Development and Production of GPS based Radiosonde

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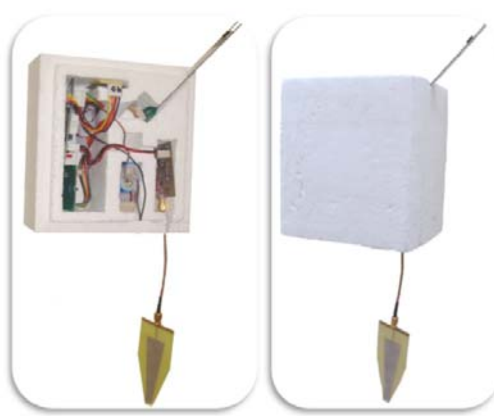
ABSTRACT

Radiosondes have been used for measurement of vertical profile of the atmosphere viz., Temperature, Humidity, Pressure, Wind Speed and Wind Direction, since long time. Constant innovations have prompted changes in the technology behind the development of the Radiosondes and its sensors. India Meteorological Department (IMD), the National Weather Agency of the Indian government has been constantly upgrading its Radiosondes for measurement of upper air data in the Indian sub-continent

GPS based Radiosonde is the latest Radiosonde being developed in-house for production at IMD workshop in New Delhi. The sonde consists of sensor package, GPS Receiver Module, Data Integrator Board (DIB) and a 1680 MHz transmitter with Antenna. The DIB is capable of collecting data from different sensor packages, as well as from GPS module every one second, and sends the integrated data frame to ground system via the transmitter. The ground system consists of 1680 MHz receiver unit and 7-element antenna system to cover the entire hemisphere of sky at all possible elevation angles. This paper delves in detail the rationale, data accuracy, stability etc. behind this development. This system has better frequency stability, low power consumption and a low cost Ground system. Initial test results have been quite encouraging and are comparable to the industry standards.

1. Introduction:

The electronic sub system of Radiosonde is used to measure the atmospheric pressure, temperature and relative humidity with high accuracy. It can also accept NMEA Position fix data from standard GPS Receiver modules for calculating winds as well as atmospheric pressures at various levels. The Radiosonde system consists of four modules viz., sensor package, Data Interface Board (DIB), GPS Module, and 1680 MHz transmitter with antenna. The sensor package mainly comprises of temperature, and humidity sensors and an



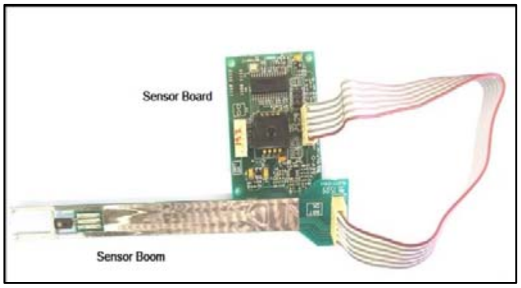
optional pressure sensor. It has been interfaced with Vaisala, Honeywell, and Chinese make sensor packages. The transmitter is a 1680MHz Frequency Shift Keying (FSK) system that transmits processed data frame from DIB to the ground receiver system for atmospheric parameter measurement. The system runs on 6-9 V alkaline battery and hence is light-weight measuring 300 grams (approx.)

2. Sensor Packages

The Radiosonde system provides interface to acquire data from various sensor packages. The rationale behind this feature is to avoid dependence on one particular make of sensor package. Currently, the sonde is successfully integrated with three different sensor packages viz., Vaisala, Honeywell, and Chinese-make sensor packages. To use the sonde for a specific sensor package, the DIB has to be programmed to suit the sensor package and the entire hardware remains the same.

a. Honeywell sensor Package

The Honeywell sensor package comprises of Boom and controller PCB. The boom PCB is in direct contact with the external atmosphere which consists of an external temperature sensor and humidity sensor. The pressure and internal temperature sensors are housed in the controller PCB. The Honeywell card sends fully calibrated and compensated data through serial peripheral interface (SPI). This sensor package is fully calibrated and the calibration data is stored inside the uC chip, making it ready to use directly.



b. Vaisala Sensor Package:

The Vaisala Radiosonde sensor package RS928 has a capacitive pressure, a temperature and two humidity sensors. The two humidity sensors are pulse heated so that while first sensor measures the other is heated. This eliminates humidity sensor from freezing due to excess condensation when the sonde is flying through cloud. Another special feature in the transducer unit is, reconditioning process, in which the humidity sensors are heated during radiosonde ground preparation to drive off any contaminants that may have accumulated during storage. Vaisala RS928 transducer unit's oscillator converts sensor capacitance information to corresponding frequency signal.

