Pilot-sonde Method of Upper Air Observations

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ABSTRACT: Most of the Meteorological agencies in the world have adopted the GPS based system of observations for use in Radiosonde observations. The GPS technique can be utilized for Pilot Wind observations also. This paper is an attempt to describe the design and development of GPS based Pilot Wind observing system for upper air exploration. The GPS based ground receiver systems being used in RS/RW observations can be used for Pilot Wind observations, hence no separate ground equipment are required. The cost of GPS modules available in the market shows a reducing trend due to competition in the market. Hence, this has become now a viable option for getting accurate Pilot Wind observations in all weather conditions up to height of more than 20 Kms, hence a considerable improvement over the traditional Pilot Wind observation method using optical theodolites.

1. Introduction:

[1]Under the co-ordination of World Meteorological Organization (WMO), as part of the global meteorological network, radiosonde measurement are generally carried out at synoptic times (0, 6, 12 and 18 UTC) across the globe. Radiosonde launches are carried out twice a day at more than 700 sites and four times a day at more than 300 sites. Besides these, around 540 stations taking pilot wind observations only.

Radiosondes measure all atmospheric variables like, pressure, humidity and temperature as well as wind speed and direction across the full vertical profile however only measurements at standard and significant pressure levels are stored and archived having typical resolutions from 100 to 1000 meters, whereas Pilot Wind observations are restricted for observations of upper air profile of wind speed and direction only.In this, the balloon is tracked for upper air wind data (Wind direction and wind speed) with the help of optical theodolites. The data availability through the conventional method of observations by optical theodolites have constraints of getting less data in disturbed weather like fog, rain, cloudiness etc when it is eagerly needed. To overcome these weather constraints a weather proof system of Pilot Wind observations is required[2].

As in the Radiosonde observations, most of the Meteorological agencies in the world have adopted the GPS based system of observations. On the same lines using the GPS technique the Pilot Wind-sonde has been developed and may be used in the upper air observations, and Pilot Wind observation network may be further modernized globally.

2. Concept

[3]The Global Positioning System (GPS) is a space-based global navigation satellite system (GNSS) that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver with some technical limitations. Originally intended for military applications but in the 1980s the government made the system available for civilian use. It consist of 24 satellites placed into the orbit. Using messages received from a minimum of four visible satellites, a GPS receiver is able to determine the times sent and then the satellite positions corresponding to these times sent.

While in upper air wind observations the latitude and longitude values obtained at each second is used for computing the drift of balloon by converting geographic co-ordinates to units electronic map (UTM) co-ordinates viz. North and East components (Northings and Eastings). Thus the wind components in zonal and meridional directions are then computed from these Northings and Eastings. The data is filtered to remove the noise before final winds are calculated.

3.Hardware requirements:

The system requirement can be divided into two parts;

A. The ground receiver system
B. The Pilotsonde

The GPS based ground receiver systems being used with RS/RW system can be used for PB observations, hence no separate ground equipment are required. There are so many different types of brands available in the world market which can be directly used.

The pilot-sonde block diagram is given below;

