AWS and its Datalogger ,telemetry link and sensors

Surface Instrument Division

Office of Climate Research and Services

भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

AWS

- **The purpose of establishing an AWS network as given by WMO.**
- **AWS are used for increasing the number and reliability of surface observations.**

They achieve this by:

- Increasing the density of an existing network by providing data from new sites and from sites that are difficult to access and inhospitable;
- Supplying, for manned stations, data outside the normal working hours;
- Increasing the reliability of measurements by using sophisticated technology and modern, digital measurement techniques;
- Ensuring the homogeneity of networks by standardising the measuring techniques;
- Satisfying new observational needs and requirements;
- Reducing human errors; Lowering operational costs by reducing the number of observers;
- Measuring and reporting with high frequency intervals or continuously.

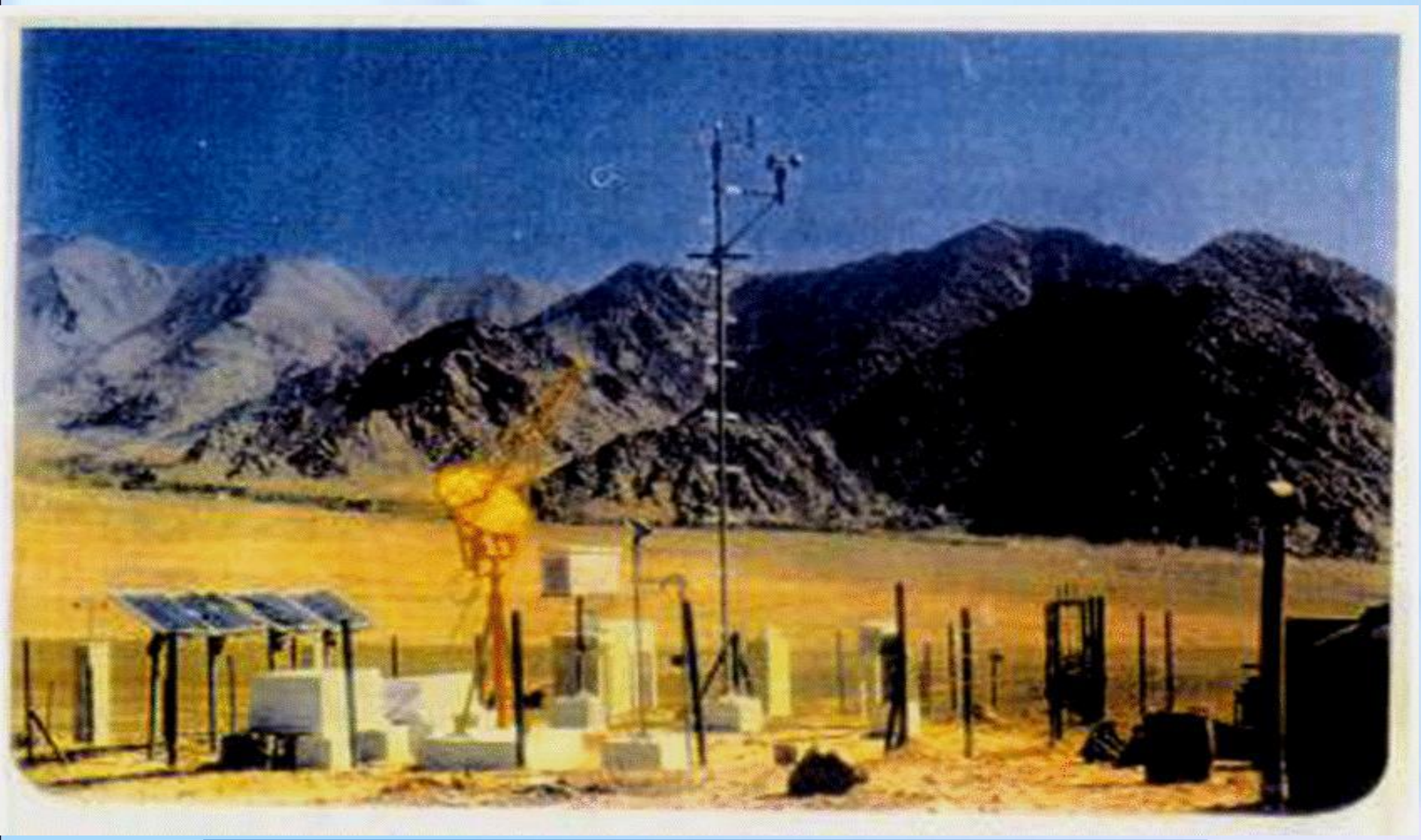
Types of AWS

- **The AWS are broadly classified into two types a) Real time and b) Non Real time (OFF LINE)AWS.**

  - In the case of **real-time AWS**, data is available almost in near real time according to synoptic requirements. These AWS use satellite-based or mobile communication links to ensure that the data reaches the end user, the weather forecaster as early as possible
  - In the case of **Non –real time(off line), AWS** record the data as per user-defined time intervals and store them in the data logger. An observer retrieves the data from the system and makes arrangement for mailing the data to the concerned officials.

