water analysis

Calorimeter or Spectrophotometer, pH meter, Centrifugal Spectrophotometer Atomic Absorption Spectrophotometer, Flame Photometer, Conductivity Meter, Turbidity Meter, Thermometer and various types of Analyzers are used for water analysis purposes.

2.1.2 Microprocessor based hydrologic data collection

During last ten-fifteen years few completely new instruments were invented, but the applicability of existing ones has been improved considerably by refining their design and introducing more electronics with digital outputs and computer technology. The advancement in technology has been significant in improving the designs of velocity/current measuring instruments, transducers, remote sensing instruments, digital recorders and data transmission by telemetry techniques.

Recently hydrologic data collection agencies have begun to use microprocessor technology for the automated collection and telemetry of hydrologic and hydrometeorological data. Flexibility, reliability, compactness, faster design time, reduced cost, compact size and easier maintenance and documentation are the advantages of using a microprocessor relative to hardwired electronic circuits. Computation ability of micro computer in an instrument may be used to generate output in scientific units even though the sensor may be non linear or may not respond to the desired variable e.g., deriving dew point from a carbon hygristor output. The computer can also average data, make statistical calculations, and solve data discontinuities such as a wind may produce. Protable Automated Mesonet (PAM) system, (Pike and Brock, 1975), a meteorological system to study sea breezes, hail storms, squall lines, and regional air pollution comprised of a trailer-mounted base station and a network of remote stations for logging data from an area upto 160 km. in diameter. Each remote station samples local sensors synchronously and transmits the data to the base station via a radio link. The PAM base station has a microcomputer for the automation of data logging, for real time data quality assurance, and for real-time data analysis and display. The remote-station (figure 6) senses parameters like temperature, humidity, wind speed and direction, rain and pressure. Event-type inputs include signals from tipping-bucket raingauges, light chopper anemometers, and frequency-type sensors. The programmable microprocessor controls data flow in the remote station. It samples the sensors at regular intervals and performs local averaging or other special functions which may be required. Also, it formats the data messages and sends them to the base station on command. Each message has parity bits and a check character for validity checks. The microprocessor has an input/output(I/O) bus structure that facilitates simple interfacing of a wide variety of I/O devices. The function of the remote station can be changed by adding peripheral equipment and by changing the operating program. A microprocessor controlled precipitation data collection system (Burgess and Hanson, 1983) can be effectively used for determining precipitation amount, intensity and distribution for various hydrologic and climatologicoal analysis. Automatic water level recorders have been in use for last few years. Flexibility in formatting the data, expanding data logging section for additional sensors and unattended operation for periods extending one year are some of the important features found in these water level recorders.

Institute of Hydrology, Wallingford, UK has been engaged in development of data loggers, hydro-meteorological sensors and flood forecasting systems, etc. Annual Report 1979-81 describes solid state data loggers developed for use with rainfall recorder, tensiometer and lysimeter. A microprocessor controlled flood forecasting system described in the report comprises of one raingauge and one river level outstation linked by radio telemetry to base station where received data are input to a microprocessor which provides system control and, via an appropriate hydrological model, a warning of flood conditions. The

