Chapter 1
Overview of Aviation of meteorological Instruments

Introduction

The present document contains set of step-by-step instructions to help Aviation Meteorological officials to carry out routine installation, maintenance and operation of aviation instruments installed at the runway for observing and reporting of weather elements SOPs aim is to achieve efficiency, quality output and uniformity of performance in compliance with the regulations laid-in.

Weather factors have marked influence on the operation and performance of modern aircrafts. The impact of a relatively small change in parameters likes Wind, Temperature, Visibility, Pressure, and Cloud base height etc. on-air operations are very high. The aviation meteorological instruments are used for continuous monitoring and display of weather parameters namely wind direction, wind speed, air temperature, dew point, humidity, pressure, runways visual range and cloud.

The present setup in IMD consists of mainly following instrument setup at runway sites

1.) DCWIS
2.) DIWE
3.) Transmissometer / RVR
4.) Ceilometer
5.) Present Weather Sensor

Criteria for Installing of Met Equipment at Airports

Criteria for installing airport installation of Met Equipment at airports:

1. Site should have free exposure conditions away from nearest boundary wall.

2. Site shall be Free from bushes, levelled and shall be same level as that of Runway.

3. Site Dimensions of at least 50m X 5mts

4. Site shall be within 120mts from Central line of runway

5. Site shall be within 300mts from runway threshold (i.e. beginning of runway).

Height of sensors:

Wind: 10m *(for detail refer to diagram of para 1.4 at page no 10)*

Temperature: 2m

Visibility, MOR & RVR: 2.5m

Role of present weather in air navigation

Weather factors have marked influence on the operation and performance of modern aircrafts. The impact of a relatively small change in parameters like Wind, Temperature, Visibility, Pressure, Cloud base height etc. on-air operations is very high.

a.) **Wind**: Wind observations are used for the selection of runways and for thedetermination of the maximum allowable take-off and landing weights. Landing is not generally allowed when a crosswind component exceeds 45 kmph

b.) **Temperature**: Temperature is important in view of engine performance and required take-off speed. High temperature means lower air density which reduces lift, resulting in the need for higher take-off speeds and consequently more runway length. If runway length is insufficient, take-off weights have to be reduced.

c.) **Pressure**: The atmospheric pressure measured at the aerodrome is used for thealtimeter setting of the aircraft. It is evident that pilots must be able to rely absolutely on the pressure values provided by the meteorological stations of the aerodrome during landing.

d.) **Visibility**: Low visibility is a crucial factor affecting traffic at aerodromes. Theminimum visibility at which take-off is allowed depends on the facilities like instruments landing systems at the aerodrome

e.) **Cloud base height**: An accurate estimate of the height of base of low clouds isvery essential for safe landing of the aircraft. This information gives advance warning to the pilot about the height at which he will be able to see the runway markings, edge lights etc. when low clouds persist over the landing area of the aerodrome

f.) **Present weather Sensor**: It measures Visibility using Principle of Forward scatter of Light. It also detects/measure Present Weather i.e. rain, rain Intensity, Snow, Snow Intensity, Dust, Smoke, Haze etc. It has also provision to evaluate RVR.

So, the availability of reliable and representative observations at aerodromes to support take-off and landing operations are of critical importance.

Location of Meteorological Instruments at aerodrome

At aerodromes there is a range of requirements and conditions in addition to adequate exposure which instrument location must satisfy and in particular these include the following:

a. Representative measurement for the aerodrome as a whole and for take-off and landing operations in particular.

b. Compliance with obstacle restriction provisions.

c. Suitability of location in respect of terrain conditions, power supply and communication facilities.

Met. elements measured	Typical equipment	Typical dimensions of equipment	Operational area for which element is to be representative	Siting provision in Annex. 3
Surface wind speed and direction	Anemometer and Wind vane	Usually mounted on tubular mast 6 to 10m (20-30ft) high. Single tube mast for both instruments appropriate in proximity to runways.	Take-off areas and touchdown zone.	No specific provision so long as observations are representative of relevant operational areas.
Temperature sensor (TTRH)		Usually mounted on tubular mast 2m (6-7ft) within a Stevenson screen	Take-off areas and touchdown zone.	
RVR	Transmisso-meter	Single/Dual baseline (10m to 75m)	Up to three transmissometers per runway	Refer to point no 1.3.1 for recommended location of RVR as per ICAO
Height of cloud	Ceilometers	Usually less than 1.5m high but rather solid structure including foundation plinth.	Generally representative of the approach area, but for precision approach runways representative for the middle marker site.	No specific provision so long as observation representative of relevant operational areas.

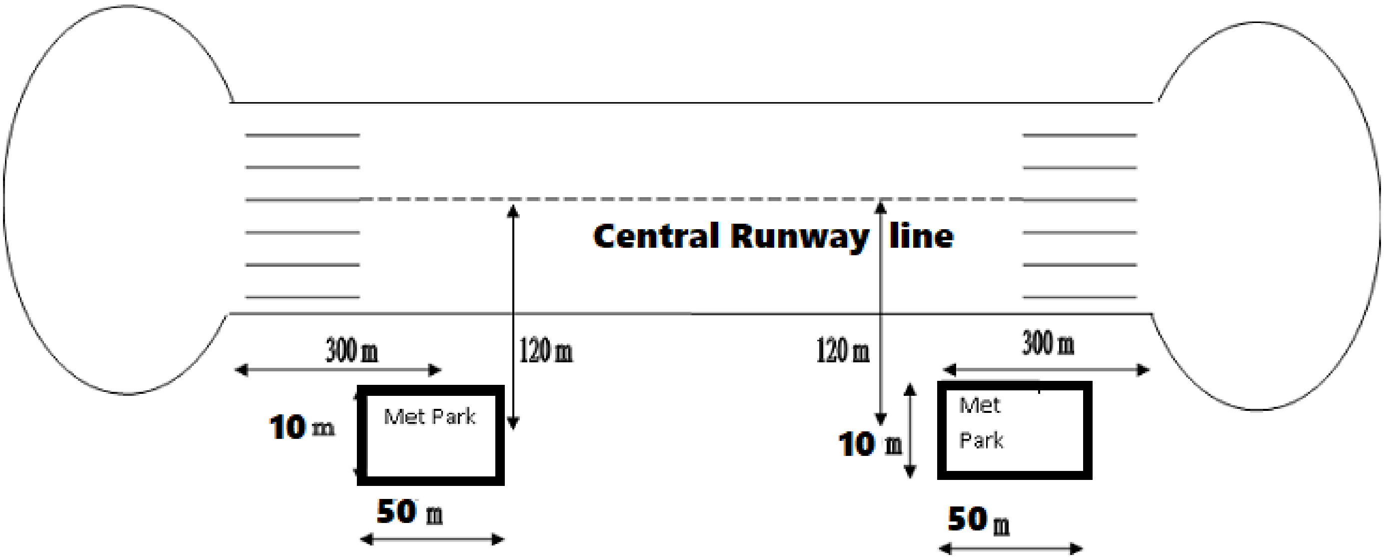
Criteria for Selecting Site for Installation of Airport Met Instruments

ICAO site selection criteria suitable for airport

The site should be representative of the touchdown zone of the runway, and it should be at lateral distance of not more than 120 meters from the central line of the runway near touchdown zone.

1) The site for meteorological instruments should be of dimension 200 meters length and 50 meters width.
2) The site should be within a distance of 300 meters along the runway from the threshold.
3) The site should be of even ground and should not get water logged during rainy season.

4) Distance of the site from nearby essential/ AC mains supply of the airport should be noted down.



5 Definitions for Category of airports (Ref: ICAO Annex-10)

Category-I : A precision instrument approach and landing with a decision height not lower than 60 m and with either a visibility not less than 800 m or a runway visual range not less than 550 m

Category-II : A precision instrument approach and landing with a decision height lower than 60 m but not lower than 30 m and a runway visual range not less than 350 m

Category-III A: A precision instrument approach and landing with a decision height lower than 30 m or no decision height and a runway visual range not less than 200 m

Category-III B : A precision instrument approach and landing with a decision height lower than 15 m or no decision height and a runway visual range less than 200 m but not less than 50 m

Category-III C: A precision instrument approach and landing with no decision height and no runway visual range limitations.

Requirement of Instruments in each category
Ref: ICAO Doc 8896/AN/893/4

Category	CWIS	Visibility sensors	Ceilometers
I	One if RWY Length<2400mts else Two nos	One if RWY Length<2400mts else Two nos	One
II	2	2	1
III-A	2	3	1
III-B	2	3	1

1.3.1 Detailed location of RVR as per the ICAO annex-3 as mentioned below

Recommendation. — Runway visual range should be assessed at a height of approximately 2.5 m (7.5 ft) above the runway.

Recommendation. — Runway visual range should be assessed at a lateral distance from the runway centre line of not more than 120 m. The site for observations to be representative of the touchdown zone should be located about 300 m along the runway from the threshold. The sites for observations to be representative of the mid-point and stop-end of the runway should be located at a distance of 1000 to 1500 m along the runway from the threshold and at a distance of about 300 m from the other end of the runway. The exact position of these sites and, if necessary, additional sites should be decided after considering aeronautical,meteorological and climatological factors such as long runways, swamps and other fog-prone areas.

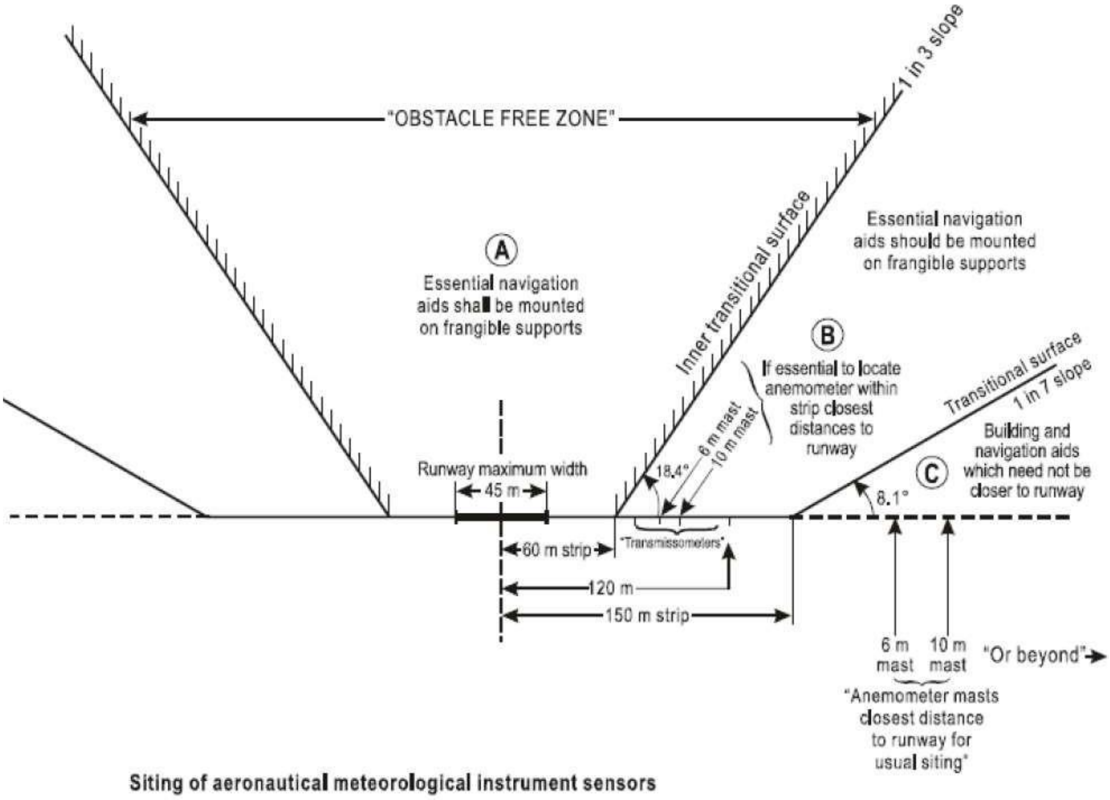
4.6.3.4 Runway visual range assessments shall be representative of:

a) the touchdown zone of the runway intended for non-precision or Category I instrument approach and landing operations;

b) the touchdown zone and the mid-point of the runway intended for Category II instrument approach and landing operations; and

c) the touchdown zone, the mid-point and stop-end of the runway intended for Category III instrument approach and landing operations.