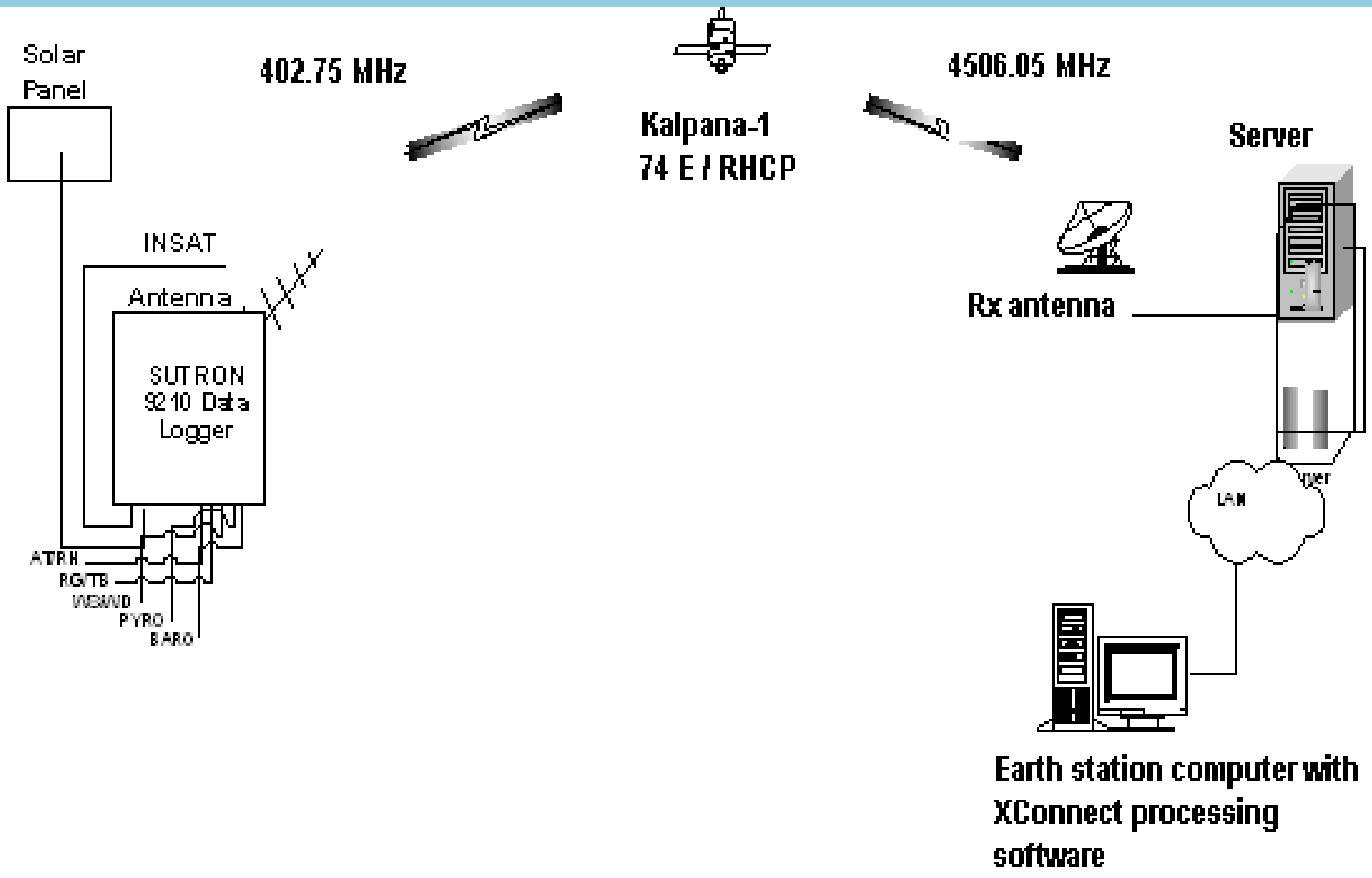
- **There is one more type of AWS known as Interrogative AWS which provides the data when the station is contacted through modem / cable link for retrieval of data during adverse weather conditions.**