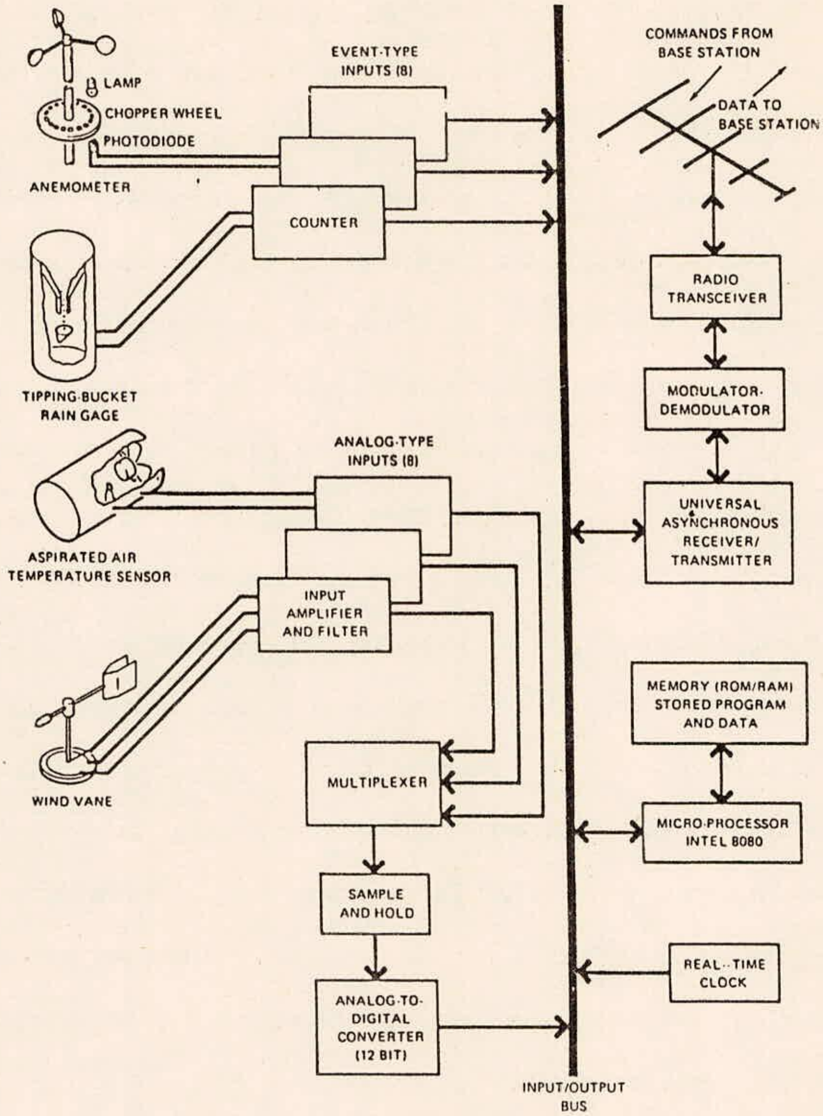


FIGURE - 6 COMPONENTS OF PAM SYSTEM

base station displays real time, rainfall and river level data and in the event of a flood warning situation gives the river height and time for the start, peak and close of the hydrograph.

The programmes of ground-water monitoring require instrumentation for collecting ground water level data continuously and unattended for long periods, as well as for specialized needs such as aquifer tests where observations are needed at very short time (for seconds) intervals. The United States Geological Survey (USGS) is developing (Latkovich et al, 1984) a Ground Water Monitoring System (GWMS), comprising of complementary instruments arranged to fit the ground water data collection needs. The GWMS consists of a shaft-encoder and pressure transducer for monitoring water levels, a data recorder, and a data retriever. The system recorder incorporates programmable microprocessor features with solid-state memory and is capable of operating with an optical incremental shaft encoder or pressure transducer. The recorder can be used to (i) monitor water levels on a long term basis (observation or network wells) or (ii) monitor water levels on very short term basis for aquifer test monitoring.

In recent years, hydrologic data collection agencies have begun to use microprocessors technology for the automated collection and telemetry of hydrological data. The U.S.Geological Survey (USGS) designs and operates the national network for acquiring data on the quality and quantity of surface and ground waters in the United States. The survey is developing (Paulson, 1984) a new generation of microprocessor-based field data collection instrumentation to meet the needs of the network. Information obtained through this network meets the needs of over 800 Federal, State and local cooperating agencies, and the nation as a whole. The National Weather Service of U.S. is also participating in this development programme and will use the system to meet meteorological data collection needs. The primary goal of the proposed data aquisition system, known as the Adaptable Hydrologic Data Acquisition System (AHDAS), is to develop a unified automated hydrometeorological data acquisition system concept that will last 20 years. The AHDAS system concept is modular and permits, through addition of new interfaces and peripheral devices, continued future development as required (figure 7). The concept includes two principal components. The field component (FC), is a battery operated microcomputer that, through a set of interface modules, will allow it to receive data from a wide variety of hydrologic and meteorological measurement systems. Through additional interfaces its memory can be expanded and it can communicate data to existing telephone or satellite communication systems. The portable field interrogator is used for central data storage and processing facilities.

2.2 Data Transmission Systems

The direct wired connection between the sensors and the recorders/ display systems is the easiest method. However, if the distances involved between the two basic components of the data acquisition system i.e. the sensors and the display devices are large, then the interfacing becomes complicated. Like data collection systems, data transmission can be achieved in two basic modes (i) analog data transmission and (ii) digital data transmission. While digital transmissions are relatively immune to noise, analog transmissions are extremely sensitive to noise. Further, the increasing resistance of long transmission lines attenuates all signals and the use of amplifiers adds distortion to analog voltages. Therefore analog signals should be converted to digital as soon as possible.

Some of the more commonly used hydrological data (WMO,1981) transmitting systems are described in the following paragraphs.

2.2.1 Direct Wire

This system involves a hard-wire connection or dedicated telephone line between the sensor and the recording device. Instantaneous, continuous or intermittent values can be displayed or recorded on the recording device. The system may