1.4 Runway complex and touchdown area



Siting of aeronautical meteorological instrument sensors

Chapter 2

Digital Current Weather Instrument System

Overview

The DCWIS can be divided into two main parts namely

a.) Field instruments
b.) ATC/MBR instrument

Field Instruments system contains following main parts:

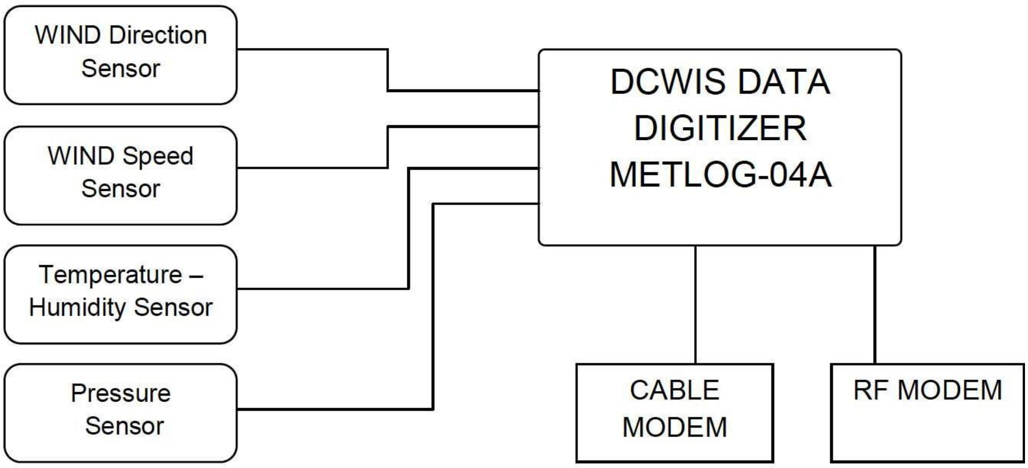
1. Meteorological Sensors
2. Wind Direction Sensor
3. Wind Seed Sensor
4. Temperature – Humidity Sensor
5. Barometric Pressure Sensor
6. Data Digitizer: Metlog-04A
7. RF Modem / Cable modem (Transmitter)

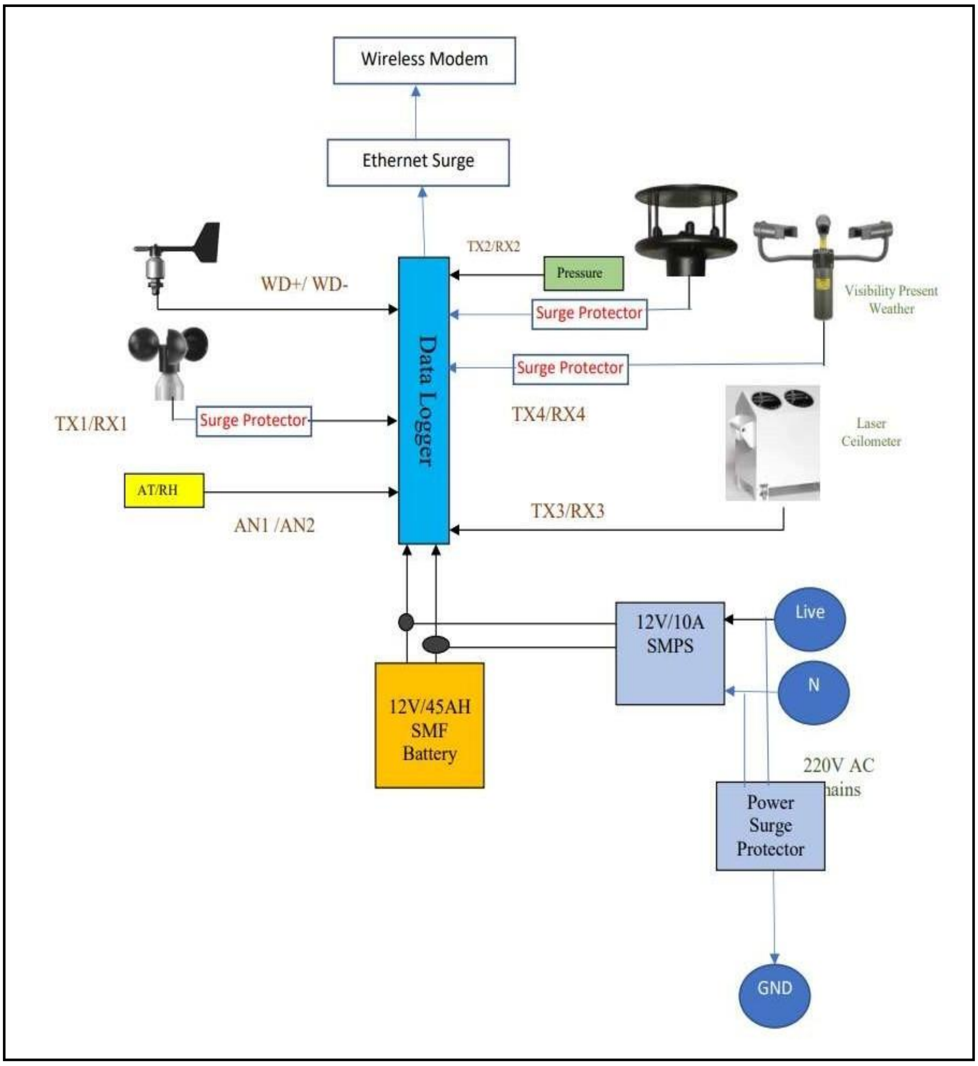
ATC / MBR Instruments consists of following main parts

1. RF Modem / Cable Modem (Receiver)
2. PC Acting as Server
3. PC Acting as Client (Slave Displays)

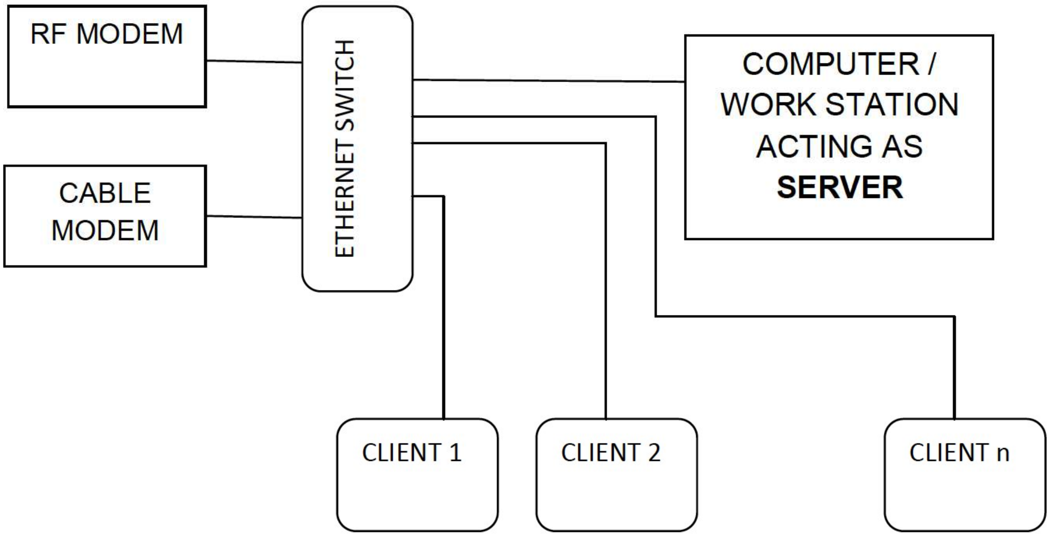
BLOCK DIAGRAM OF DCWIS SYSTEM

Field Instruments:

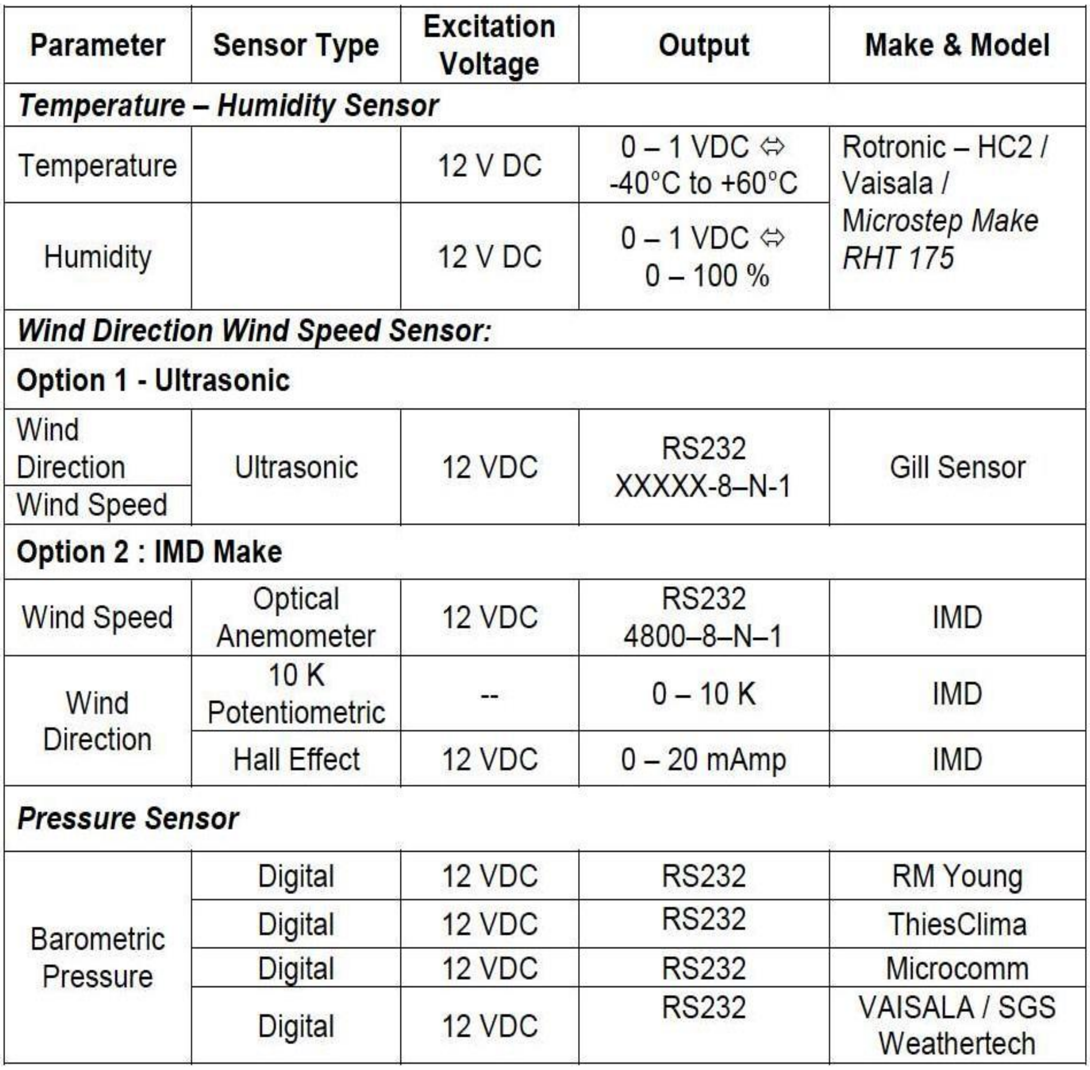




ATC / MBR Instruments:

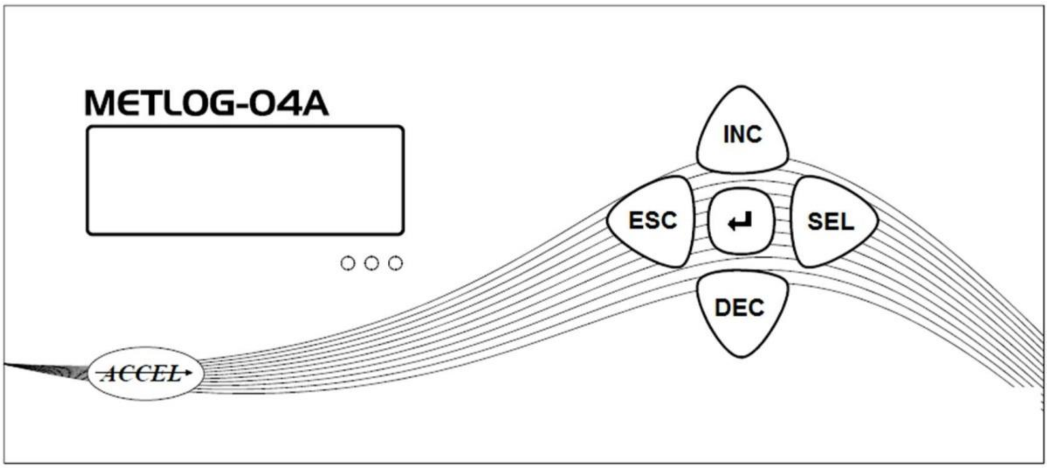


Type of sensors interfaced to Data Digitizer:

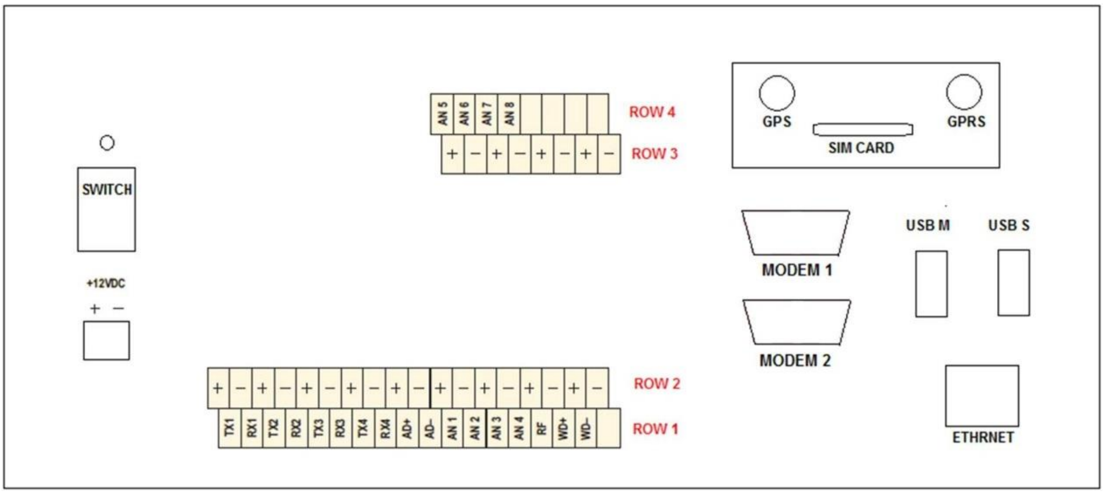


Parameter	Sensor Type	Excitation Voltage	Output	Make & Model
Temperature – Humidity Sensor				
Temperature		12 V DC	0 – 1 VDC ⇔ -40°C to +60°C	Rotronic – HC2 / Vaisala / *Microstep Make RHT 175*
Humidity		12 V DC	0 – 1 VDC ⇔ 0 – 100 %	
Wind Direction Wind Speed Sensor:				
Option 1 - Ultrasonic				
Wind Direction	Ultrasonic	12 VDC	RS232 XXXXX-8–N-1	Gill Sensor
Wind Speed				
Option 2 : IMD Make				
Wind Speed	Optical Anemometer	12 VDC	RS232 4800–8–N–1	IMD
Wind Direction	10 K Potentiometric	--	0 – 10 K	IMD
	Hall Effect	12 VDC	0 – 20 mAmp	IMD
Pressure Sensor				
Barometric Pressure	Digital	12 VDC	RS232	RM Young
	Digital	12 VDC	RS232	ThiesClima
	Digital	12 VDC	RS232	Microcomm
	Digital	12 VDC	RS232	VAISALA / SGS Weathertech

Front Panel :



Back Panel:



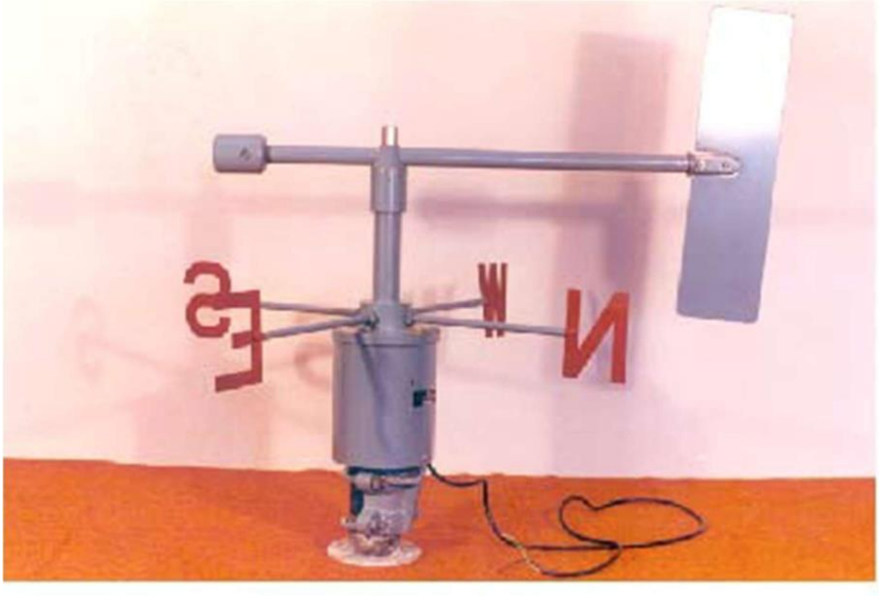
Sensor details of DCWIS

1. Wind Vane

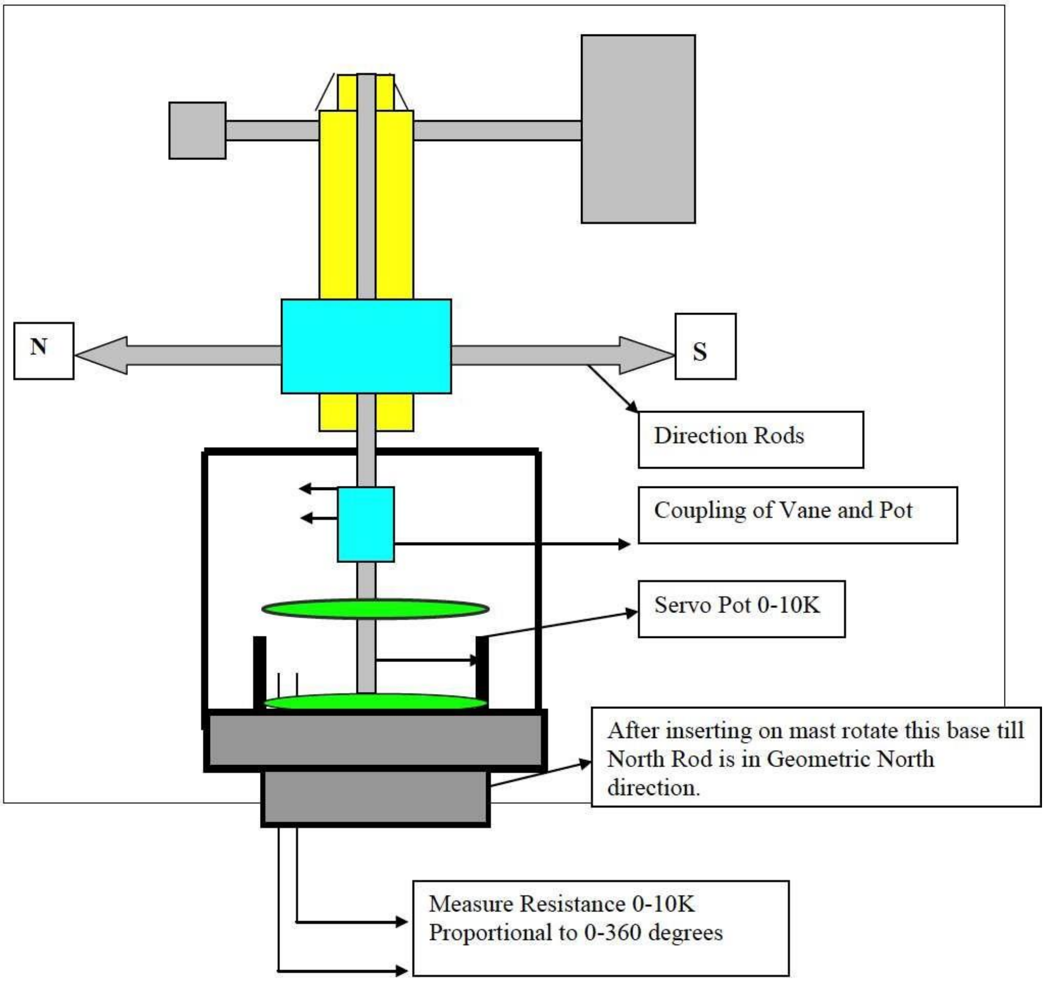
Wind vane is the instrument used measure direction of flow of wind. At present there are two types of wind vane

a) Potentiometric wind vane

The sensor used for measurement of wind direction is an IMD-make potentiometric wind vane. The potentiometer in the wind vane is a servo-micro torque potentiometer and has a maximum resistance of 10 kilo-ohms over an end gap of about 4 degrees. The potentiometer is coupled to the wind vane shaft so as to give a resistance output increasing linearly with the increasing of wind direction. Thus 0 KΩ corresponding to the north, 2.5 KΩ for east, 5 KΩ for south, 7.5 KΩ for west and the variation of 0-360 degree corresponds to 0 to 10 kilo ohms



Cross sectional view of wand vane



Calibration procedure for Potentiometric Wind vane:

1. Mark geometric North using magnetic compass.
2. Measure resistance output of pot using multimeter. Move the vane till the resistance is exactly zero ohms.
3. Now arrest vane movement. Rotate North Direction Rod and align to the wind vane position. Fix the north direction rod. (tighten the screws)
4. Fix wind direction sensor without disturbing the position of direction rods. Now rotate whole wind direction sensor (base of the sensor) over the mast using screw mechanism. Align North rod to exact North direction.

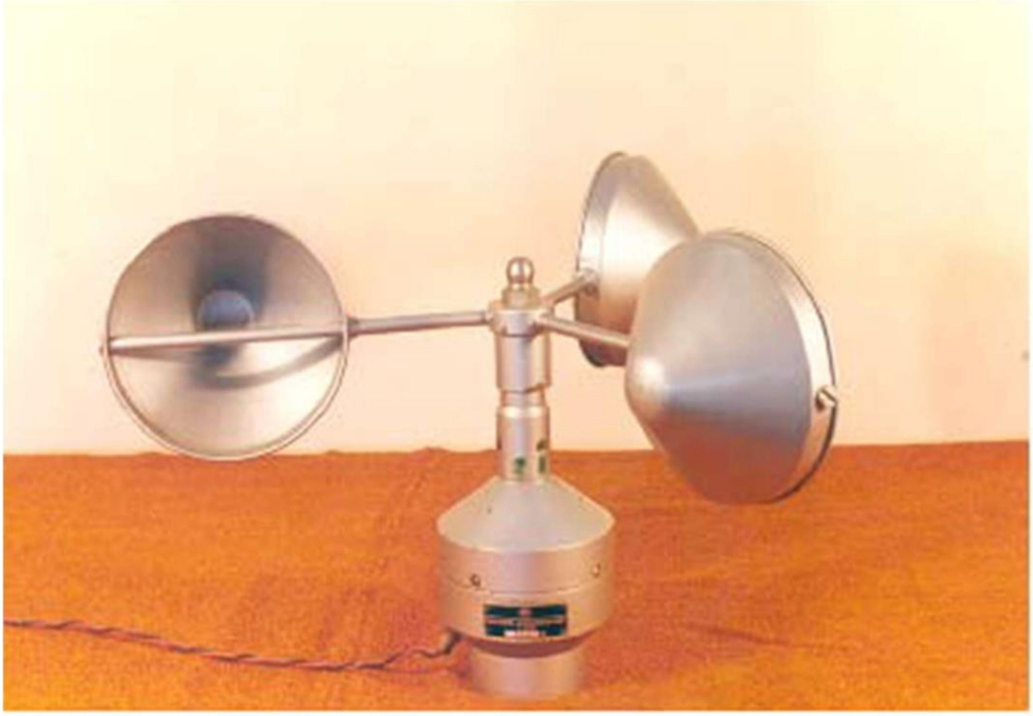
b.) Hall Effect wind vane

Hall Effect wind direction sensor works on principle of hall voltage. It is contact less. Hall voltage is proportional to sin of angle between the hall chip carrying fixed current. There are two hall plates perpendicular to each other if one give hall voltage proportional to sine of wind direction, perpendicular hall plate gives hall voltage proportional to cosine of angle, angle is proportional to ratio of the two hall voltages this eliminating current magnetic field created etc. Hall Effect sensor are contactless hence no friction so responds to very low wind or very less threshold

2.) Anemometer

Anemometer is used to measure wind speed.