DCP(DATA COLLECTION PLATFORM) AT LEH



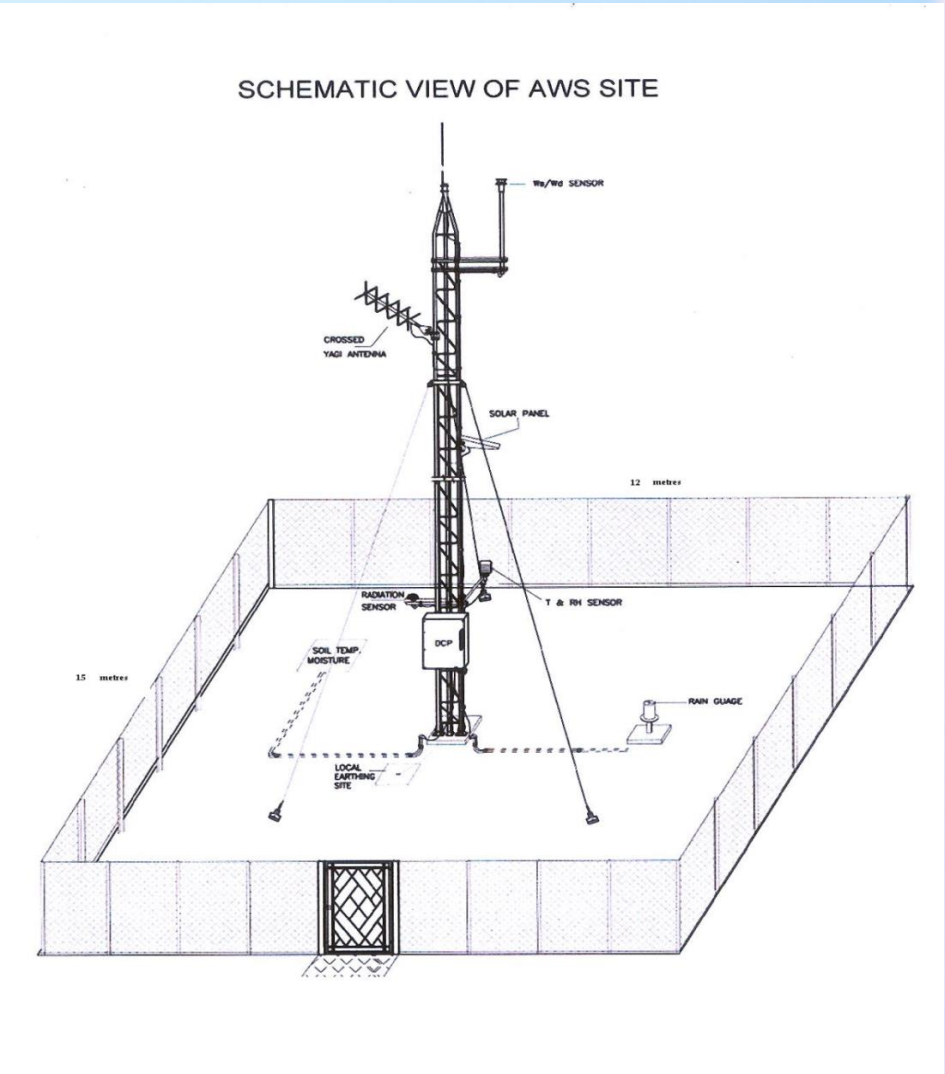
AWS IN MAILAM(TN)

Satellite Communication



Satellite based AWS

- DATA LOGGER
- UHF TRANSMITTER
- YAGI ANTENNA
- GPS
- BATTERY/CHARGER
- SOLAR PANEL
- SENSORS



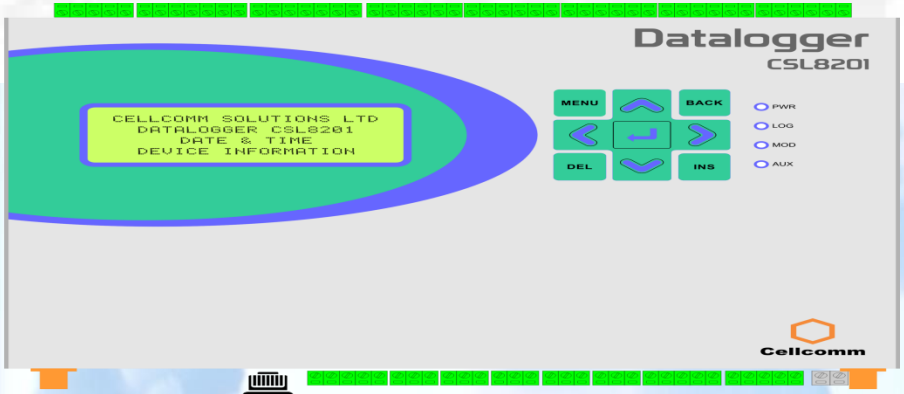
DATALOGGER

- A DATA LOGGER (ALSO DATALOGGER OR DATA RECORDER) IS AN ELECTRONIC DEVICE THAT RECORDS DATA OVER TIME OR IN RELATION TO LOCATION EITHER WITH A BUILT IN INSTRUMENT OR SENSOR OR VIA EXTERNAL INSTRUMENTS AND SENSORS.
- INCREASINGLY, BUT NOT ENTIRELY, THEY ARE BASED ON A DIGITAL PROCESSOR (OR COMPUTER).

