#### **GPS** Radiosonde System





Semiconductor Laboratory Department of Space, Govt. of India

www.scl.gov.in

#### About SCL

- Semi-Conductor Laboratory (SCL) is an autonomous body under the Deptt. of Space, Govt. of India
- Engaged in Research & Development in the area of Microelectronics to meet the strategic needs of the country.
- SCL has integrated facilities and supporting infrastructure all under one roof and undertakes activities focused on Design, Development, Fabrication, Assembly & Packaging, Testing and Quality Assurance of CMOS and MEMS Devices for various applications.

#### SCL Activities Outline

- ASICs and Standard Blocks: Many of the ASICs, CCDs and standard blocks developed by SCL are being used in launch vehicle, satellites and payloads.
- VLSI Design: SCL implements full EDA Flows for Digital, Mixed Signal and Analog ASIC Design.
- Wafer Fabrication Lines:
  - 180 nm, 8" CMOS Process for Fabrication of products in Digital, Mixed Signal and Analog domains
  - Micro-Electro-Mechanical-System (MEMS): Fab line
- Packaging, Testing and Screening: For High-reliability devices
- Systems Assembly: Development of Electronic Systems & Subsystems viz. Radiosonde



#### Introduction

- The GPS Radiosonde is used to measures the atmospheric parameters up to a height of 40 kms using hydrogen or helium balloons.
- The indigenous Radiosonde system designed and developed by ISRO is named as Pisharoty Sonde system.
- The atmospheric parameters, temperature and humidity, (TH) are measured using sensors and pressure along with wind velocities are derived from GPS data.



• Provide a low cost GPS Radiosonde system using the state of the art technology meeting the standard specifications.

Parameter	Range	Accuracy
Pressure	0 to 1100mBar	±1.4 mBar
Temperature	-100°C to +50 °C	±1°C
Humidity	0 to 100% RH	± 5% RH
Wind velocity	0 to 500 m/s	±0.1 m/s

# Features of developed system

- No custom made ICs/components.
- All commercially off the shelf (COTS) ICs.
- SMD components (machine solderable).
- No tuning elements.
- Ease of manufacturing.
- Low cost and portable ground station.

### GPS Radiosonde system



### On board system

- Temperature and Humidity sensors.
- GPS receiver module with integrated patch antenna.
- FSK transmitter (400-406 MHz) with 17 dBm power.
- Quarter wave monopole transmitting antenna.
- Thermal protection package.
- Battery for power.

### Ground station and Data display

- Auto tracking with dual antenna system (Monopole and Quadrifilar).
- Dual channel FSK Receiver with sensitivity of -117dBm (BER 10<sup>-3</sup>).
- The Processing and Display software is a Windows based user friendly software with real time/offline numerical/graphical/tabular display of processed data in multiple windows.

#### Weight comparison of Radiosondes

Dr. Graw : 250 grams

- Vaisala RS-92 : 270 grams
- Meisei : **150** grams
- SCL RS : 100 grams

### **Technical Details**

Onboard System – Radiosonde

# Block diagram



## Data Acquisition System

- Single card system
- **Consists of:**
- Sensors to measure temperature and humidity while pressure is calculated parameters.
- The voltage outputs from the sensor circuits are given to a Sigma -Delta Analog to Digital Converter (∑-∆ ADC).
- The microcontroller initializes the ADC as well as reads the data from ADC corresponding to each channel.

# **Temperature Sensor**

- Type : Thermistor Bead (NTC)
- Range : -200°C to +200°C
- Nominal Res @25°C : 1K
- Dissipation Constant in still air : 0.15mW/°C

# Humidity Sensor

#### Type

- Humidity Range
- Operating temperature
- Accuracy
- Response time

- : Humidity Sensor with electronics
- : 0 to 100% RH
- : -40 to +85 deg C
- : < 3.5% RH
- : < 15 s typ.

#### **GPS** Module

- GPS receiver module provides Time, Latitude, Longitude, Altitude of the Radiosonde
- Wind velocity is calculated using the above data
  - Features:-
    - 3.0 V to 3.6V operation.
    - 12 parallel channels.
    - Update rate at 1 sec interval.
    - Integrated patch antenna.
    - Sensitivity of -146 dBm

#### Transmitter

Transmitter is realized using a low power UHF transmitter chip followed by an MMIC power amplifier and transmitting antenna.