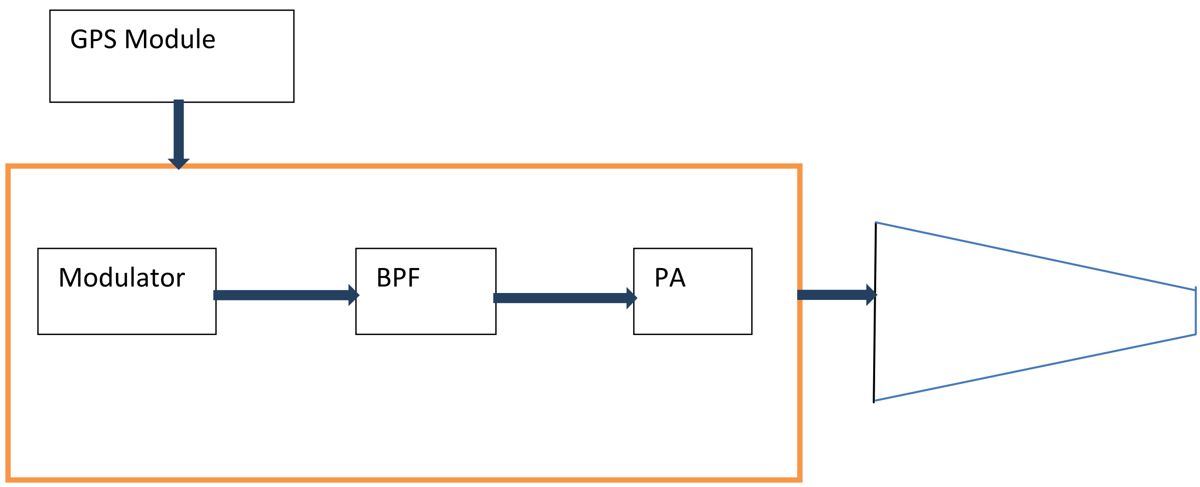

Fig.-1

The fig. 1 above shows the block diagram of Pilot-sonde. It uses a basic integrated circuit to generate the radio frequency and this carrier frequency can be frequency modulated. The GPS signal is modulated on the carrier frequency. Output of the modulator is filtered using a band pass filter (BPF) and amplified by a medium power amplifier (PA). The final output power is +22dBm at the antenna input port. A wideband printed monopole antenna with 3 dB gain is used to radiate the signal whose schematic is shown in fig. 2 below;

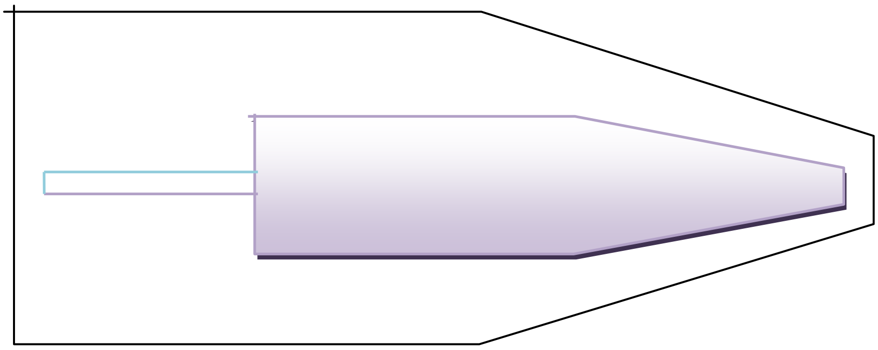

Fig.-2

4. WORKING

The schematic circuit diagram of Transmitter is given below in fig-3;