Continue..


CR1000
CAMPBELL SCIENTIFIC


CH1
COM
CH2
CH3
COM
CH4
CH5
COM
CH6
CH7
COM
ALARM1
A2/EXT
SITE-LOG
Data Logger


Datalogger
CSL8201
CELLCOMM SOLUTIONS LTD
DATALOGGER CSL8201
DATE & TIME
DEVICE INFORMATION
MENU
BACK
DEL
INS
PWR
LOG
MOD
AUX
Cellcomm


ESC
ENT
AMP
DATA LOGGER
Model No: DLAWSAM1


Sutron 9210 XLite
LEFT
SELECT
RIGHT
SUTRON

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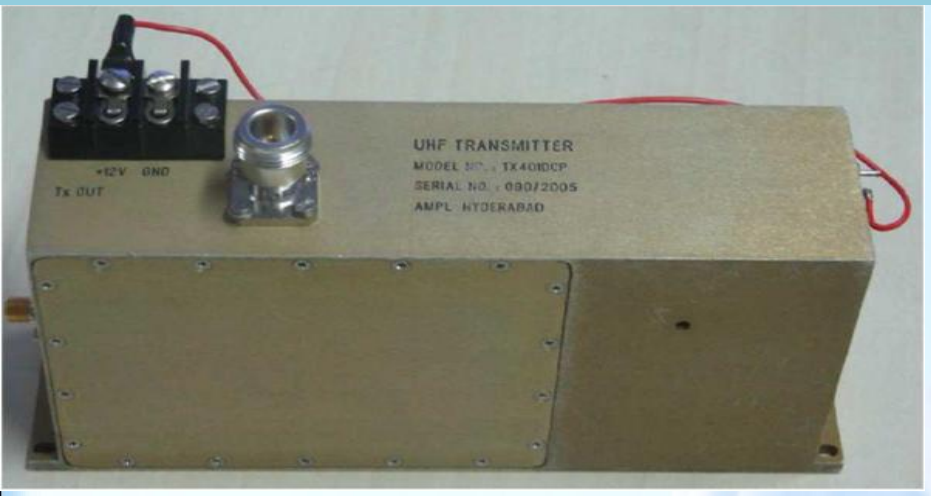
- **Data loggers** can monitor temperature, humidity, carbon dioxide, pH, pressure, voltage, current, and pulse – making them useful for a number of **applications**.
- Most **data loggers** operate on batteries, but some models can also be powered externally.
- Usually **data loggers** consume very low power.
- Many **data loggers** have non-volatile memory which ensures that recorded **data** is still safe if the battery fails or power is lost.