The Vaisala sensor package generates eight different frequencies. The Vaisala sensor package is interfaced with the Data Integrator Board, which digitizes the Vaisala sensor's package pulse signals (7 – 10 KHz) and transmits each digitized frequency value to the

transmitter. The frequency of pulse signal is measured with accuracy of 0.01 Hz by the onboard micro-controller of DIB. To achieve this accuracy, the pulse repetition period of 700 pulses is measured using 10 MHz clock.

c. Chinese Sensor Package:

The chinese sensor package comprises of Boom and controller PCB. Sensor boom is in direct contact with the external atmosphere, which consists of an external temperature sensor and humidity sensor. The sensor card sends resistance and capacitance values in hexa-decimal format, corresponding to temperature and humidity respectively through serial peripheral interface (SPI). This physical parameter data is extracted using calibration coefficients provided along with each sensor package.

3. GPS Receiver Module:

The Radiosonde can be used with any standard OEM GPS receiver module with fully integrated antenna package. The GPS Receiver Module is interfaced with receive pin of the serial port on DIB. The GPS module provides data in different formats as per the standard "NMEA 0183, Version 3.01". The position-fix data (frame starting with $GPGGA) is acquired by the DIB and sent to the transmitter.

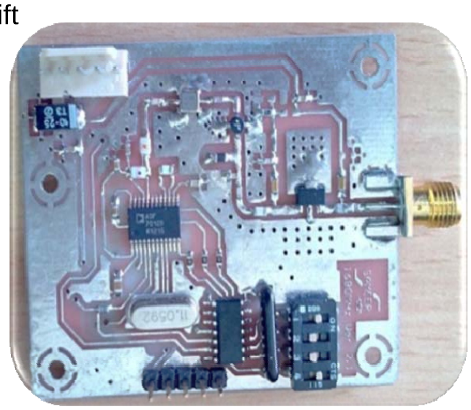
The GPS receiver module gives the position data in terms of geographic coordinates which are referred to the global geodetic datum, WGS 84 (World Geodetic System 1984). For the purpose evaluating the drifts, the geographic co-ordinates are converted to map coordinates (like Universal Transverse Mercator system, UTM), which are in terms of distance units.

4. Data Integrator Board

The Data Integrator Board is a micro-controller board designed to acquire and integrate data from sensor package, GPS Receiver module and provides the data frame to transmitter. It can interface several sensor packages like Honeywell, Vaisala, Chinese sensor packages and any standard OEM GPS receiver with UART interface. DIB also provides supply to sensor card as well as GPS module. The acquired data is sent to the transmitter

synchronously, with the clock signal being provided from the transmitter module at a baud rate of 2400bps.

5. Transmitter



The transmitter is a 1680/403MHz Frequency Shift Keying (FSK) system that transmits processed data from the Data Integrator Board to the ground receiver system through radio telemetry. The transmitter is interfaced with the 1680/403MHz transmitter port on the DIB card. The Data TTL pin carries the string to be modulated (Modulating signal), in synchronization with the transmitting clock and is then transmitted to transmitter card for further modulation. Monopole Patch antenna is used to transmit the data from the transmitter, which radiates at 1680MHz.

6. Ground Receiver System

The Radiosonde Ground system consists of an indoor receiver unit, IDU (common for both 403 and 1680 MHz) along with an outdoor Antenna Unit, ODU (Separate for 403 and 1680 MHz). The ground based receiver acquires and demodulates the Radiosonde signal containing GPS, sensor data, battery parameters and sends it on a serial RS232 port. This data is acquired by PC based software in real time. The software further processes and displays the data as required by IMD.