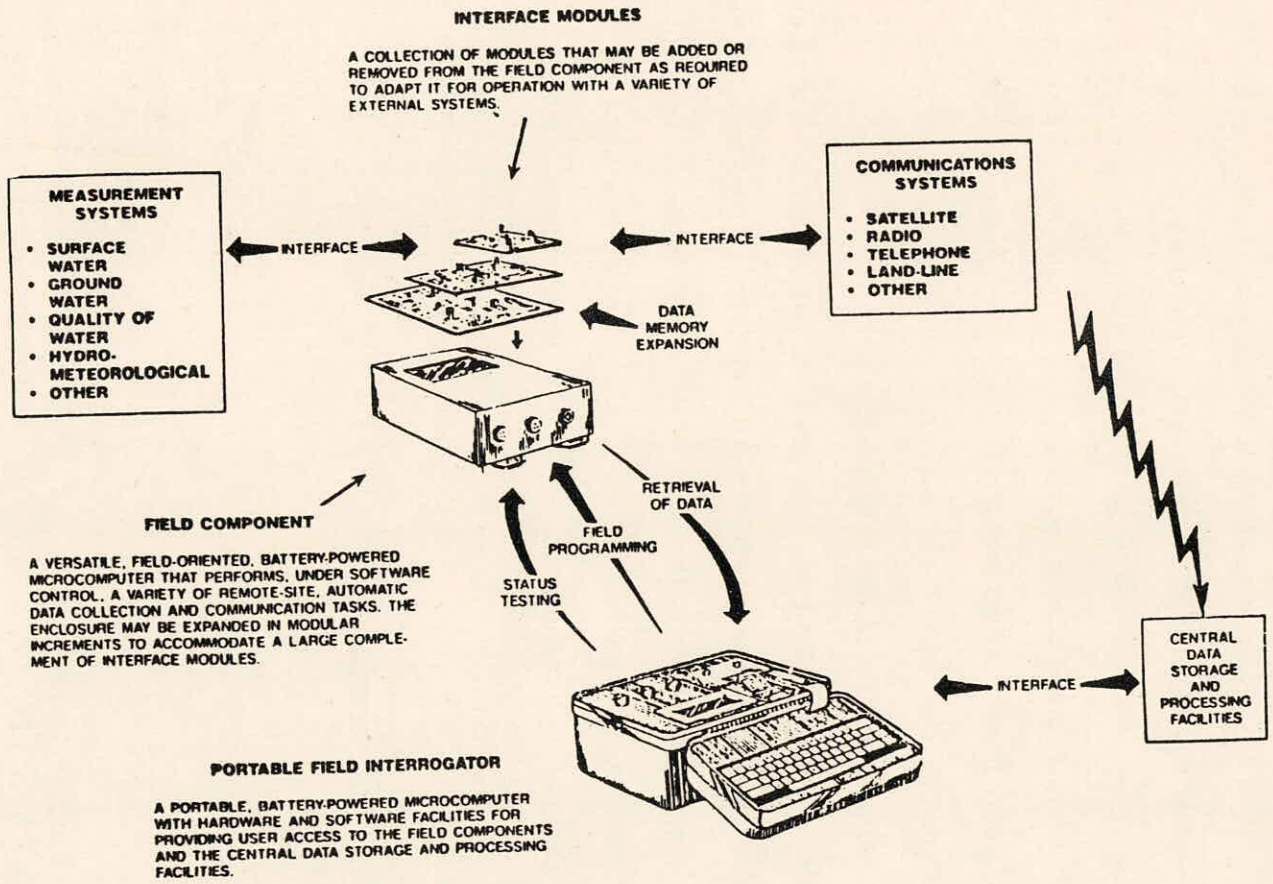


FIGURE 7 - COMPONENTS OF AHDAS

accomodate more than one parameter at each site and can relay the data to another location.

Low voltage direct wire systems are used to relay water level recorder information from the gauging station to a convenient nearby location for ready access by the observer. These systems show good reliability.

These systems are not costly and are relatively easy to maintain. They are useful in remote areas if the observer has a transceiver, whereby he can be in direct contact with a collection centre, relay point or forecast centre. For larger distances involved, these systems have limited application and are particularly useful in short-distance transmissions.

In cases where digital signal comprising of number of bits is to be transmitted parallel transmission is effectively done for medium-distances, using multiplexers and demultiplexers. In this scheme, several signals can be combined and transmitted along the same wire. At the receiving end, they are separated and handled like conventional signals. A typical arrangement is shown in figure 8.

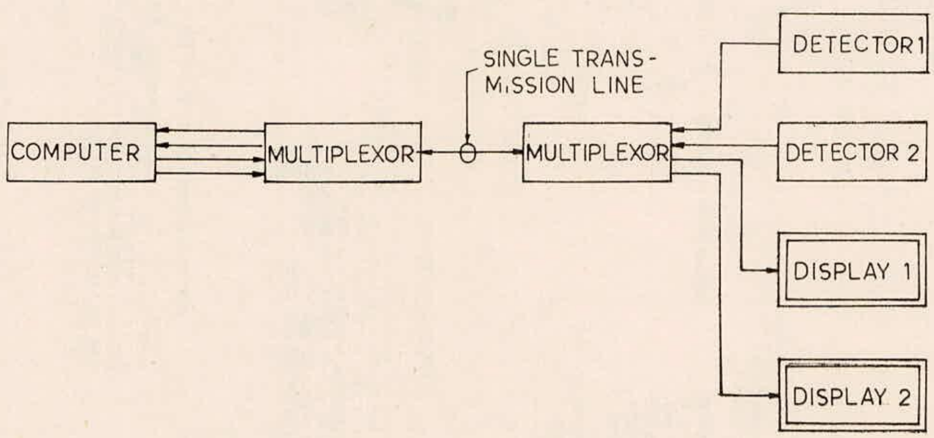


FIGURE 8- PARALLEL TRANSMISSION SYSTEM USING MULTIPLEXER

2.2.2 Telephone Line:

This system utilizes commercially available telephone circuits (Figure 9). Either a manual, automatic dial or computer-controlled dial system can initiate the interrogation. Whenever interrogated the observational site responds and transmits current observational data and any data held in memory if the station is so equipped.