Optical anemometer gives digital as well as analog outputs with respect to the wind speed in knots. Suitable scaling has been provided in the data logger for other units, such as Kilometres per hour, meters per seconds etc. The basic operating element is an opto-coupler, which is having a transmitter and a receiver with a toothed wheel connected to the shaft of the cup anemometer. The receiver, which is a photo detector, receives infrared light from the transmitter through the gaps between the teeth of the wheel generates pulses proportional to the true wind speed. These pulses are counted by an inbuilt counter in the 16–bit microprocessor (Microchip makes model no.12F682).

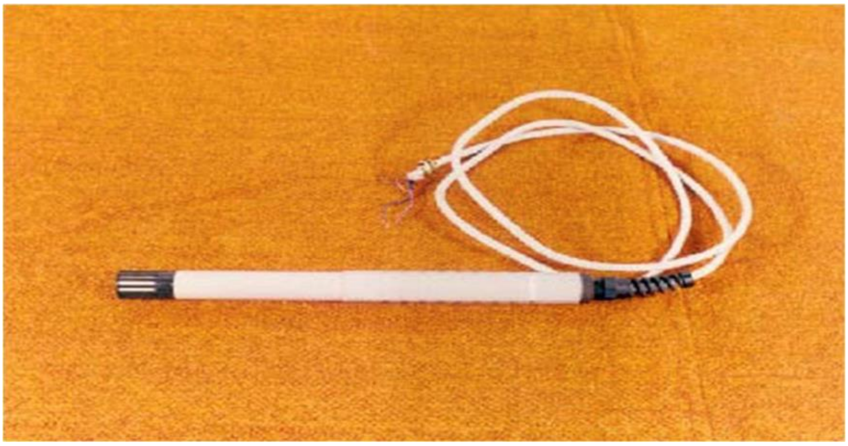


The following table shows the average number of generated pulses from the optical anemometer at different wind speeds in knots. These values are obtained at the time of calibration of the anemometer in wind tunnel.

No.of Pulses	22	56	76	165	200	290	340	396	525	600	650	790
Wind speed in knots	2.5	6.3	8.5	18	22	33	38.6	45	60	68	72	89

3. Hygroclip

Hygroclip is a combined sensor for both temperature and relative humidity.



a.) Temperature sensor

Pt-100 is used to measure temperature. Pt100 is an RTD sensor. It consists of an element that uses resistance to measure temperature. The abbreviation **RTD** comes from **"Resistance Temperature Detector".** It is a temperature sensor in which the resistance depends on temperature; when temperature changes, the sensor's resistance changes. So, by measuring the sensor's resistance, an RTD sensor can be used to measure temperature. Platinum has a reliable, repeatable and linear temperature-resistance relationship. RTD sensors made of platinum are called **PRT**, **"Platinum Resistance Thermometer".** The most common platinum PRT sensor used in the process industry is the **Pt-100** sensor. The resistance is 100 ohms at 0°C. and the resistance increases linearly with the increase in temperature. It has a measuring range of -40 to 60 C^o for temperature. Its output is 0-1 volts dc.

b.) Humidity sensor

The basic sensor for relative humidity is a **thin polymer**, which is having the property to absorb moisture from the air, and changes its electrical permittivity in proportion to the relative humidity. The polymer is placed between the parallel plate capacitor as a dielectric. It has a measuring range of 0-100% for relative humidity. Its output is 0-1 volts dc.

4. Pressure sensor

Measuring air pressure is important both in weather forecasting. Digital barometers are deployed at the airport for measurement of atmospheric pressure. A micromechanical sensor that uses dimensional changes in its silicon membrane to measure pressure. As the surrounding pressure increases or decreases, the membrane bends, thereby increasing or decreasing the height of the vacuum gap inside the sensor. The opposite sides of the vacuum gap act as electrodes, and as the distance between the two electrodes changes, the sensor capacitance changes. The capacitance is measured and converted into a pressure reading.

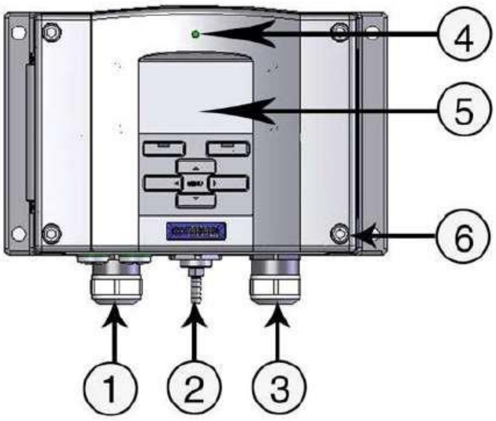


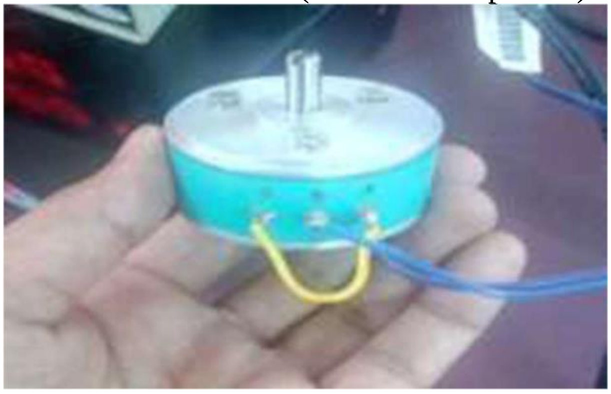
Figure 1 **Barometer Body**

Numbers refer to Figure 1 above:

1 = Cable for signal/powering Ø 8 ... 11 mm
2 = Pressure port
3 = Cable for optional power supply/relay module Ø 8 ... 11 mm
4 = Cover LED
5 = Display with keypad (optional)
6 = Cover screw (4 pcs)

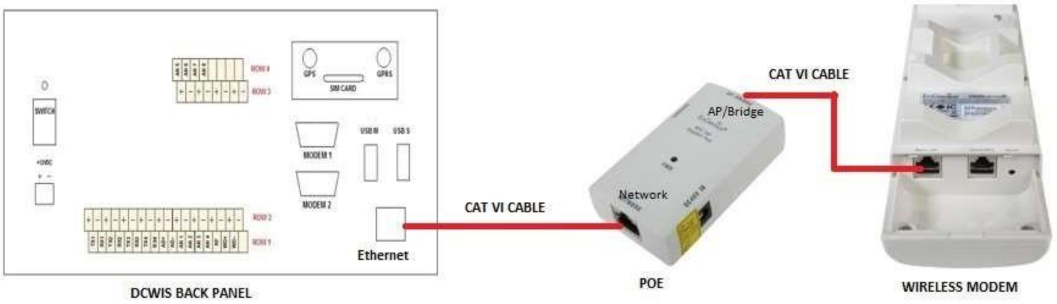
Connection of 10 KΩ Servo POT and North Setting of Wind Vane

1. 10 K Servo pot terminal A and C are shorted, then one wire is taken from one of the shorted terminals (terminal A in picture) and other wire is taken from terminal

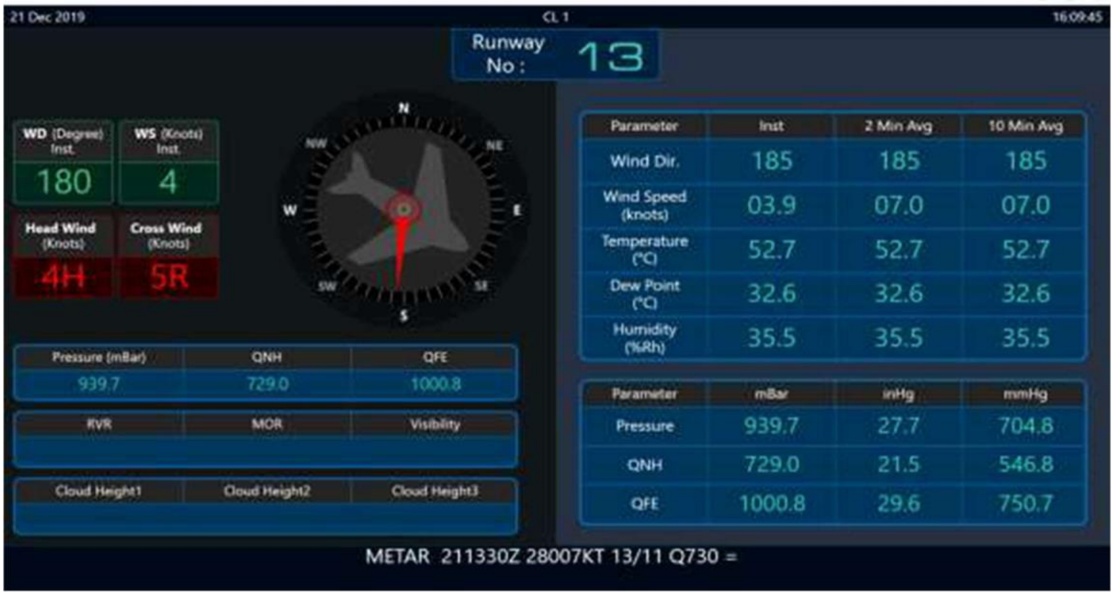


2. Fix the servo pot in the base of wind vane assembly with the help of three clamps.
3. Now loose the direction rod ring (E,S,W,N) for the rotation by screw driver.
4. Align NORTH direction rod with maximum resistance of servo pot (max resistance is approx. 10K ohm)
5. Tight the aligned North direction rod with max. Resistance of servo pot.
6. Check the resistance with direction of E=2.5k ohm, S=5.0k ohm, W= 7.5k ohm, N = 10 K ohm / 0 Ohm
7. Tighten the screws of direction rod ring of Wind vane.
8. Connect to DCWIS4A logger pins as described in section 1.2.