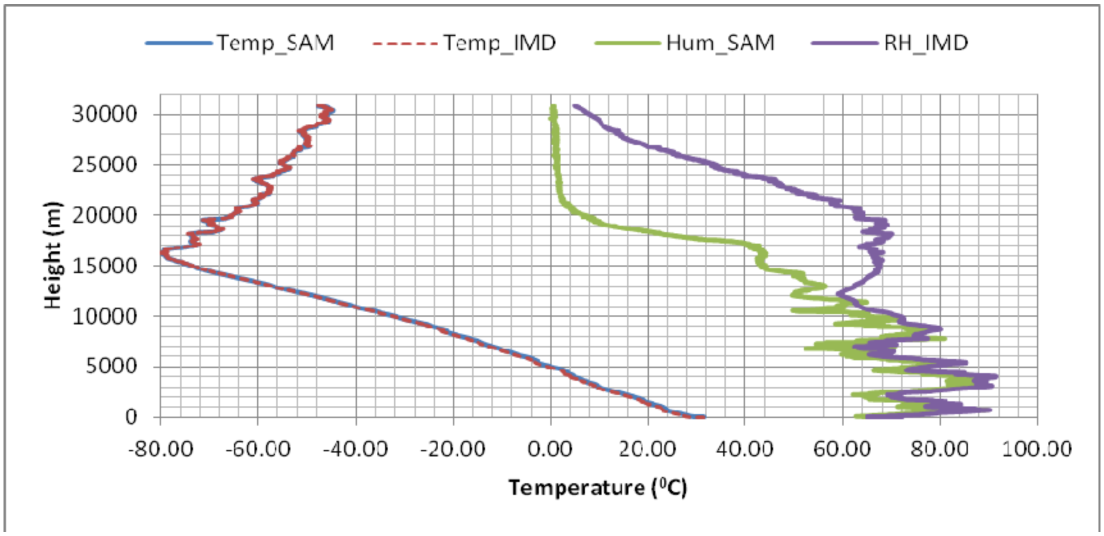
7. Testing & Validation

A series of simultaneous test flights had been undertaken both at Chennai and Mumbai during Sep, 2013 and Jan, 2014 respectively.

The performance of all sub-systems of radiosonde and ground receiver system have been evaluated and validated. During the flights, both vaisala and chinese sensor packages were flown.

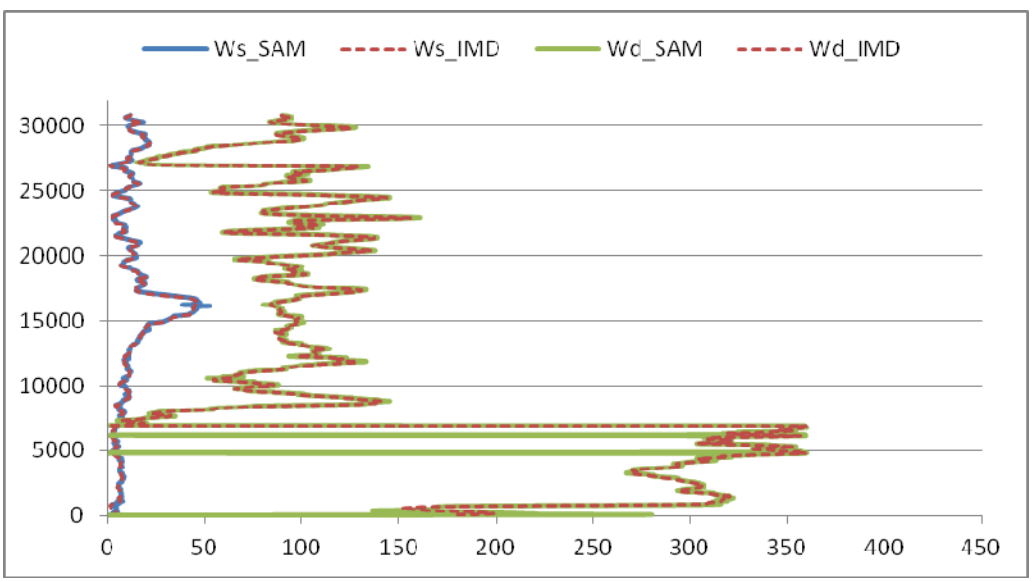
8. Results

Comparison is done between data acquired from GPS-sonde developed with reference Radiosonde available at IMD, Chennai. Comparison shows a good agreement between data from both the radiosondes, though the humidity values of reference sonde are doubtful above the height of 12 km.



9. Conclusion

Test results have been conducted and compared with Vaisala MW31 system. Comparison details are given below and are in good agreement with the tolerance limits of the concerned parameter.