UHF Transmitter



TDMA TECHNOLOGY

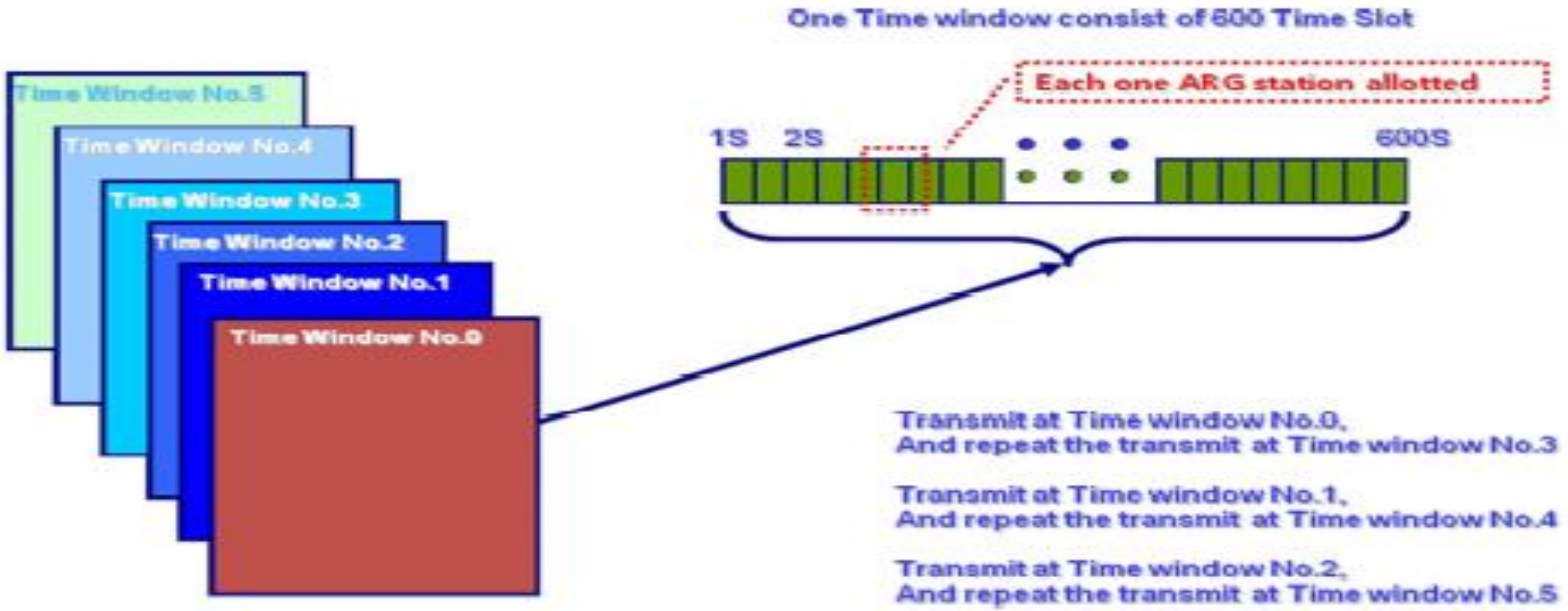


Figure 2-2 TDMA Time Windows

As per Figure 5 of TDMA Time Windows, the data will be transmitted 2 times per hour during 0~30 minutes and 30~60 minutes in TDMA Mode. Therefore, the number of ARG site to transmit the data per hour is 1800 sites in TDMA Mode.

In PRBS Mode, the data will be transmitted three times from Time Window as randomly.

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- Each TDMA type of transmitting AWS / ARG has a unique GPS synchronised time of transmission stamped on the body of the system at the time of installation.
- TDMA technique is an open loop system with timing derived from GPS receiver which is part of AWS/ARG.
- TDMA frame duration is one hour.
- The one hour frame is divided into 2 time windows, each of 30 minute duration.
- Each AWS is assigned 1-second time slot in any of the 30-minute slot and the repeat transmission is after 30 minutes, which falls in the next time slot.
- So, 1800 AWS/ARG (in a single carrier) will be able to transmit in 30 minutes slot with repeat transmission and without any collision.
- Sufficient guard time is available and there is no probability of data collision in TDMA type of transmission

YAGI ANTENNA FOR UPLINK

In AWS/ARG, crossed Yagi antenna is used for uplinking the data to the satellite from the remote field sites.

An antenna is a transducer that converts radio frequency electric current to electromagnetic waves that are then radiated into space.

The electric field or "E" plane determines the polarisation or orientation of the radio wave.

Power supply for AWS

- The AWS are operated with a DC power supply from a 12V / 65 AH Sealed Maintenance Free (SMF) battery which is float-charged by the solar panel of 40W capacity.
- Solar charge regulators are used to regulate the charging voltage from the solar panel which can be even 18V during day time.
- The charge regulators ensure that the battery gets only a voltage of up to 14.5V while charging.

Mounting of solar panel

- The main element of a solar panel is the photo-voltaic cell, a semi-conductor device.
- The cell absorbs photons when exposed to sunlight (solar radiation) and produces a voltage potential across the junction of the semi-conductor.
- The most commonly used solar cell is the silicon cell with a PN junction.
- The open circuit voltage for the 30W solar panel is 21V and short circuit current is 2.4 A.
- The solar panel is mounted in the southern direction at a height of about 3-4 m from ground level with an inclination angle which is the total value arrived at by adding the numerical value of the latitude of the place to 10 to 15 degrees.
- This is to ensure that solar panel is oriented towards the sun throughout the year in that place so that at least six to seven hours of sunlight fall on the solar panel at any point of time in a year.

GPS ANTENNA FOR DATALOGGER CLOCK TIME SYNCRONIZATION

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

GPS is used in AWS/ARG for time synchronisation with RTC clock of data logger/transmitter.

GPS time is theoretically accurate to about 14 nanoseconds

Place the GPS antenna in a clear open space as much as possible or high up on the AWS mast on a horizontal position, facing the sky. This arrangement helps to achieve a "full sky" view with the antenna

PARABOLIC ANTENNA FOR DOWN LINK

In the AWS / ARG data receiving earth station, 3.8m parabolic dish antenna is used which has a gain of 45 dB and receives extended C-band signals from satellite INSAT-3D.