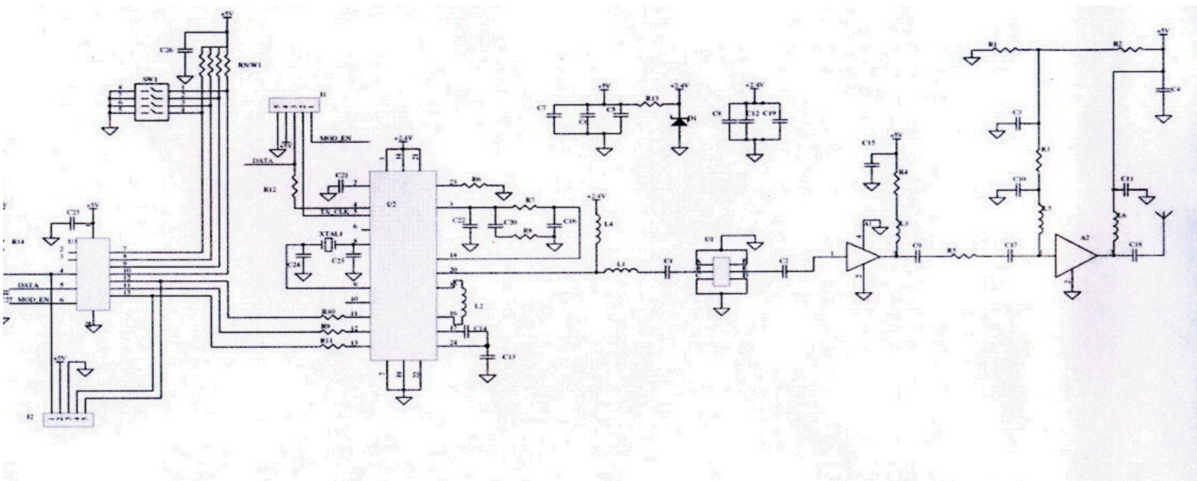

Fig-3

A low cost, 14 pin Micro-controller (8 bit RISC) in SOIC package, having in-circuit serial programming facility is used in the transmitter circuit. The microcontroller has power on reset and power saving sleep mode facilities. The microcontroller provides input to the modulator in RS-232 (TTL level) format.It also provides the selection of carrier frequency (1677-1683 MHz). The positioning signal from GPS module is modulated by modulator. The FSK (Frequency Shift Keying) modulation technique has been used in the transmitter. It generates 840 MHz fundamental and 1680 MHz harmonic frequency. The modulator has the facility to program output power and frequency. The modulated signal is passed through a band pass filter, which filter out the fundamental frequency of 840 MHz and allows the 1680 MHz frequency to pass. A SAW filter having bandwidth of 20 MHz is employed in the circuit. The signal before transmission is amplified using pre-amplifier with 22 dB gain and a power amplifier having 16 dB gain. The amplified signal is transmitted using a monopole antenna. The detailed technical specifications are given below in table-1 for transmitter and in table-2 for GPS module;

a. Technical Specifications of Transmitter

Table-1

S.No.	Parameter	Specifications
1	Frequency range	1680 MHz +/- 3 MHz
2	Modulation	FSK
3	Frequency Deviation	+/- 50 KHz
4	Frequency Step	1 MHz
5	Carrier frequency settings	By DIP switch settable
6	Output Power	+22 dBm +/- 1dB at antenna input
7	Antenna Gain	3 dBi
8	Antenna Type	Printed Monopole Antenna
9	Supply Voltage	+5V
10	Current	190 +/-30mA @+5V

b. Technical Specifications of GPS module;

Table-2

S.No.	Parameter	Specifications
1	Dimensions	30.0 x 30.0 x 8.0 mm
2	Antenna	Fully integrated Embedded
3	Channels	20
4	Tracking	Code pulse carrier tracking
5	Tracking capability	20 satellites simultaneously
6	Horizontal accuracy	2.5 m (CEP),5.5m 2dRMS
7	Velocity accuracy	Speed<0.01m/s; heading <0.01˚

8	Operating Environment temperature	–10°C to +60°C,Humidity- up to 95% non-condensing Altitude-305 m to 18000 m
9	On-board Filtering	L1 –75 MHz, –30 dB, L1 +50 MHz, –20 dB
10	Electrical input power range	3.3VDC - 0.3/ + 0.3VDC, on board battery back-up for SRAM and RTC
11	Power Consumption	average sustained power (after 1st solution)152 mW
12	Data interfaces	CMOS-level (3.3 VDC) Selected NMEA-0183/SiRFbinary messages:SiRF binary interface
13	Acquisition / Reacquisition Performance	@-125 dbm Hot start TTFF: <1s (90%), 500 ms (typical) valid almanac, time, position and ephemeris Warm start TTFF: 36 s (90%), 31 s (typical) valid almanac, time and position Cold start TTFF: 38 s (90%), 33 s (typical) valid almanac

5. SOFTWARE REQUIREMENTS: The wind computation part of the RS/RW software has been used in the pilotsonde observations, as it is capable of displaying real time wind data with graphical user interface, complete processed results along with plots, generation of flight report and coded PB messages.

6. DISCUSSION and CONCLUSION: Ten sets of ascents have been compared between conventional pilot balloon using 30 gm balloons and GPS based pilotsonde using 300 gm balloon, on trial basis during July 16-25th 2012. The details are given in the figure- 4 below;