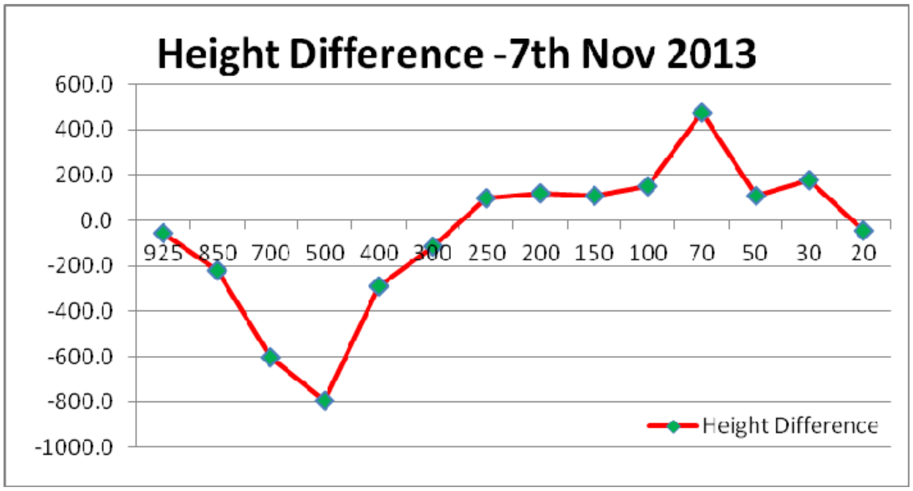


Fig-A

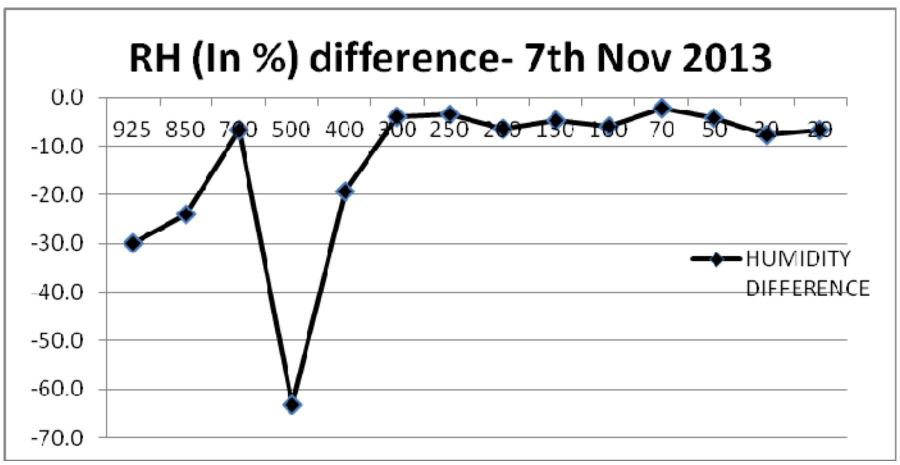


Fig-B

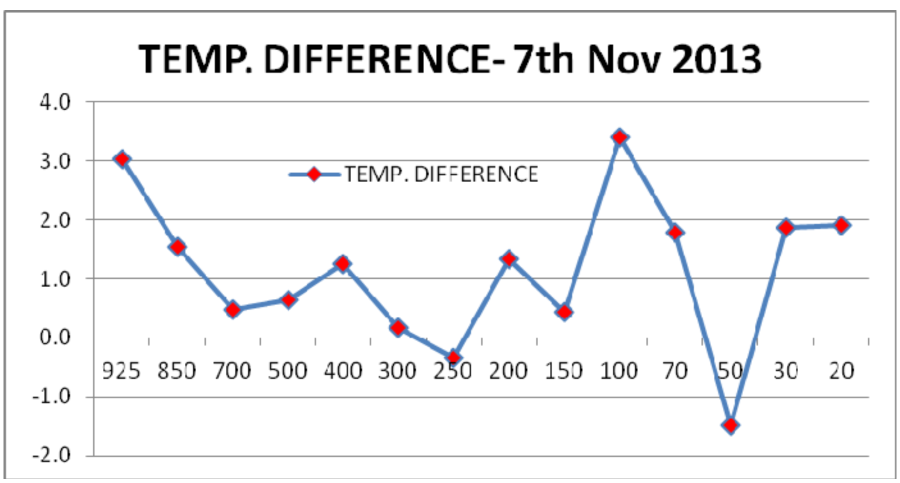


Fig-C