#### Features

- Uses Fractional-N PLL
- 2.3 V to 3.6 V operation
- Low current consumption:17mA@433 MHz

# Spectrum of carrier



Date: 15.FEB.2007 12:37:25

# Spectrum of modulated signal



## Transmitter specifications

- Transmitter frequency
- Frequency stability
- Modulation type
- Frequency deviation
- Data rate
- Carrier phase noise
- Output power

- : 400 to 406 MHz
- : ± 1 ppm (-20 °C to 70 °C)
- : FSK
- : ±5.0 kHz
- : 1 Kbps
- :-90dBc/Hz@1 kHz
- : 19dBm

#### Transmitting antenna specifications

- Type
- Center Frequency
- Band width
- Beam width
- Gain
- Polarization
- VSWR

- : Quarter wave monopole.
- : 403 MHz
- : ± 4MHz
- : 80°
- : 2dBi
- : Linear
- : <1.5

**GPS Radio sonde Ground Station** 

#### Ground Station



#### Radio sonde Receiver Unit



#### Features

- Auto tracking using dual antenna system (Monopole and Quadrifilar antenna).
- Low Cost.
- Low Power Consumption (5V/250mA).
- AC/DC Operation.
- In built rechargeable battery with battery charger for 5 hours backup.
- Less Maintenance No moving parts.

#### Feature Cont...

- SD/MMC interface for add-on memory up to 512MB for real time data storage.
- Remote accessing through TCP/IP for Data Collection/ Monitoring/ Configuration.
- Low IF Receiver (100KHz)
- Programmable features such as
  - RF Frequency
  - Data rate
  - IF band width
  - Video Bandwidth
  - Frame Sync word
  - Frame Length

## Block Diagram



#### Radio sonde Antenna

#### Monopole

- Frequency
- Bandwidth
- Gain
- Polarization

- : 403 MHz
- : ±4MHz
- : 2dBi
- : Linear
- : <1.5

#### Quadrifilar Helix

- Frequency
- **Bandwidth**
- Gain
- Polarization
- VSWR

- : 403 MHz
- : ±2MHz
- : 4dBi
- : RCP
- : <1.5

### QFH & Monopole Antenna







### Antenna pattern

#### Gain Profile of Monople and QFH Antennas



#### LNA

- Gain : 13dB
- **Noise Figure**
- **Return Loss**
- **Filter** 
  - Center frequency
  - Band Width
  - Insertion Loss
- : 403 MHz

: 2.5dB

: 15 dB

- : 1.5 MHz
- : 5dB

#### Features:-

- On-chip VCO
- Fully automatic AFC,AGC
- Digital Received Signal Strength Indication
- Low power (30mA/3V)
- Low cost
- Single conversion
- Programmable data rate
- On-chip bit synchronizer

# Processing and display



- The Software provides a user friendly means of acquiring, processing, viewing, analyzing, and archiving meteorological and GPS data transmitted by GPS Radiosonde.
- The processed/displayed parameters mainly include:

#### **PTH Parameters**

Pressure, Temperature and Humidity

#### **GPS** Parameters

- Altitude, Latitude, Longitude
- Wind velocities (East –West and North- South)
- Wind speed and direction
- Ascend rate

#### Features

- Real time storing, numerical, tabular and graphical display.
- Offline processing and display.
- Multiple windows can be operated simultaneously.
- Processed data file generation.
- Calibration coefficient programmability.
- Real time display of receiver status.

#### Main window



# **Comparison with RADAR**



#### Comparsion of VSSC-GPS RS and RADAR Ascent on 24-04-2008 (0645IST) from SHAR



#### Comparsion of VSSC-GPS RS and RADAR Ascent on 24-04-2008 (0645IST) from SHAR



#### Comparsion of VSSC-GPS RS and RADAR Ascent on 25-04-2008 (0630IST) from SHAR



#### Comparsion of VSSC-GPS RS and RADAR Ascent on 25-04-2008 (0630IST) from SHAR

# Comparison with GRAW at Naval Base, Cochin

#### Comparison with Graw Sondes at Cochin Naval Base on 27.01.2011 at 17:10 hrs IST



#### Comparison with Graw Sondes at Cochin Naval Base on 27.01.2011 at 17:10 hrs IST



# Comparison with Vaisala at IMD Delhi



#### Comparison ascent with Vaisala on 13.12.2010 at 14:00 hrs IST from IMD Delhi