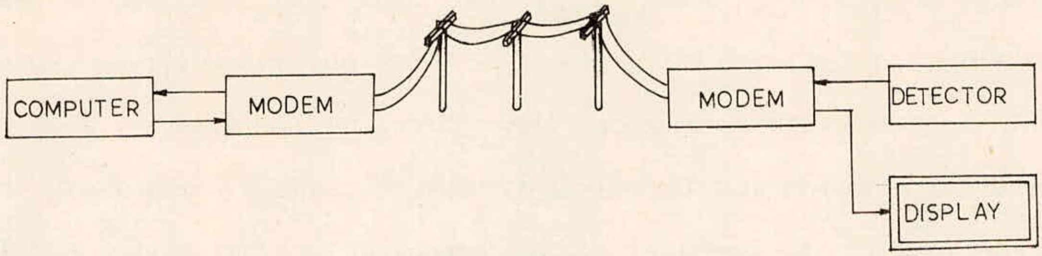


FIGURE 9 - TRANSMISSION USING TELEPHONE LINE

Data transmitted, depending on the sensor type, may be tones or other audible sounds. The sounds may be slow, slow enough to count and manually record or they may be rapid, requiring special equipment to record and either display or print out the information.

With the availability of relatively inexpensive mini-computer systems, the use of available telephone lines provide a rapid means of automating data collection directly at the observing site. This presupposes the availability of telephone lines at or near the observation point and a certain degree of reliability of the telephone system, particularly in periods of storms and floods.

This system involves a minimum of investment in communications equipment. The major components are a mini-computer or specially configured tele-typewriter at the collection centre or forecast centre and a communications interface at the sensor sites.

2.2.3. Line-of-sight radio telemetry:

This system depends on Very High Frequency (VHF) line of sight transmission (usually less then 50 km.) and does not therefore require relay stations. Greater distances can be achieved if the remote stations are elevated such as on a mountain side.

The network of remote stations can be designed to initiate a transmission whenever an event occurs. The receiving stations can be equipped to process the data or relay them to a central processor. More than one collection centre may be employed for larger basins and, in addition, this system can be extended for use with satellites. Data could be relayed from the collaboration centre to a satellite for further relay. Line-of-sight radio systems are less costly than radio-relay primarily because they are not dependent on relay towers but offer benefits as well as limitations . The benefits are that the system is not compromised by the possible failure of a relay tower facility through which all or parts of the data flow. One limitation is that transmissions are usually restricted to line-of-sight distances, generally less than 50 km on level terrain. This system has particular value and application in relatively small basins where data may be collected from within the basin at a collection centre.

A short range digital telemetry system, for line-of-sight radio telemetry, based on microprocessor is described (Sinvhal and Goyal 1985) in figure 10.

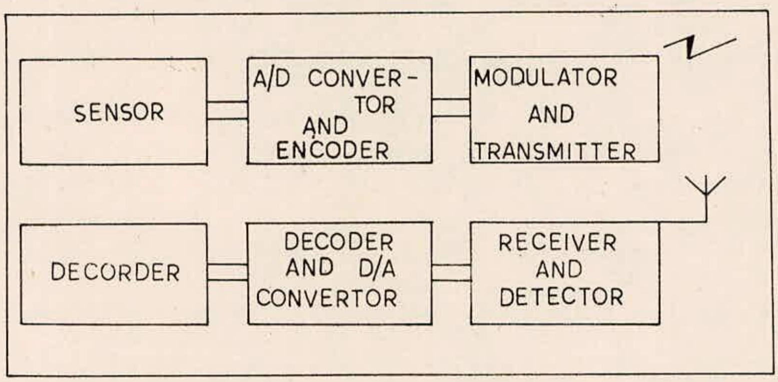


FIGURE - 10 BLOCKS OF A SHORT RANGE DIGITAL TELEMETRY SYSTEM

The system has two units-the transmitter and the receiver. The transmitter performs sampling, encoding and transmission of the signal from the sensor. This signal is received, decoded and registered by the receiver located at a distance.

The analog signal from the sensor is fed to an analog-to-digital convertor which converts the signal into a digital signal. The serial data in the form of pulse-code-modulated signal is fed to the modulator and power-amplifier for propagation into space through a transmitting antenna. The signal arriving at the receiving antenna is composed of pulsed radio-frequency signal and is processed through demodulator/detector comprising of intermediate frequency transformer, a local oscillator, a mixer and an envelope detector, after converting serial data into parallel form, it is fed to the recorder for ultimate recording.

2.2.4 Radio Relay:

This system features radio equipment that includes the use of High Frequency (HF) , Very High Frequencies(VHF) , Ultra High Frequencies (UHF) , and Super High Frequencies (SHF).

Super-high frequencies are generally used where multiplexed channels are required for data transmission such as from an Earth command station to a satellite. Ultra-high frequencies are used between Earth-orbiting satellites and data-collection platforms as well as between relay stations.

In such systems the computer initiates an identifying signal which is transmitted from the data control unit over a multichannel microwave link to a relay station. The signal is then carried over a VHF link from the relay station to other relay stations, to repeater stations and finally to remote reporting stations. The remote station responds to the proper identifying signal and transmits observational data to its assigned repeater station. The repeater station relays the data to the relay station and then to central control.

Radio relay provides a range of systems to meet particular needs of users. This capability requires an extensive maintenance programme of electronic technicians where UHF and SHF are employed such as with computer-controlled interrogation systems. Both HF and VHF are used in the basic collection of data and are the least expensive radio systems.