Communication setup at Runway site



One Runway‟ Client screen is as shown below,


21 Dec 2019

CL 1

16:09:45

Runway No : 13

WD (Degree) Inst.	WS (Knots) Inst.
180	4

Head Wind (Knots)	Cross Wind (Knots)
4H	5R

Pressure (mBar)	QNH	QFE
939.7	729.0	1000.8

RVR	MOR	Visibility

Cloud Height1	Cloud Height2	Cloud Height3

Parameter	Inst	2 Min Avg	10 Min Avg
Wind Dir.	185	185	185
Wind Speed (knots)	03.9	07.0	07.0
Temperature (°C)	52.7	52.7	52.7
Dew Point (°C)	32.6	32.6	32.6
Humidity (%Rh)	35.5	35.5	35.5

Parameter	mBar	inHg	mmHg
Pressure	939.7	27.7	704.8
QNH	729.0	21.5	546.8
QFE	1000.8	29.6	750.7

METAR 211330Z 28007KT 13/11 Q730 =

Chapter 3
Distant Indicating Wind Equipment

DIWE-03 specially designed to monitor Wind Direction and Wind Speed Inputs for small /medium airports

This system contains following main parts:

1. Data Logger: DIWE –ver 03
2. Sensors (Wind direction and wind speed)
3. Mini Slave Displays (Wind Direction – Wind Speed)
4. PC Software

Block diagram of DIWE

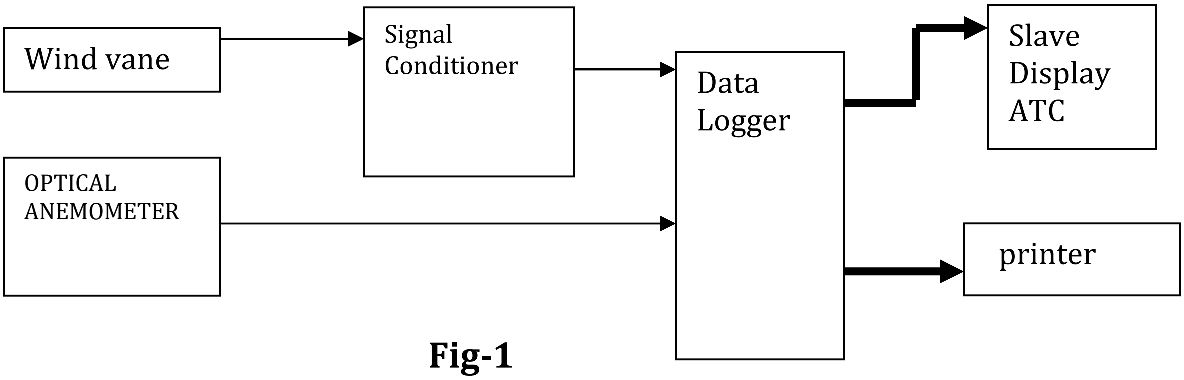
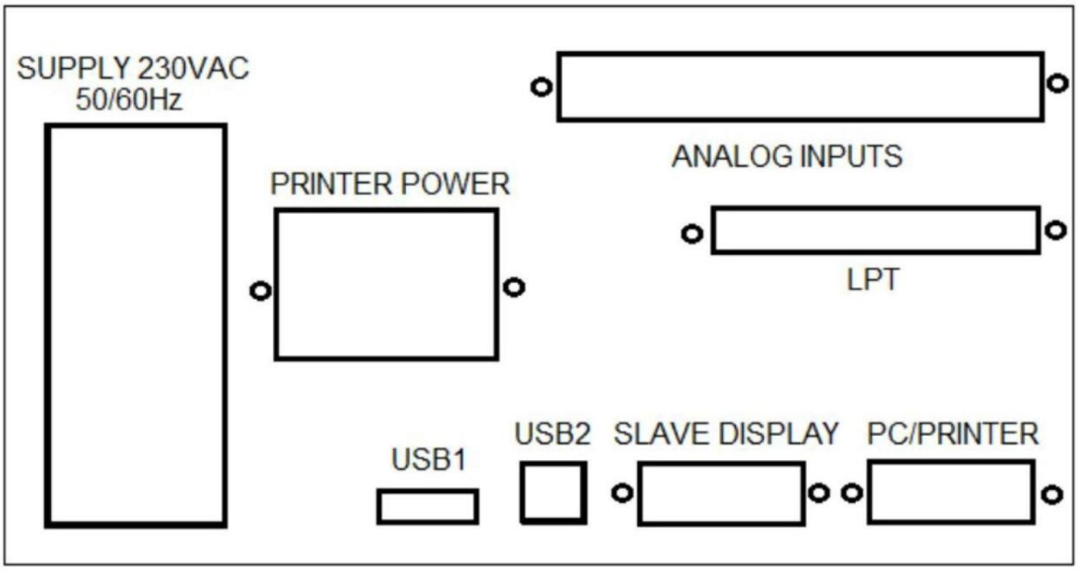


Fig-1

Front panel

Back panel



Connect the sensors as per the Block diagram

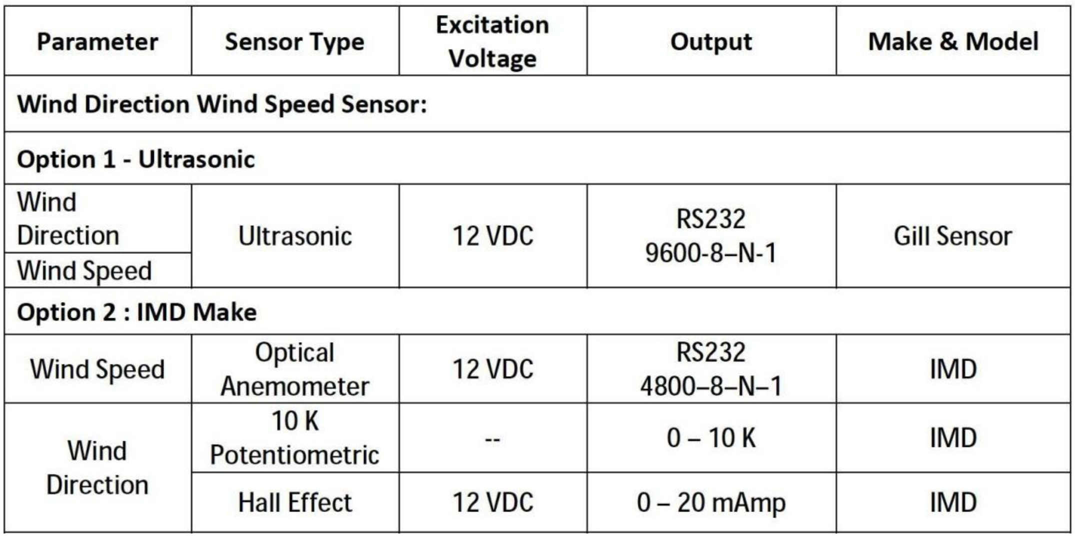
a. **Wind Direction:** Measure the wind direction by keeping Vane in N-E-S-W directions. Measure the corresponding resistance using multimeter.

b. **Wind Speed:** Measure the wind speed by rotating cups of optical anemometer manually and note different readings. Measure the output voltages with multimeter at Pin No. 2 and 3. Supply voltage should be measure between Pin No 1 and 3 it is always 10-12 V DC.

Functions of DIWE

- Reads Wind Direction and Wind Speed sensors connected to it.
- Converts the sensor values into digital format.
- Transmits the data over RS422 to Slave Display.
- Stores the data in the internal memory
- Through PC Software user can monitor all the parameters in run time
- Stored data can be downloaded on a PC using Windows based PC software provided with the System.

Sensors interfaced to DIWE-03



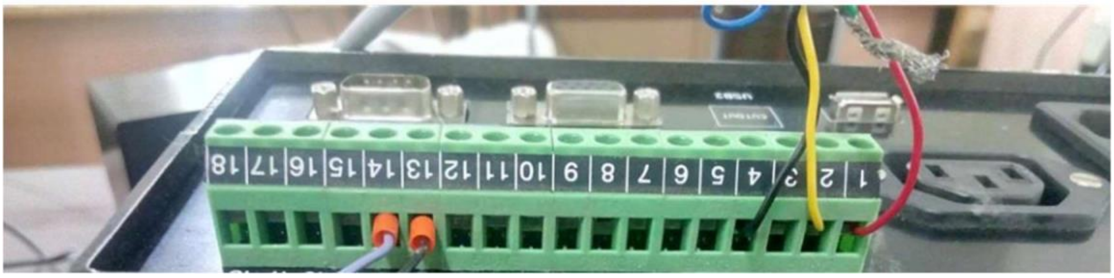
Parameter	Sensor Type	Excitation Voltage	Output	Make & Model
Wind Direction Wind Speed Sensor:				
Option 1 - Ultrasonic				
Wind Direction	Ultrasonic	12 VDC	RS232 9600-8–N-1	Gill Sensor
Wind Speed				
Option 2 : IMD Make				
Wind Speed	Optical Anemometer	12 VDC	RS232 4800–8–N–1	IMD
Wind Direction	10 K Potentiometric	--	0 – 10 K	IMD
	Hall Effect	12 VDC	0 – 20 mAmp	IMD

Connection Diagram

The Analog pin connection diagram for three type of pin details has been described below

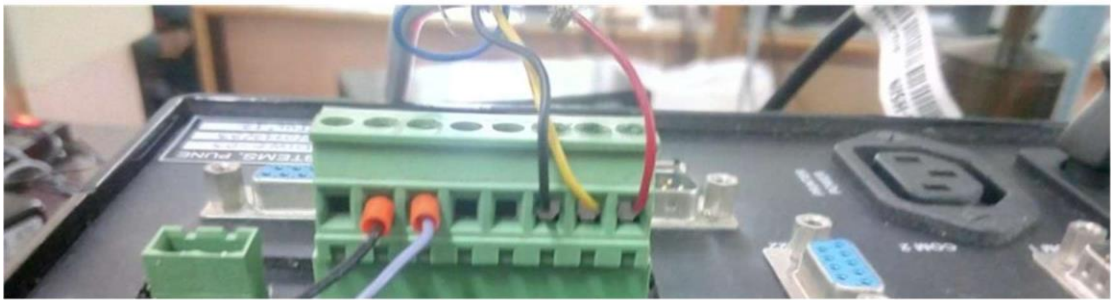
1. For DIWE logger having 18 PIN connector (Accel)

    PIN1: +12VDC(RED) (Supply for Optical Anemometer
    PIN2: (Yellow Wire from Anemometer)
    PIN4: GND signal for optical Anemometer (Black Wire from Anemometer)
    PIN13: Potentiometric Wind Vane +
    PIN14: Potentiometric Wind Vane –



2. For DIWE logger having 8 PIN connector (Accel)

    PIN1: +12VDC(RED)(Supply for Optical Anemometer
    PIN2: (Yellow Wire from Anemometer)
    PIN3: GND signal for optical Anemometer (Black Wire from Anemometer)
    PIN6: Potentiometric Wind Vane +
    PIN7: Potentiometric Wind Vane –



3. DIWE logger having 10 PIN connector (Arks)

PIN1: +12VDC(RED) (Supply for Optical Anemometer
PIN2: (Yellow Wire from Anemometer)
PIN3: GND signal for optical Anemometer (Black Wire from Anemometer)
PIN8: Potentiometric Wind Vane +
PIN9: Potentiometric Wind Vane –

Chapter 4

Visibility

Introduction

Visibility is defined as the greatest distance at which an object can be seen and recognized by an observer with normal sight under normal condition of day light illumination or at night could be seen and recognized if the general illumination were raised to the day light level. The visibility at night however, cannot be measured easily because the range at which lights can be seen depends not only on the atmospheric transparency, but also on the intensity of the light source and illumination of the background. Visibility is always restricted to some extent by the effect of the light being scatteres and absorbed by atmospheric particles like:

a. Lithometeors (Haze, sand, dust, smoke and volcanic ash.
b. Hydrometeors (Mist and fog)

Meteorological visibility is a quantity to be estimated by a human observer. But this estimation is subjective, and varies with the individual. The essential meteorological quantity that can be measured objectively is the transparency of the atmosphere, and is represented by Meteorological Optical Range (MOR). In aviation there are two types of visibility measurements; one is meteorological visibility and the other is runway visual range. But WMO has adopted Meteorological optical range (MOR) as the measure of visibility for both general and aeronautical purposes. **Runway visual range** (RVR) is the range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying the centre line. It is not an observation like surface winds, visibility etc, but it is an assessment based on (a) atmospheric factors such as extinction coefficient of the atmosphere (b) physical/biological factors such as visual threshold of illumination(Back) and (c) operational factors like runway light intensity.

Characteristics of Weather Phenomena reducing the Visibility

Mist and fog are, in many parts of the world, the primary causes for visibility restrictions. Mist is reported when the visibility is at least 1000 m but not more than 5000 m with relative humidity greater than 90%. Fog is reported when the visibility is less than 1000 m. Heavy precipitation may also cause low visibilities restricting aircraft operations. Snow is one of the most common factor reducing visibility in cold climates.