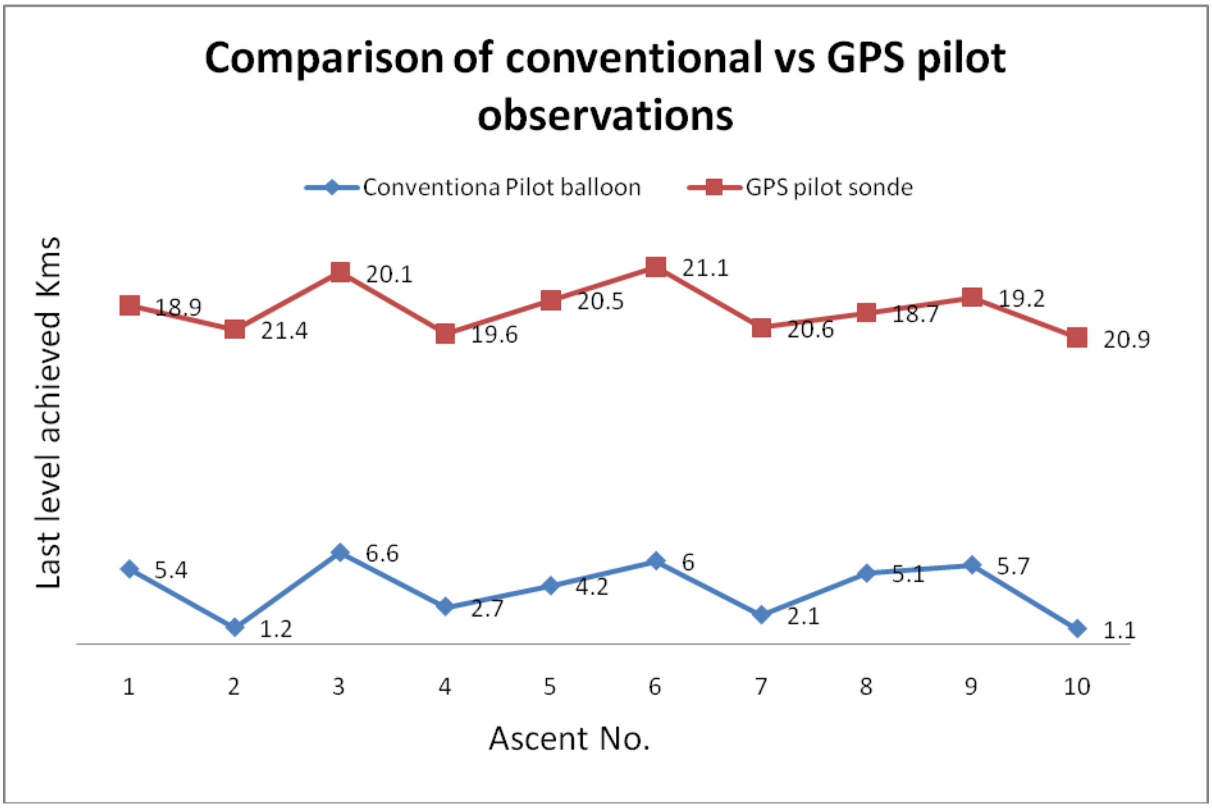

Fig-4

It is evident from GPS based Radiosonde ascent that the flight termination in most of the cases is balloon burst. The GPS receiver does not lose the signal while ascending. The data availability depends mainly on the quality of balloon in all weather conditions. Whereas, the presently used Pilot Wind observations using optical theodolites are heavily dependent on weather conditions. We get more data in clear weather and the data availability decreases with adverse weather when the data requirement increases and we get less data or no data although it is eagerly required by the forecaster. The average height of Pilot Wind observations is of the order of just 4 to 5 km only, mainly because of weather constraints. The use of GPS based system in PB observations is expected to remove all these constraints and average height coverage increased to 20 Kms or more using pilot sonde. The only disadvantage of the system is to provide each of the station;

i) A GPS receiver system at each station with PC set up instead of optical theodolite.

ii) Daily consumption of GPS Pilot-sonde.

The receiver and PC set up are one time investment only (most of the pilot wind observation stations are already equipped with PC) against the provision of optical theodolites, hence no additional financial burden. The additional financial liability is the use of daily GPS based pilot-sonde. For the data availability to a large extent, in most of the cases up to 20 Kms of height, especially in adverse weather conditions, when the data is eagerly awaited, the investment is justified. Hence it is feasible to implement the use of pilot-sonde on operational basis in upper air network at Pilot wind observing stations. Initially it may be implemented on trial basis selecting some important stations as per the requirement of individual networks.

7. ACKNOWLEDGEMENT:

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