2.2.5 Satellite

Two types of satellite are employed for data collection: polar - orbiting and geostationary. A polar-orbiting satellite circles the earth once about every 90 minutes and is therefore available for use as a relay station only while passing overhead within view of the Earth platform. A geo-stationary satellite is in a fixed location in space relative to the earth above equator and as it always views the same area of the earth is therefore available for continuous data relay. Length of Antenna and power requirements in case of polar-orbiting satellite are smaller as compared to the geostationary satellite, because of difference in their altitudes.

Two basic types of data collection platform radio sets are most commonly used with the geostationary satellite: interrogated and timed. With the interrogated type a call-up demand can be initiated. With the timed platform, reporting intervals are preselected and remain fixed at the site until changed. All data collection platforms(DCP) communicate with the satellite in the UHF BAND. Data are received directly at the central readout facility and may be relayed over other communication facilities to various users.

A timed-platform type satellite system is outlined (Sinvhal and Goyal,(1985) in figure 11.

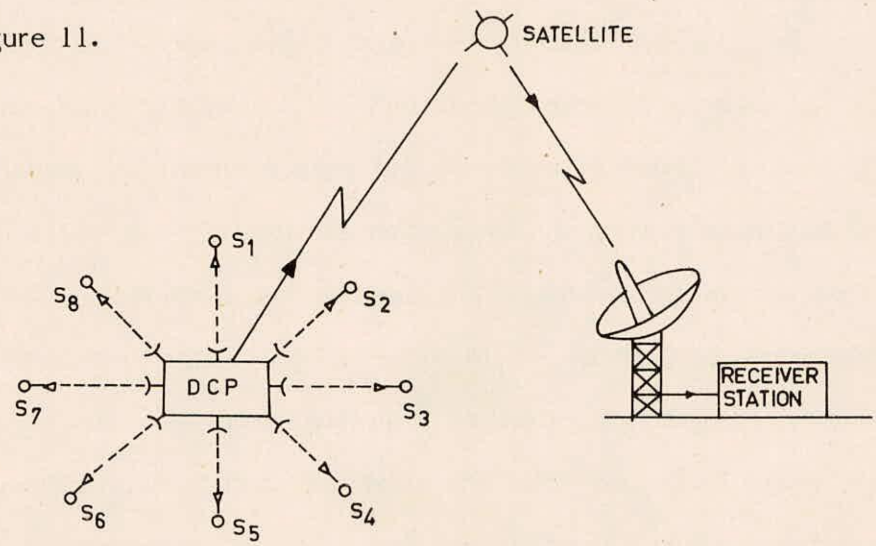


FIGURE 11 - SATELLITE-BASED TRANSMISSION SYSTEM

In this satellite based system data from a number of stations is collected at a Data Collection Platform(DCP) which stores the data. The DCP transmits the data to a geostationary satellite at preset times. A number of stations can be linked to a central recording station via a satellite.

2.2.6 Meteor-burst

Meteor-scatter, more commonly, meteor-burst communications relay on the ionization in meteor trails to re-radiate or reflect radio waves in the low VHF frequency range for distances upto 2,000 km.

The meteor trail characteristics dictate the techniques for utilization of the medium as a communications path. As these meteor trails only exist for a few seconds, a burst(very short) transmission mode must be used. Also, the availability of ionized meteor trails varied with the time of day and the month of the year, requiring proper selection of operating frequencies.