Sand storm and dust storm reduce visibilities in arid and desert areas

Weather parameter	Typical MOR value	Absorbing	Wavelength dependent
Sand storm		Yes	Possible
Dust storm		Yes	Possible
Smoke		Possible	Possible
Haze	1000-5000	Possible	Yes
Mist	1000-5000	No	No
Fog	30-1000	No	No
Drizzle	>1000	No	No

Rain	>1000	No	No
Snow	>300	No	No
Blowing snow	>30	No	No

Definitions related to Meteorological Visibility

Some important terms related to the measurement of visibility are defined as follows:

a) **Meteorological Optical Range** is defined as the length of path in the atmosphere required to reduce the luminous flux in a collimated. beam from an incandescent lamp, at a colour temperature of 2700 K , to 5% of its original value. Luminous flux is a quantity represents the magnitude of the response of the human eye to the light beam. MOR has been adopted by WMO as the measure of visibility for both general and aeronautical uses.

b) **Visibility, meteorological visibility (by day) and meteorological visibility at night:** are defined as the greatest distance at which a black object of suitable dimensions (located on the ground) can be seen and recognized when observed against the horizon sky during daylight or could be seen and recognized during the night if the general illumination were raised to the normal daylight level.

c) **Air light:** is light from the sun and the sky which is scattered in to the eyes of an observer by atmospheric suspensoids (and, to a slight extent, by air molecules) lying in the observers cone of vision. Airlight is the fundamental factor limiting the daytime horizontal visibility.

d) **Visual range (Meteorological):** distance at which the contrast of a given object with respect to its background is just equal to the contrast threshold of an observer

e) **Luminous flux (F):** *is the magnitude of light energy emitted, received or transmitted per second.* Unit is lumen

f) **Luminous intensity (I):** *is the luminous flux per unit solid angle.* Unit is candela.

g) **Luminance (L):** *is the luminous intensity per unit area.* Unit is candela per square metre.

h) **Illuminance(E):** *is the luminous flux per unit area.* Unit is lux.

i) **Luminance contrast (C):** *is the ratio of difference between the luminance of an object and its background and the luminance of the background.*

j) **Contrast threshold (ε):** *is the minimum value of luminance contrast that the human eye can detect.* i.e. the value which allows an object to be distinguished from its background. This quantity varies with the individual.

k) **Illuminance threshold(E_t):** is the smallest illuminance, at the eye, for the detection of point sources of light against a background of specified luminance. The value of E_t varies with lighting conditions.

l) **Extinction coefficient (σ):** is the proportion of luminous flux lost by a collimated beam, emitted by an incandescent source at a colour temperature of 2700 K , while traveling the length of a unit distance in the atmosphere. The coefficient is a measure of the attenuation due to both absorption and scattering.

m) **Transmissivity** or **Transmission factor** or **Transmission coefficient (T):** is defined, for a collimated beam from an incandescent source at a colour temperature of 2700 K, as a fraction of luminous flux which remains in the beam after traversing an optical path of a unit length in the atmosphere.

n) **Transmittance (t_b) :** is the transmissivity within an optical path of a given length (say b) in the atmosphere.

RVR measuring techniques

1. Instrumented technique
2. Human observer technique

Instrumented technique:

Common practice is to use **Transmissometer** to measure transmittance of the atmosphere or to use **Forward-scatter** meter to measure the atmospheric extinction coefficient. Then RVR is calculated by considering other factors like characteristics of light and expected detection sensitivity of the pilot’s eye under prevailing conditions of background luminance

Human observer technique:

An observer counts the number of runway lights or markers visible from an observing position near the runway. This number is converted to runway visual range, making due allowance for the differences in light intensity, background, etc., from different viewing positions of the observer and pilot.

Limitations of Human observer technique

- Accuracy and consistency are poorer than those of instrumented RVR systems.
- Multiple locations along the runway must be monitored simultaneously.
- Updating frequency and averaging period as required cannot be adhered to, and
- Fluctuations of RVR, including tendencies, cannot be indicated

RVR is the range over which the pilot of an aircraft on the center line of a runway can see the runway surface markings or the lights delineating the runway or identifying the center line. It is not an observation like surface winds, visibility etc., but it is an assessment based on (a) atmospheric factors such as extinction coefficient of the atmosphere (b) physical/biological factors such as visual threshold of illumination and (c) operational factors like runway light intensity

Presently IMD has installed NAL make Drishti RVR. The base length of drishti RVR is 30m.

The most important factor in assessing RVR is to establish the atmospheric extinction coefficient or the related value for atmospheric transmittance. The extinction coefficient represents the attenuation of light passing through air due to two effects:

- The scattering of light by airborne particle.
- The absorption of light by airborne particles

Two different equation are used to measure RVR

i. Koschmieder’s Law

ii. Allard’s law

Koschmieder’s Law is a method of assessing visibility based upon the relative luminance of a black body against the luminance of the background it is viewed against. It is principally used to assess IRVR in daylight. When calculated from the extinction coefficient using World Meteorological office (WMO) assumptions the result is known as the Meteorological Optical Range (MOR).

Allard’s Law is a method of assessing the visibility of sources of light (such as runway lights). It requires values for extinction coefficient, the luminous intensity of the lights being viewed and the background luminance and is principally used toassess IRVR at night.

Instrumental RVR is measured using two methods:

1. Transmissometer
2. Forward scatter meter

Transmissometer

An instrument that takes a direct measurement of the transmittance between two points in space over a specified path length or base line is known as transmissometers.

The main components of a transmissometer are a light source and a photo detector, where the former forms the transmitter unit and the latter form the receiver unit. The distance between the transmitter and the receiver is called the baseline length of a transmissometer. The base parameter of transmissometer is MOR. MOR is calculated using Koschmieder’s equation.

MOR = (3*b) / $\log_e$ (1/t)

b = baseline length of transmissometer

t = transmissivity within an optical path of a given length (b) in the atmosphere.

At present IMD is using NAL make Drishti RVR for measurement. The baseline length (b) is 30m

On putting 30m baseline length MOR calculation using Koschmieder's equation reduces to

MOR= (3*30) / $\log_e$ (1/t)

= 90 / $\log_e$ (1/t)

t is measured using ratio of reference photodiode voltage at light source(Transmitter) and received photodiode voltage at receiver.

T = K* (PD/Ref) where K is

calibration constantRVR is

calculated using:

a. Atmospheric transmittance from the Transmissometer

b.The background luminance from the background luminance sensors
c. Runway light intensities

Meteorological visibility at night:

The distance at which a light (a night visibility marker) can be seen at night is not simply related to MOR. It depends not only on MOR and the intensity of light, but also on the illuminance at observer's eye from all other light sources.

In 1876, Allard proposed the law of attenuation of light from a point source of known intensity (I) as a function of distance (χ) and the extinction coefficient (σ). The illuminance (E) of a point light source is given by :

$$E= I.\ \chi^{-2}.\ e^{-\sigma\chi} \text{ …………………………(1)}$$

When the light is just visible, E = E_t and the distance can be treated as runway visual range(R):

$$E_t = I.R^{-2}.e^{-\sigma R} \text{ …………………………..(1)}$$

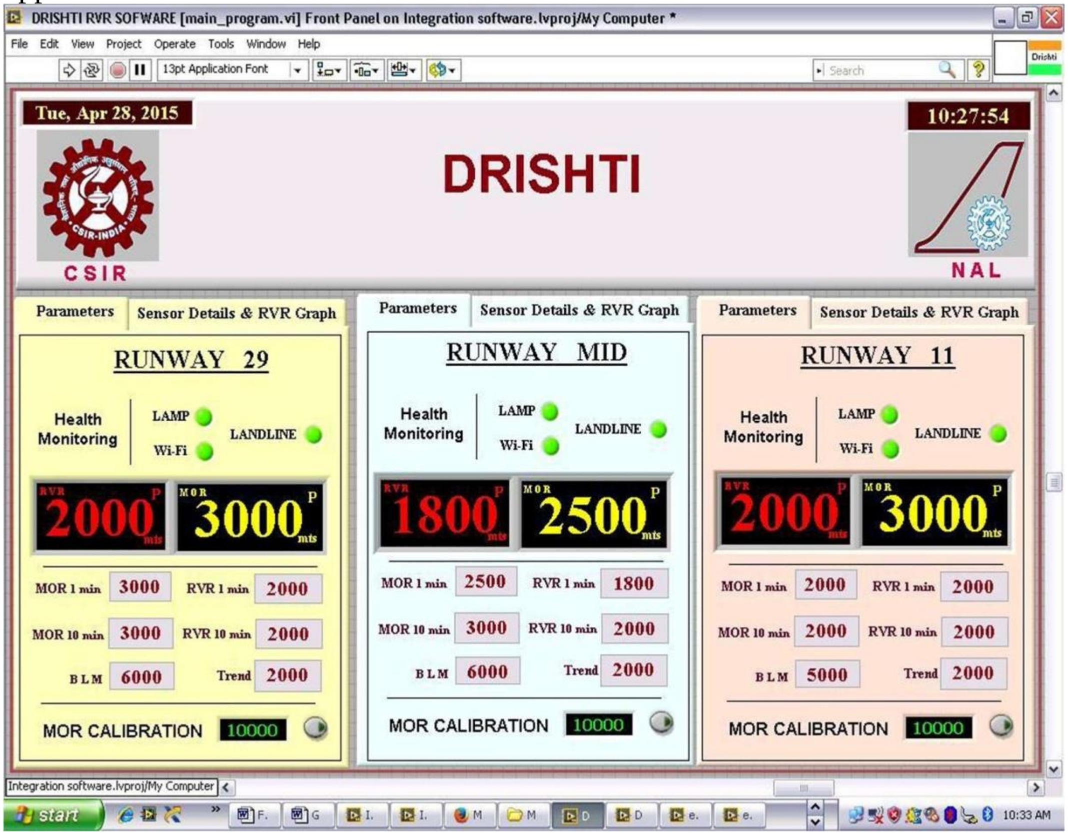
As per equation (2) $e^{-\sigma} = t^{(1/b)}$ …………………(2)

$$\therefore \quad \mathbf{E_t = I.R^{-2}.t^{(R/b)}} \text{ …………………………..(3)}$$

Equation (3) can be used for the calculation of RVR.

c.) Drishti RVR System and Display

The drishti RVR computation software window for 3 RVR system will appear asbelow



DRISHTI RVR SOFWARE [main_program.vi] Front Panel on Integration software.lvproj/My Computer *

13pt Application Font

Tue, Apr 28, 2015

10:27:54

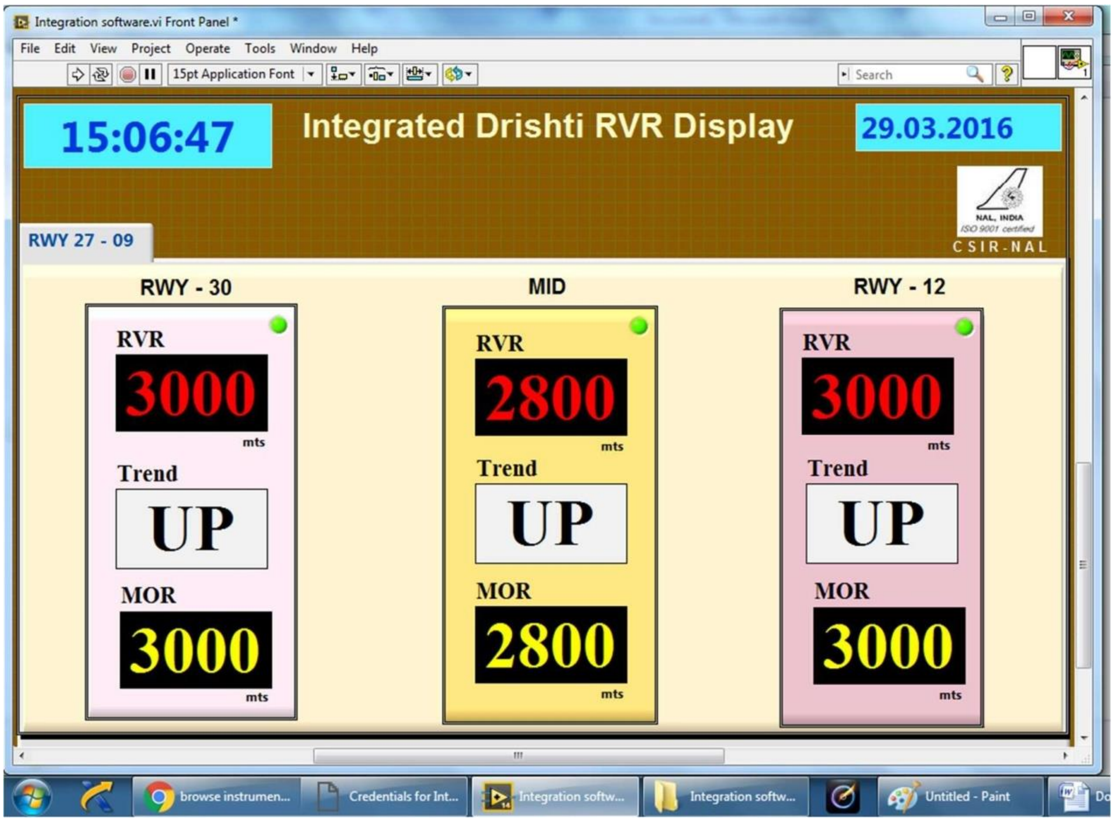
DRISHTI

	RUNWAY 29	RUNWAY MID	RUNWAY 11
Health Monitoring: LAMP	●	●	●
Health Monitoring: Wi-Fi	●	●	●
Health Monitoring: LANDLINE	●	●	●
RVR (P, mts)	2000	1800	2000
MOR (P, mts)	3000	2500	3000
MOR 1 min	3000	2500	2000
RVR 1 min	2000	1800	2000
MOR 10 min	3000	3000	2000
RVR 10 min	2000	2000	2000
B L M	6000	6000	5000
Trend	2000	2000	2000
MOR CALIBRATION	10000	10000	10000

Integration software.lvproj/My Computer

10:33 AM

d.) Integrated RVR Display



15:06:47

Integrated Drishti RVR Display

29.03.2016

RWY 27 - 09

RWY - 30	MID	RWY - 12
RVR 3000 mts	RVR 2800 mts	RVR 3000 mts
Trend UP	Trend UP	Trend UP
MOR 3000 mts	MOR 2800 mts	MOR 3000 mts

Drishti system at field side consists of Transmitter and receiver separated by base length 30m.