The parabolic antenna is essentially an electromagnetic wave lens which focuses the RF energy (signal) into a narrow beam and converges on a single point known as focus.

The signal is fed to the low noise amplifier via the feed horn assembly on the antenna which is referred to as feed.

TDMA Earth Station

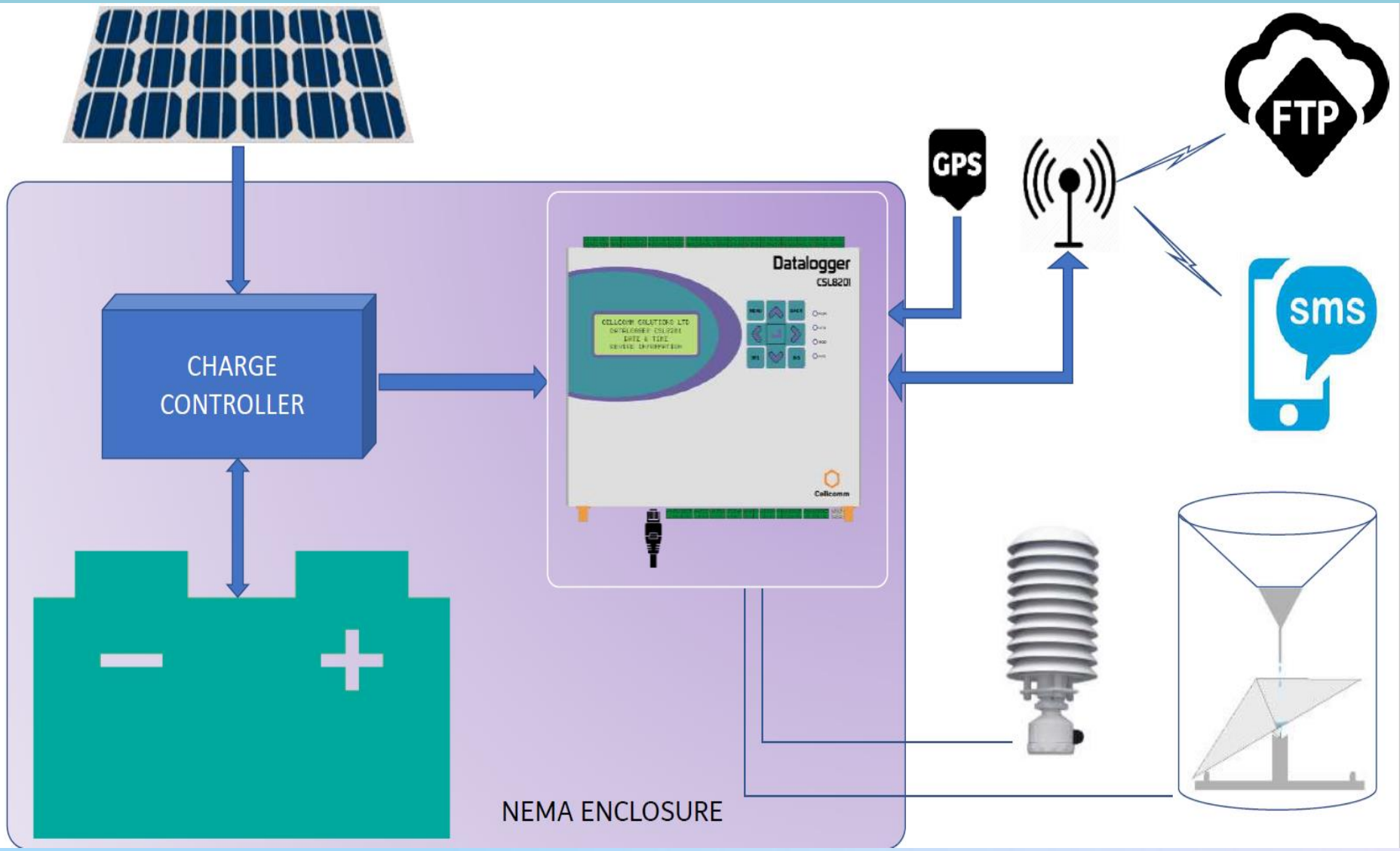
GPRS BASED AWS

- GPRS based Data logger used for AWS.

Feature of GPRS Based Data Logger:

- Station ID and Static IP address with Port No is required.
- GPRS based communication with 2G/3G/4G MODEM.
- Dual way communication.
- Quality Control at field Level.
- Reception of AWS data through Email from AWS site.