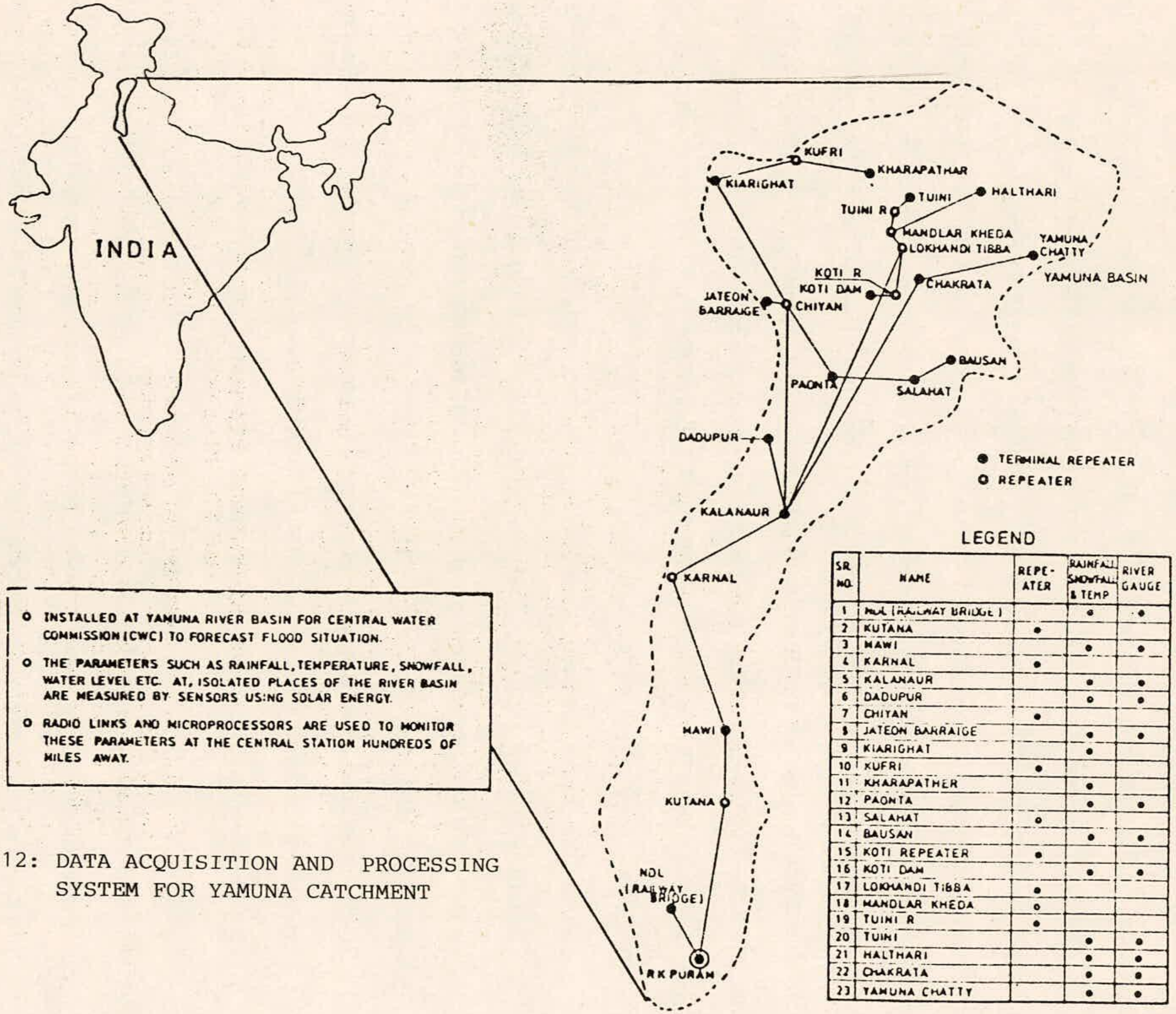
The meteor-burst transmission system consists of two master polling stations plus the remote stations where the hydrological observing sites are located. The master stations can be linked to a central computer over dedicated telephone circuits, if required. The system can operate unattended and interrogating can be computer-controlled. Remote stations can be powered by batteries charged by solar panels.

The meteor-burst telemetry technique allows coverage of vast areas because of long-range paths involved. The use of meteor-trails for signal reflection creates an unlimited number of potential paths for transmission, which minimizes blockage problems due to terrain obstacles. Also, the technique offers greater flexibility in terms of number of stations and the interrogation facility with the various remote stations.

2.3 Recent Developments in India

In recent years, flood forecasting and flood control systems have been given the high priority amongst the various hydrological and meteorological studies in India. A telemetry system has been installed and commissioned (Singh and Muazzam, 1984) in river Yamuna catchment by M/s Gujarat Communications and Electronics Limited, Baroda under UNDP scheme for the Central Water Commission, India. The system called Data Acquisition and Processing system (figure 12) involves slave data collection and repeater stations located at unmanned or manned, remote sites in the Yamuna catchment for collection, a master tele-processor system at a central station at New Delhi for collecting data from slave stations and a computer at the same place for processing the data for the forecast.

The radio-links comprise several routes accomplished using single channel Duplex, VHF Transceivers. Each remote site is equipped with sensors,transducer and a slave-teleprocessor equipment. A master control equipment located at a convenient point in the system interrogates sequentially each of the unmanned remote stations and acquires data such as Temperature, Atmospheric pressure, Rainfall, River Water level, Battery voltage and other equipment health parameters. As the rate of change of weather and flood parameters is low the system requirement specifies interrogation once in an hour. As such to conserve the precious electrical energy in the solar cell charged batteries in the remote stations, all radio transmitters are held in power-off mode. A sequential hold and transfer logic employed in slave tele-processor enables switching -on time of each of the transmitters to be brought to a minimum. The Master Teleprocessor displays data collected from each of the remote stations on a CRT display as per the preplanned format and also provides necessary interface for feeding the data to a high level Hewlett Packard (HP) computer as also other peripheral units such as printers, magnetic tape/diskette etc. The HP computer is deployed for flood forecasting as per the river model already developed. The system establishes a new opening in the automatic recording and transmission of flood



SR. NO.	NAME	REPE-ATER	RAINFALL SNOWFALL & TEMP	RIVER GAUGE
1	NDL (RAILWAY BRIDGE)		•	•
2	KUTANA	•		
3	MAWI		•	•
4	KARNAL	•		
5	KALANAUR		•	•
6	DADUPUR		o	•
7	CHIYAN	•		
8	JATEON BARRAIGE		•	•
9	KIARIGHAT		•	
10	KUFRI	•		
11	KHARAPATHER		•	
12	PAONTA		•	•
13	SALAHAT	o		
14	BAUSAN		•	•
15	KOTI REPEATER	•		
16	KOTI DAM		•	•
17	LOKHANDI TIBBA	•		
18	MANDLAR KHEDA	o		
19	TUINI R	•		
20	TUINI		•	•
21	HALTHARI		•	•
22	CHAKRATA		•	•
23	YAMUNA CHATTY		•	•

FIGURE 12: DATA ACQUISITION AND PROCESSING SYSTEM FOR YAMUNA CATCHMENT

data without involving man either for observation or for transmission. This eliminates human errors and reduce the time of observation and transmission of data. The next phase of the modification/development of telemetry systems for flood forecasting involves the use of satellite.