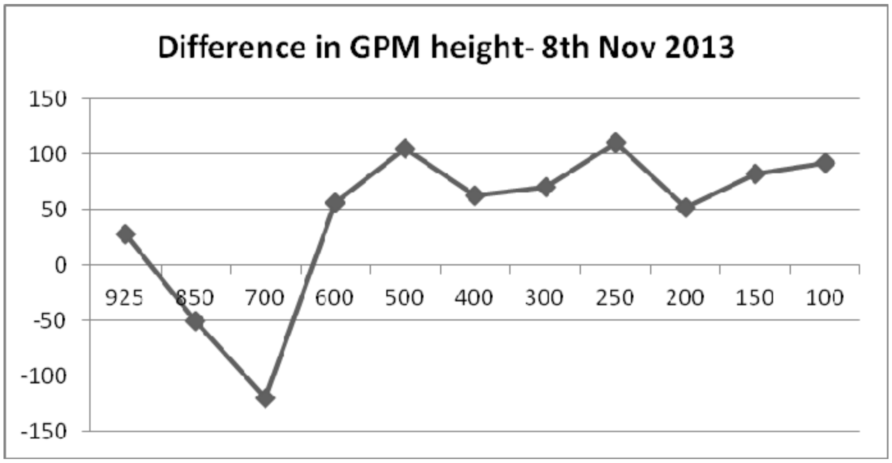


Fig-D

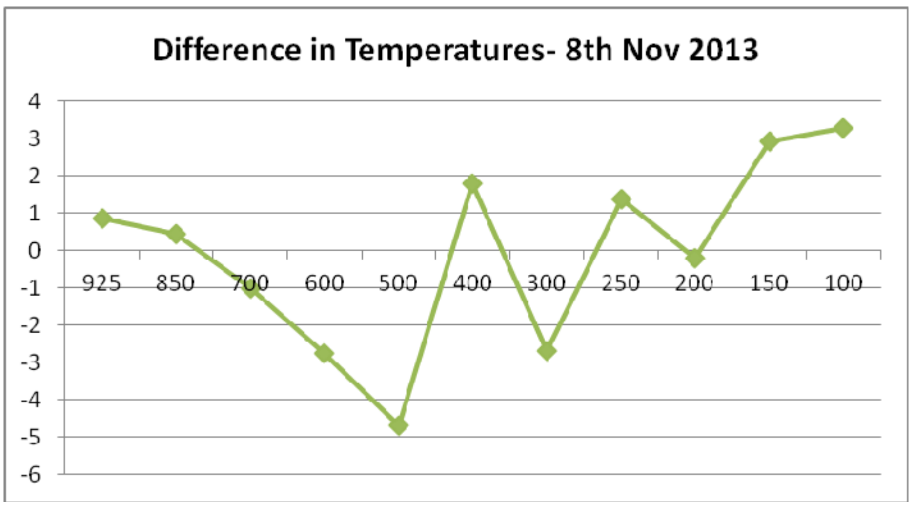


Fig-E

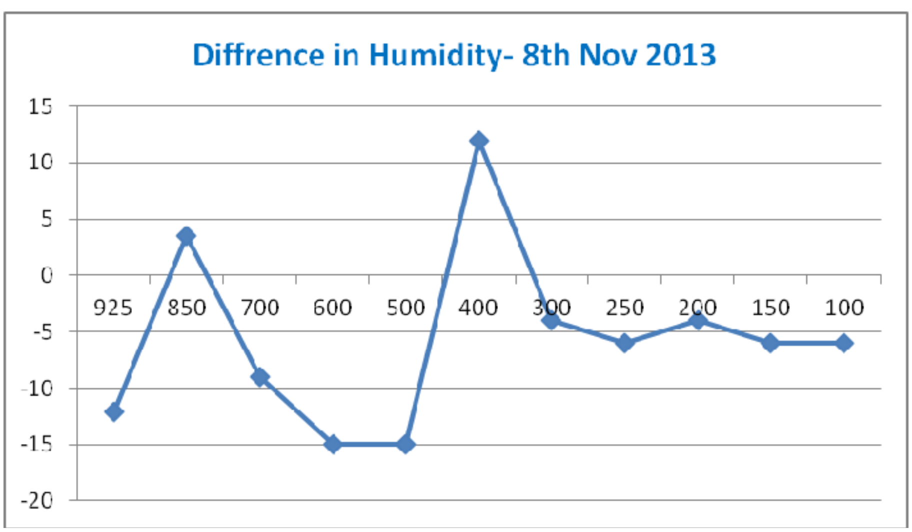


Fig-F