Transmitter lamp (LED white light) send collimated beam of light which is received by an optical detector in the receiver (photodiode).

Receiver measure the attenuation of light intensity received from the light source traversing through the atmosphere. The attenuation factor depends on the atmosphere condition between transmitter and receiver like dust particles, fog and rain etc which is representative condition of runway.

BLM is mounted on the receiver side which gives the background light of atmosphere ie bright light, twilight, night, normal day light. Photodiode used as a sensor.

Sensors data will be processed through signal conditioning circuit and converted into digital using 24 bit A/ D converter. Real time embedded controller named FPGA(Field Programmable Gate Array) is also used to convert digital signals. FPGA controller is used to asses and transmits the data to MBR (Met Briefing Room). Data is further processed by drishti embedded software developed by NAL under industry Lab-View platform with visual instrumentation concept.

Processed data sent to MBR upto 10km through two mode of communication (wifi and Landline).

RVR and MOR calculated by Lab view environment by Drishti RVR software using internationally accepted Allard’s and Koschmieder’s Law at MBR PC server.

Chapter 5

Ceilometer

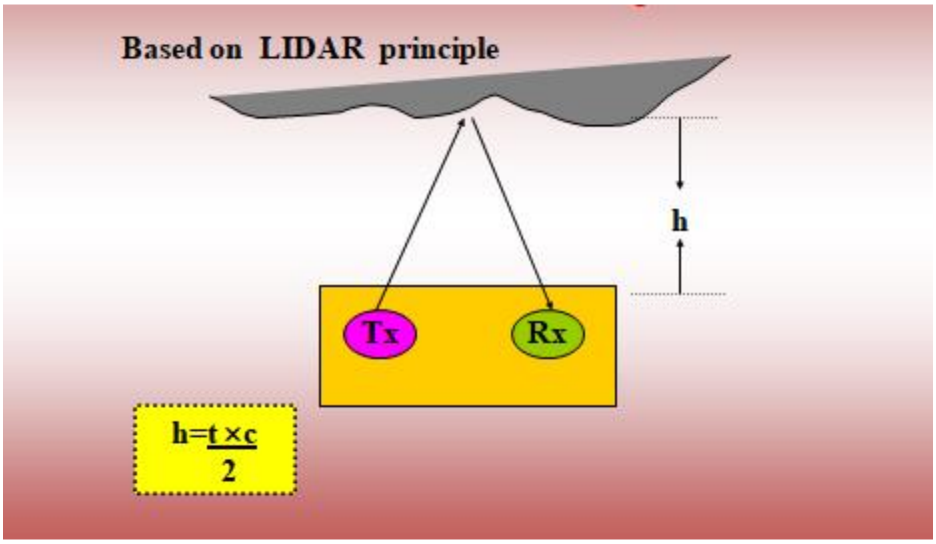
Introduction

The ceilometer is designed for the outdoor environment. The electronic circuits and the optic lenses are protected by a box consisting of a bottom plate, on which the electronic/optical unit is bolted, and a covering hood. The hood has a gasket for sealing against the bottom plate.
The ceilometer measures cloud height or vertical visibility uptp 7600m (25000 feet), The cloud height is measured continuously and can be displayed on several types display units depending upon different needs
The ceilometer functions according to the **LIDAR principle** LIDAR - Light Detection and Ranging where short laser pulses are sent out in a vertical direction and the time of returned reflections are measured continuously. The amplitude of reflected light, the backscatter signal caused by haze, fog, mist, precipitation and clouds is measured as the laser pulses traverse the sky. The resulting backscatter profile, i.e signal strength versus time, is stored and then processed to determine the height or cloud bases. Knowing the speed of light, the time delay between the launch of the laser pulse and the detection of its backscatter signal indicates the cloud has high

$$\text{Cloud base} = \frac{\text{Time x speed of light}}{2}$$

The transmitter in the ceilometer is a semiconductor laser diode. The output power is limited to a level not dangerous for the human eyes provided that the emitted radiation is not concentrated and viewed with the aid of an optical system

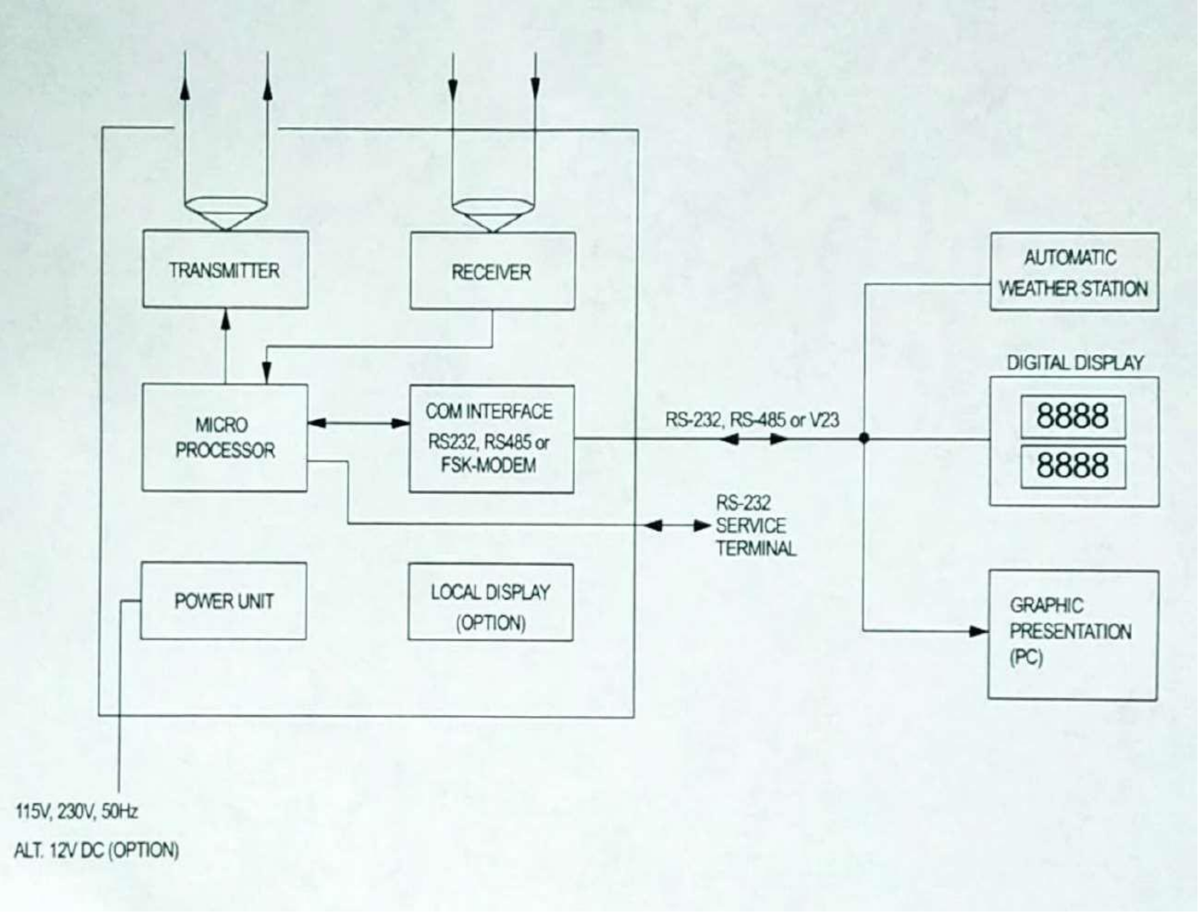
The CBMESOB is able to detect up to three cloud heights simultaneously, Additionally, the sky coverage algorithm can calculate up to four cloud layers and amount. Besides cloud bases, it detects whether there are other obstructions to vision i.e. vertical visibility. No adjustments in the field are needed. The embedded software includes service and maintenance functions and gives continuous status information from internal monitoring.



CBMESOB consists of the following parts

- Power unit
- Master unit
- Processor unit
- Power sensor
- Internal heaters
- Optics

Block diagram of Ceilometer



The electronic and the optical units are mounted on the bottom plate and consist of the following sub units

- Hood
- Case
- Transmitter lens
- Receiver lens
- Mirror unit for transmitter
- Mirror unit for receiver
- Master unit

- Power sensor
- Power unit
- Heater
- Local display (option)

Location

- At location of the ceilometer, the following rules should be considered:
- The ceilometer must have free sight straight upwards.
- Do not locate the ceilometer in the vicinity of trees. Leafs and branches from the trees can fall down on the windows of the ceilometer and disturb the function.
- Avoid location in the vicinity of buildings.
- A shady location is to prefer to a location in direct sunshine, as the stress/aging of the components inside the ceilometer will be less on behalf of lower temperature.
- The "window side" of the hood should be faced from the sun to minimize the light noise.
- The ceilometer should be mounted straight vertical. If it inclines there will be a measuring error, which is negligible under 5 (+0.4%), but will be approximately 2% at 10° inclination.

Equipment Grounding

Equipment grounding protects the electronics of the ceilometer against lightning and prevents radio frequency interference.

The quality of the grounding can be checked with a geo resistance meter. Ensure resistance is according to national telecom standards, typical 5 ohms or less

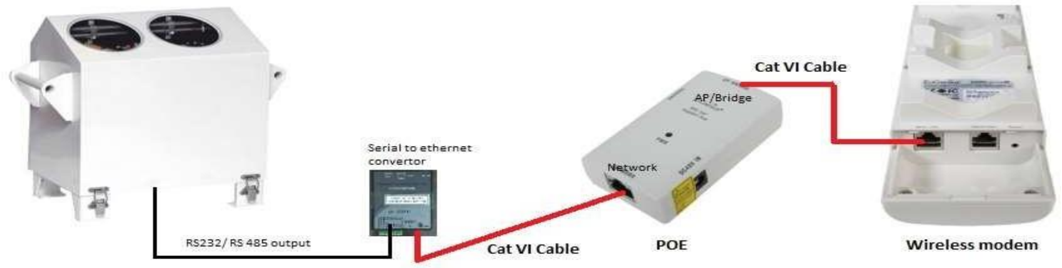
Power Connection

The ceilometer is designed to be supplied from mains, 115V or 230V AC (see label at the power connector at the bottom of the equipment) or alternatively 12V DC (option). It is important that the connection is correct.

At the connection of the ceilometer, consideration shall be taken to the following points:

- Power cable should be suitable for its purpose (environment, security requirements etc.).
- Check the power supply voltage at the ceilometer.
- Protective earth shall be connected.

Communication setup at runway site



Chapter 6
Transmission of Runway met data

The runway met data from field site is transmitted to the MBR/ATC using two modes of communication

1.) Landline Communication
2.) Wireless communication

The landline communication servers as the primary mode of data communication and wireless data communication servers as standby mode of data communication.