We are aware that the real time hydrological forecasting depends, to a large extent, on the availability of hydrological/meteorological data at the forecasting station. A sophisticated hydrological model and fast computer system serve their useful purpose if the data acquisition system is reliable and fast. After implementing the pilot project based on line-of-sight telemetry, as described above, a pilot scheme has been proposed, and currently being implemented, for Yamuna catchment using the facilities of INSAT-1B(Ghanekar et al.,1984); Datar et al.,1983). The application of INSAT-1 system for hydro-meteorological data provides for the following studies:

(i) round the clock,regular, half-hourly synoptic images of weather systems including severe weather,cyclones, sea-surface and cloud-top temperatures, water bodies, snow etc. over the entire territory of India as well as adjoining land and sea area,

(ii) Collection and transmission of meteorological, hydrological and oceanographic data from unattended remote platforms,

(iii) timely warning of impending disasters from cyclones, floods, storms etc, and

(iv)dissemination of meteorological information including information including processed images of weather systems to the forecasting offices.

The satellite system developed by the India Meteorological Department (IMD) (figure 13) consists of (a) Data Collection Platform (DCP) transponder on board INSAT-1B,(b) DCPs at remote ground stations, and (c) Ground reception and data processing facilities. The major components of the DCP system on ground are sensors-rainfall, temperature, wind pressure etc.; Data Conversion