GPRS Communication



Sensors used in AWS /Agro AWS /ARG

- **The meteorological requirements for sensors used at AWSs are not very different from those of sensors at manual observation stations.**
- **The sensors must be robust, fairly maintenance-free and should have no intrinsic bias or uncertainty in the way in which they sample the variables to be measured.**
- **In general, all sensors with an electrical / electronic output are suitable.**
- **Depending on their output characteristics, sensors can be classified as analogue, digital and "intelligent" sensors.**
- **Analogue sensors:** Sensor output is commonly represented by a continuously varying signal and small fluctuations are meaningful as well like voltage, current, charge, resistance or capacitance. Signal conditioning is the process in which the transducer(sensor) analog outputs are converted into voltage levels (for example 0 to 100 % humidity corresponds to 0 to 1 V) for further processing in the data logger.
- **Digital sensors :**Sensors with digital signal outputs have information contained in a bit or group of bits(zeros and ones) and sensors with pulse or frequency output. Rain gauge is a digital sensor.
- **Intelligent sensors/transducers:** Sensors including a microprocessor performing basic data-acquisition and processing functions and providing an output in serial digital or parallel form are called intelligent sensors. The Gill ultrasonic sensor is an intelligent sensor with a microprocessor arrangement mounted in the neck of the sensor which performs the basic data acquisition and processing.

TEMPERATURE HUMIDITY SENSORS

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- Air temperature and Relative Humidity is a combined probe with separate sensors for both.
- The sensing element for temperature is a high precision PT 100(platinum resistance) sensor.
- The measuring range of temperature –40° to +60°C corresponds to an output of 0 to 1V.

- The sensor for relative humidity is capacitance based.

- 0-100% RH corresponds to 0 to 1V.

Pressure sensors

- **Pressure sensor** is a device for pressure measurement of gases or liquids

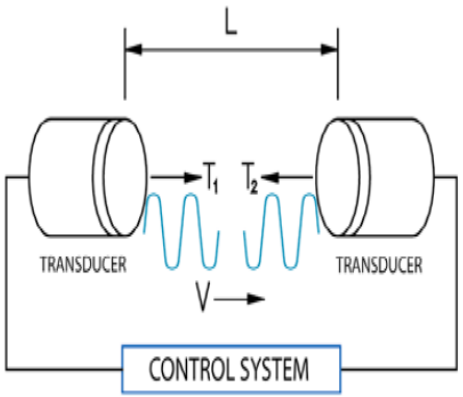
- A barometric **pressure sensor** is a **sensor** that detects **atmospheric pressure**. ...
- A typical example of a barometric **pressure sensor** is a piezo-resistive type that uses silicon semiconductor. ROHM barometric **pressure sensors** are silicon-based piezo-resistive types.
- Aneroid barometer consists of an aneroid cell inside. The aneroid cell expands/contracts when there are small changes to **atmospheric pressure**.

- Low power design makes it ideally suited for remote monitoring applications.
- Capable of operating from elevations of 2300 feet below sea level to 18,300 feet above sea level
- Low power consumption
- Solid state construction

Wind sensors

- Gill-make ultrasonic wind sensor which is a very robust, lightweight unit with no moving parts.
- The measurement range is 0-116 knots (0 to 60 mps) for wind speed and 0-359° for wind direction .
- It requires power supply of 12 V and has digital output as RS 232.

- The Windsonic measures the time it takes an ultrasonic pulse of sound to travel from the North transducer to the South transducer, and compares it with the time for a pulse to travel from S to N transducer.
- The times are also compared between West and East, and E and W transducers.
- WS/WD is obtained by determining which way the wind is going faster.



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- The transducers fire ultrasonic pulses to the opposing transducers.
- In still air (zero wind speeds) time of flight between the two transducers is same for all pulses, both forward and reverse directions.
- When the wind blows, it increases the time of flight for pulses travelling against the wind.
- So from the changes in the time of flight, the sensor calculates the wind speed and direction.
- For instance if a Northly Wind is blowing, then the time it takes for the pulse to travel from N to S will be lesser than the time taken for the pulse to travel from S to N whereas the W to E, and E to W times will be the same.
- The wind speed and direction can then be calculated from the differences in the times of flight on each axis.
- This calculation is independent of factors such as temperature, altitude and humidity. The microcontroller embedded in the neck of the sensor computes the wind speed and direction and reports them to the data logger .