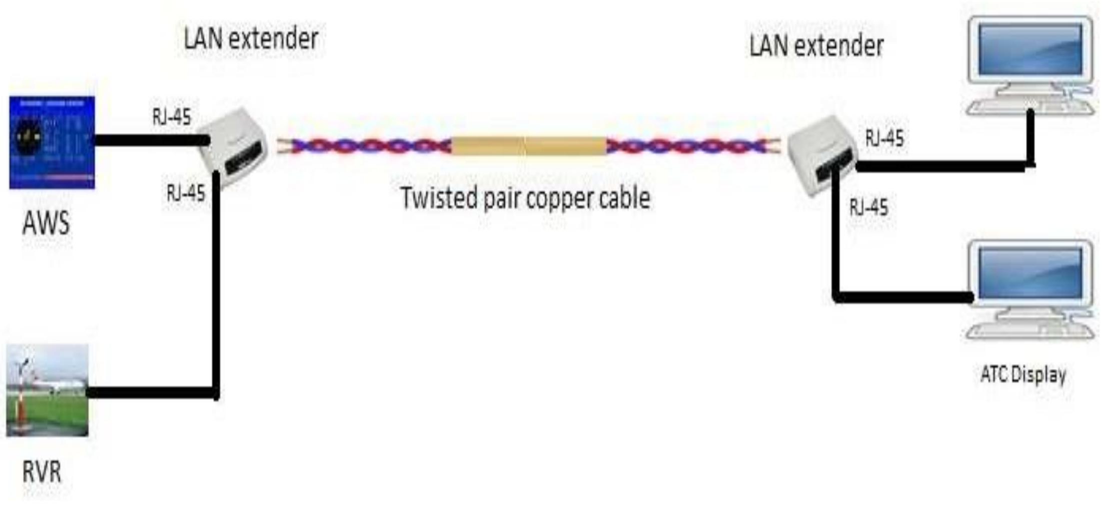
Landline communication using copper cable

The landline communication has been traditionally implemented through twisted copper pair cables. The twisted pair cable contains a pair of copper wires- usually color coded – that are twisted around each other. The application is basically a LAN extension for which high speed lan extenders are used. LAN extender uses a fixed IP address for identification and communicating via cable. The Modem uses Packet switching. Converts Ethernet signals to TTL and modulates (QPSK)and sends over a pair of cable and also receives QPSK signal demodulates convert TTL and finally to Ethernet signal.

The typical specifications of LAN extender are:

a.) 4 ports RJ45 for 10/100Mbs Ethernet port for data interface
b.) RJ-11 port for G. SHDSL connection
c.) 1 console port for local configuration and management

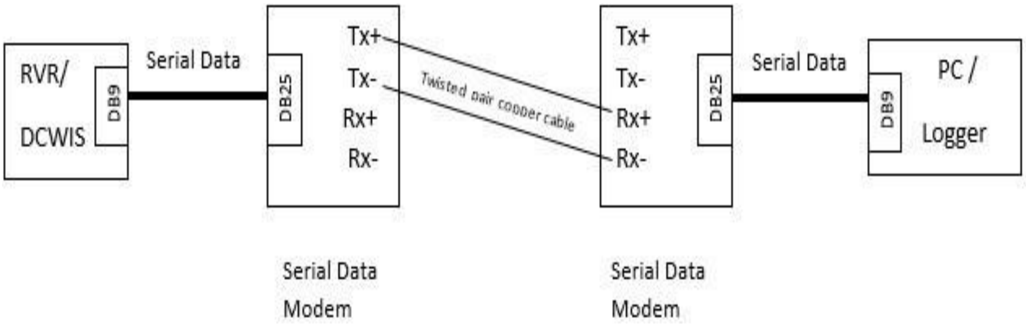
Block diagram (Ethernet data)



At places where serial data is only available from the DCWIS/DIWE/RVR the serial data may be transmitted over copper cable using serial line driver /serial data modems. Serial line drivers are available with data rates up to 19200 bps. The line drivers are designed to interconnect RS232 compatible devices where dedicated copper cables are available.

The default data rate of 9600 bps is generally employed in IMD. For longer distance lower data rate of 1200 bps should be employed for successful data transmission. The copper line is connected at Tx, Tx- terminals of modem at the runway site and at Rx+,Rx- terminals of modem at the MBR site. The Tx+ and Tx- terminal of transmitting modem must be connected with Rx+ and Rx- terminals respectively.

Block Diagram (Serial Data)



Resistance plays an important role in the selection of twisted pair copper cable. The data transmission distance covered depends both on the specifications of the LAN extender/serial line driver and the copper cable deployed. For new installation the required specifications of copper cable, LAN extender, Serial line driver may be obtained from SID Pune

Landline communication through OFC

Fiber optics has revolutionized the data communication. Because of its advantages over electrical transmission optical fibers have largely replaced the copper wire communication

The process of communicating using fiber-optics involves the following basic steps:

1. Creating the optical signal involving the use of a transmitter, usually from an electrical signal
2. Relaying the signal along the fiber
3. Receiving the optical signal
4. Converting it into an electrical signal

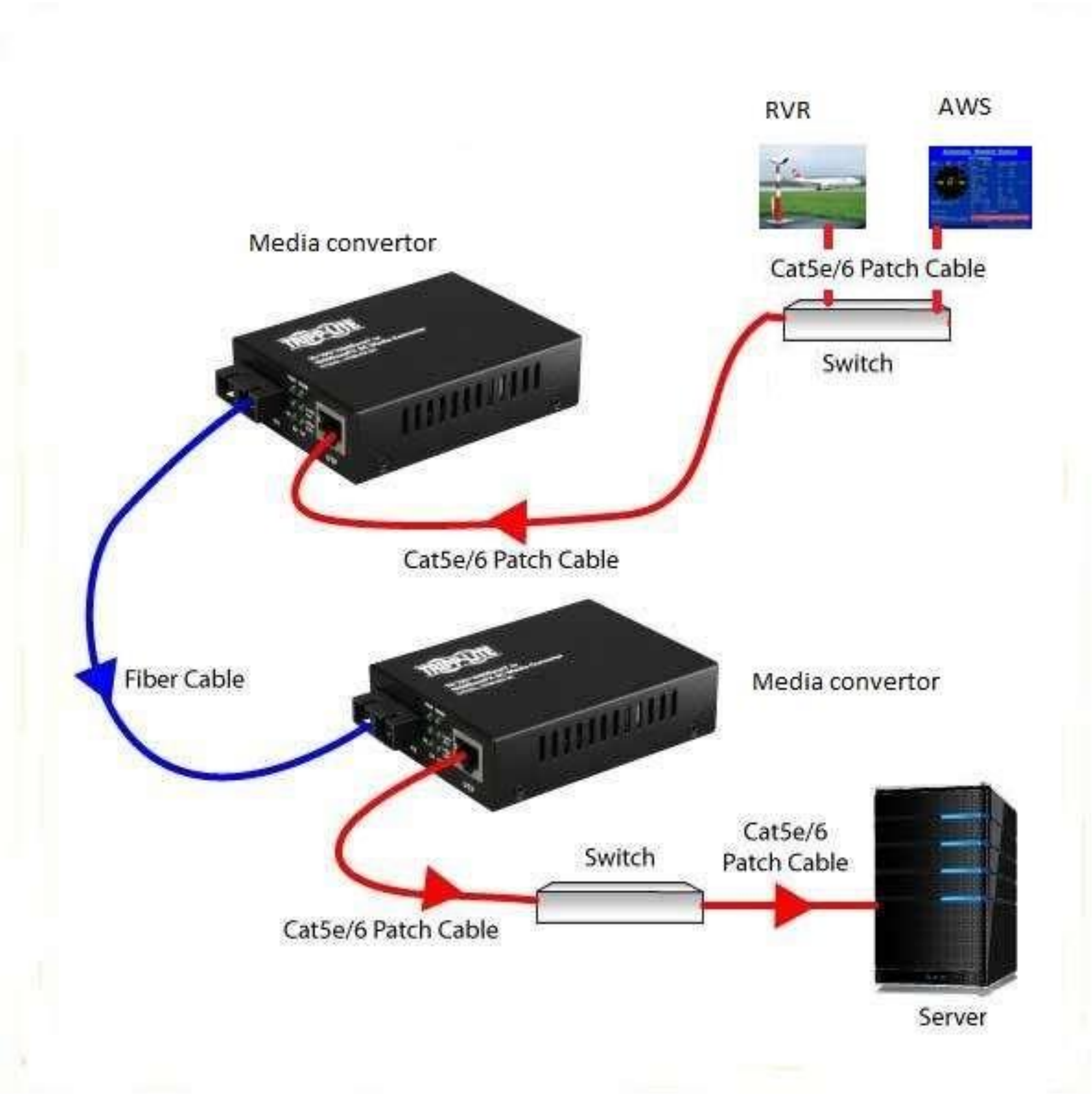
The basic components are light signal transmitter, the optical fiber, and the photo detecting receiver. is a method of transmitting information from one place to another by sending pulses of infrared light through an optical fiber. The light forms an electromagnetic carrier wave that is modulated to carry information. Fiber is preferred over electrical cabling when high bandwidth, long distance, or immunity to electromagnetic interference is required.
The classification based on the mode of propagation of light is as follows:

- **Single Mode Fibers:** These fibers are used for long-distance transmission of signals.
- **Multimode Fibers:** These fibers are used for short-distance transmission of signals.

At present at IGI Airport Single mode fibers have been deployed to cover long distance. The major specification of OFC are

Sno	Specification of Cable	Requirement
1	General requirement	
1.	Life of Cable	25Years
II	Type of Cable	Single Mode Optical Fibre as per ITU-T REC G652D
2	No of Fibres	6/12Core with six different colours.
3.	IMFD	8.8µm to 9.8 µm
4	Cladding Diameter	125 µm ± 1 µm
5	Cladding Non-Circularity	<=1%
6	Core-Clad Concentric error	<=0.6 µm
7	Diameter over primary coated with Double Cure acrylate (Shall be measured on uncoloured	245 µm ± 10 µm
8	Coating Cladding Concentricity	<=12 µm
III	Transmission Characteristics	
1	Attenuation at 1310nm	<=0.36dB /KM
2	Attenuation at 1550nm	<=0.23dB/KM
3	Attenuation at 1625nm	<=0.26dB/KM

Block Diagram



OFC Media convertor

A **media converter** is a device used to connect media that would otherwise be incompatible. It is used to link fiber optic cable to twisted pair for supporting ethernet-compatible devices. It may also link together networks comprised of coax cable, and single-mode to multi-mode fiber optic cable. In IMD fiber optic cable to ethernet convertor is deployed. The Optical end of media convertor can be SC, LC, FC etc. depending upon the requirement.

Media convertor types
- a.) Single mode media convertor
- b.) Multimode media convertor

Selection on media convertor depends upon the OFC deployed (i.e single mode optical fiber cable or multimode fiber cable) Generally single mode OFC is laid for met data transmission form the runway to the MBR/ATC etc.

Single mode Media convertor deployed at IGIA Delhi

Single mode OFC connectors

**For new installations the specifications of OFC cable, Media convertor, switch, network layout, connectors etc. may be obtained from SID Pune*

Wireless data communication

Wireless Modems used in the field of aviation instrumentation for communication of data from Runway site to MBR/ATC. Wireless data communication is deployed as standby mode of data communication. In case of failure of primay landline communication channel wireless data transmission can be deployed for restoration of met data in less time. Wireless mode is easy to deploy.
The frequency used for Transmission is 2.4 GHZ or 5.8GHZ ± 22MHZ with at least 12 Channels. These modems are to be configured for establishing communication. The Modems can transmit up to 29dBm radiating power with internal antenna of 10dbi gain so that no external antenna is required. The minimum receiving signal strength capability is up to -90dbm. The modems is capable of communicating in a free air with no obstacle up to 10KM radial distance however during heavy rain or Fog the max range of communication may be limited to 8Km or more due to some percentage of scattering and reflection of 2.4GHZ or 5.8GHZ signal.

The wireless modems are deployed in point-to-point communication. The modem deployed at runway is configured in Access point (AP) mode and modem deployed at ATC tower is configured in client bridge (CB) mode

Block diagram