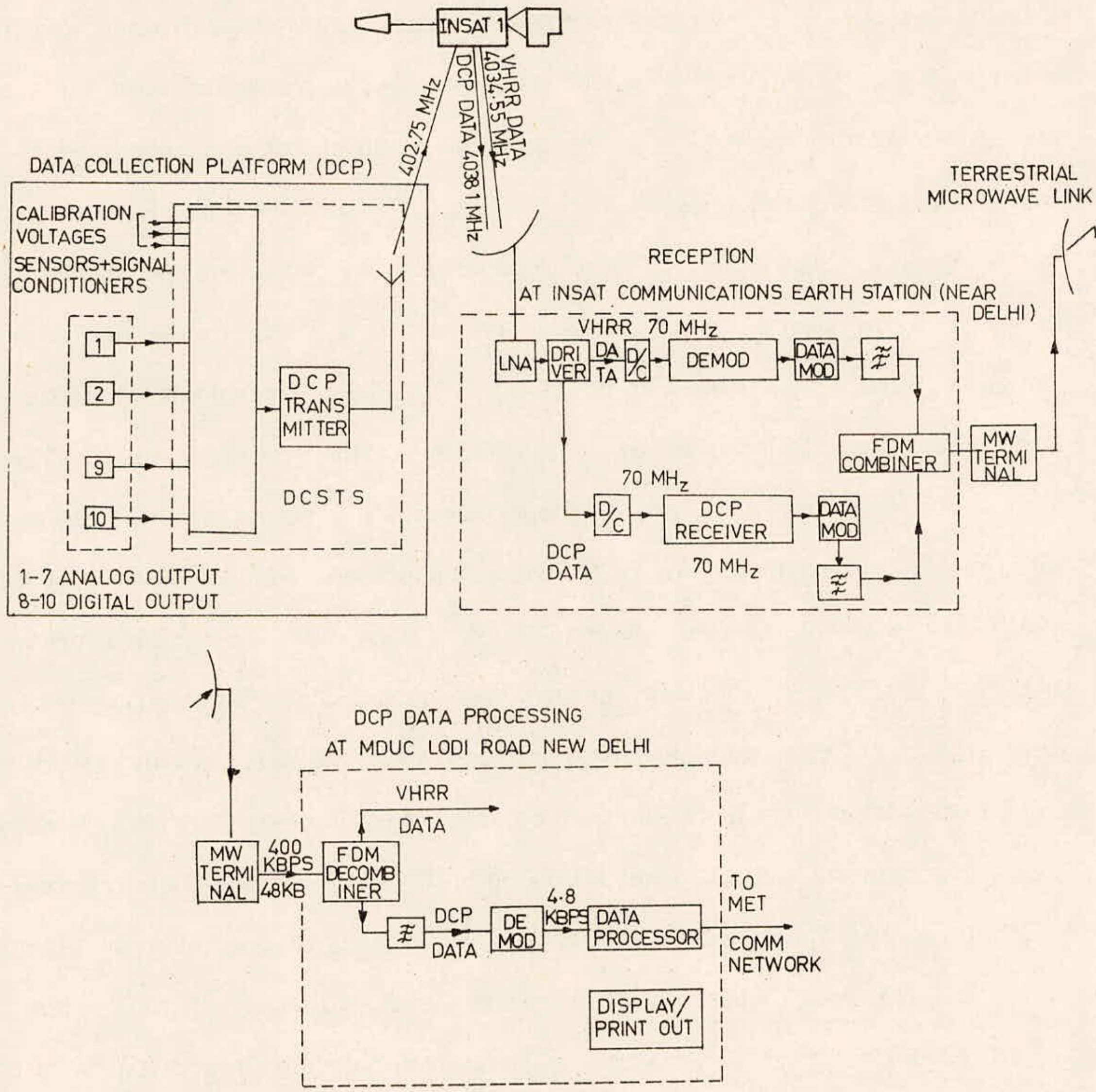


FIG.13-INSAT-1 DATA COLLECTION SYSTEM

Storage and Transmission Sub systems (DCSTS) and Installation and other hardware at site. Each DCP is designed to handle 10 sensors. Three of them have digital output while 7 have analog output. In practice each DCP automatically records information once every hour and stores in Data Conversion Storage and Transmission Sub-systems(DCSTS). Each group of DCPs transmits data to satellite during ten minute interval allotted to each group. Data is transmitted to satellite on an uplink frequency of 402.75 MHz. DCP data is then received at Delhi Earth Station (Sikandrabad Distt. Bulandshahr 60 km.from Delhi). The data is then suitably formatted and transmitted over P & T microwave link to Meteorological Data Utilization Centre (MDUC) at India Meteologicoal Department Lodi Road, New Delhi. Out of a 100 DCPs IMD has provided 10 DCPs for data required in connection with Flood Forecasting purposes. INSAT-1 provides for data collection from 400 DCPs using the present channel, and an additional 400 DCPs with the second channel. Such a vast data communication facility available in INSAT-1 can also be utilised by the flood forecasting set up of Central Water Commission which is charged with the responsibility of Hydrological Forecast and its dissemination on important Inter-State rivers. For hydrological forecasting purpose the following data is required hourly on real-time basis during the flood season and at larger intervals of one daily on other days during the year -(i) Stage or river water level, (ii) Discharge or river flow rate,(iii) Rainfall, (iv) Temperature,(v) Snow accumulation. In addition information on weather including imagery of water bodies and rainfall forecast is required from Flood Meteorological Offices of I.M. D.

A HP-1000F computer system has already become operational at Central Water Commission. Models for hydrological forecast have been developed for application on river Yamuna. Similar models applicable to other river systems in India will also be gradually developed. As a computer system with all the facilities is neither possible at over 150 forecasting sites in the country nor it is possible to provide the same even at the Division level of the flood forecasting set up,it is proposed to develop Hydrological Observations & Flood Forecasting Offices (HOFFO) into Hydrological Secondary Data Utilisation Centre (HSDUC). These will be linked with the HDUC at Delhi from where the proposed data will be sent to HSDUC.

3.0 REMARKS

Most hydrological observation network and collection systems have developed in response to particular localized problems or scientific interests without taking into account future requirements. For various reasons the quality, quantity and timely availability of hydrological data has been inadequate for present development needs in general, and in particular, for the timely preparation and issuing of hydrological forecasts and warnings. However, recent advancement in the fields of microprocessor technology and telecommunications are being increasingly utilized in hydrometeorological data acquisition systems. Adaptation of new technology is considered to have large potential in improving the existing situation. In recent years, number of new, versatile data logging systems have been developed for applications in hydrology and meteorology. Many private and government organisations and institutions are actively engaged in developing data-loggers using state-of-art technology.

In modern technology, point-to-point wireless communication manually operated system is being replaced by modern systems like telemetry through UHF/UHF/Microwave or Satellite. Hydrological observing systems, manual or automatic, can be linked to a data-collecting and disseminating centre through transmission methods ranging forom direct wire to radio relays, satellites and meteor-burst.

A variety of telemetry systems are available at present based on land lines, line of sight radio or a mixture of both. Direct communication via cables called land line telemetry, generally employ either current, voltage, frequency position or impulses to convey information. Radio frequency telemetry employ either amplitude, frequency or phase modulation. In case of telemetry through radios, line-of-sight communication is used such as VHF, UHF and microwave etc. This system employ number of repeater stations to overcome earth's curvature for long-distance transmission requirement. The concept of telemetry network leads to local independent systems which often prove expensive because of the high installation and maintenance costs of relay stations, cables and hardware redundancy. Such systems often suffer from lack of reliability during severe weather conditions when the need for the data is at a premium. Satellite-based systems do not suffer from these disadvantages and even eliminate the requirement of repeater-stations. In long span of time such systems prove to be cost-effective considering the logistic aspect of the transmission-requirement. Increasing use of geostationary satellites facilitates designing and operating satellite-based telemetry systems. Another recent technique i.e. meteor-burst telemetry allows coverage of vast areas and offers minimum blockage problems due to terrain obstacles. However, because of very short duration availability of meteor-trail occurances, this technique would be of limited applications.

Major break through in microprocessor-technology has opened new fields of applications including hydro-meteorology. It can be effectively used for data collection as well as transmission. Remote field applications requiring low-power, compact and flexible instrumentation utilize microprocessor-based systems thereby reducing the involved hardware and controlling the various operations through software. In hydrometeorological forecasting programme, most important aspect is real-time processing of the data for timely preparation of forecasts and warnings. Improvoements in processing techniques and methods should be given higher priority so that these can be implemented cost effectively on microprocessor-based systems.

Current trends indicate that the next major advance in hydrology depends on upgrading the hydrological data-collection-transmission and -processing systems. Upgrading these data-acquisition systems in hydrology and meteorology calls for automatic stations to facilitate the collection and relay of data. International co-operation and support is required to introduce less expensive, faster and more reliable modern technoligies.

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