L = Distance between transducer faces, C=speed of sound (The speed of sound is the distance travelled during a unit of time by a sound wave propagating through an elastic medium. In dry air at 20°C (68°F), the speed of sound is 343.2 metres per second), V= velocity of gas flow (here air) T1 = Transit time of ultrasound in one direction, T2 = Transit time of ultrasound in the opposite direction

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$$T_1 = \frac{L}{C+V} \quad \text{and} \quad T_2 = \frac{L}{C-V}$$

$$\text{Therefore : } V = \frac{L}{2}\left\{\frac{1}{T_1} - \frac{1}{T_2}\right\} \qquad C = \frac{L}{2}\left\{\frac{1}{T_1} + \frac{1}{T_2}\right\}$$

L = Distance between transducer faces,

C=speed of sound (The speed of sound is the distance travelled during a unit of time by a sound wave propagating through an elastic medium.

In dry air at 20°C (68°F), the speed of sound is 343.2 metres per second),

V= velocity of gas flow (here air)

T1 = Transit time of ultrasound in one direction,

T2 = Transit time of ultrasound in the opposite direction

In AWS, vector averaging of wind speed and direction is done from the 180 samples (@ one per sec) for the three minutes prior to the top of the hour, say, 57:00 to 60:00/00:00 at which hourly observations are sampled for all the sensors.

Rainfall sensors

- Diameter of the orifice: 20 cm
- 0.5 mm Rainfall is equivalent to 0.05 cm.
- Amount of water (Volume of water) required for one tilt is 3.14*10*10*0.05 = 15.7 cc

The sensor is the tipping bucket mechanism and is mounted at a height of 0.6 to 1 m. The collector diameter is 20 cm.

So 15.7 cc (product of collector area and resolution) of rain water corresponds to 0.5 mm of rainfall.

Each bucket is calibrated to tip when 15.7 cc of rain water is collected in it. At any given time one bucket is always in collection mode. As the bucket tips it causes a magnet to pass by a ruggedized mercury switch, momentarily (0.05 sec) closing the switch. The contact closure initiates event or count accumulation in the data logger. Once the rain is measured, the rain water is directed into drain tubes that allow it to exit through the base of the gauge.

Continue..

- The collector diameter for Astra TBRG is 159.6 mm and collector area is 200 cm_2.
- Since the resolution of the gauge is 0.5 mm, 10 cm_3 / 10 ml (product of collector area and resolution) of rain water corresponds to 0.5 mm of rainfall.
- Each tipping bucket is calibrated to tip when 10 cm_3/10 ml of rain water is collected in it.
- At any given time one bucket is always in collection mode. As the bucket tips it causes a magnet to pass by a ruggedised mercury switch, momentarily (0.05 sec) closing the switch.
- The contact closure initiates event or count accumulation in the data logger.
- Once the rain is measured, the rain water is directed into drain tubes that allow it to exit through the base of the gauge.

- The rainfall accumulated for the 24 hours period ending 03 UTC of today commencing from 03 UTC of the previous day is taken as the cumulative rainfall reported at 03 UTC of today.
- The rainfall value is reset at 03 UTC and fresh logging and accumulation of the rainfall, if any, takes place as per IMD convention.

Soil sensors

- The Soil Moisture Sensor is a Stevans hydra probe using a SDI-12 output and the unit of measurement of soil moisture is water fraction by volume(wfv).

- The Hydra soil moisture probe determines soil moisture and salinity by making a high frequency (50 MHz) complex dielectric constant measurement which resolves simultaneously the capacitive and conductive parts of a soil's electrical response.
- It's "dielectric impedance" measurement principle differs from TDR, capacitance, and frequency soil sensors by taking into account the energy storage and energy loss across the soil area using a 50 MHz radio frequency wave.

Continue…

- The Delta-T (ML2x) theta probe is used for soil moisture at 20 cm measurement in Agro AWS.
- The sensor determines soil moisture by making a high frequency (50 MHz) complex dielectric constant measurement which resolves simultaneously the capacitive and conductive parts of the soil‟s electrical and conductive response.
- The capacitive part of response is indicative of soil moisture.
- Soil Moisture is measured as volumetric soil moisture content θ_v (m_3/m_3 or % volume).
- Measuring range is from 0 to 1 m_3/m_3.
- It does not require routine maintenance but requires calibration every year with gravimetric method.

SUNSHINE DURATIONS

CSD3 measures sunshine duration. Sunshine duration is defined by WMO as the time during which the direct solar radiation exceeds the level of 120 W/m^2.

It has no moving parts and uses 3 photo-diodes with specially designed diffusers to make an analogue calculation of when it is sunny.

The output is switched high or low to indicate sunny or not sunny conditions. The calculated direct irradiance value is also available

Measurement is performed by instruments called sunshine recorders. For the specific purpose of sunshine duration recording, Campbell–Stokes recorders are used, which use a spherical glass lens to focus the sun rays on a specially designed tape. When the intensity exceeds a pre-determined threshold, the tape burns.

The total length of the burn trace is proportional to the number of bright hours