The Venus SAGE Atmospheric Structure Investigation

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- Experiment Goals and Objectives -

- To accurately define the state properties as a function of altitude from below the 10^{-4} mb level (~150 km) to 92 bars (surface).
- To measure the stability of the atmosphere, and identify convective layers and stable layers, where they exist.
- To detect cloud levels from changes in the lapse rate at their boundaries.
- To provide state properties within the cloud levels, and thus provide supplementary information on cloud composition.
- To search for and characterize wave structure within the atmosphere.
- To search for and measure the intensity and scale of turbulence.
- To measure descent and surface wind speed and direction.
- To provide Lander altitude and attitude during decent for descent imaging analysis.
- To provide a back-up landing sensor.
Example Venus Profile

- **Altitude**
  - $dz \sim 250$ m (upper atm.)
  - $dz \sim 20$ m (lower atm.)

- **Acceleration & Attitude**
  - $a \sim 3 \mu g$ (threshold)
  - $a \sim 0.05 \text{ g}$ (peak)
  - $\Theta_v \sim 0.5 \text{ mrad s}^{-1}$

- **Pressure**
  - $dP \sim 0.1 \text{ mb}$ (100 mb)
  - $dP \sim 25 \text{ mb}$ (92 bars)

- **Temperature**
  - $1 \text{ K}$

- **Surface Wind**
  - $w < 0.05 \text{ m/s}$
- Instrument Accommodation -

Pressure Vessel

Wind / Temperature Boom

Pressure / Temperature Boom

IMU
Measurement:
- Acceleration in 3 axis (x,y,z)
- Roll, pitch and yaw rates

Accelerometers:
- x, y and z axis low impact sensors
- +/- 20 g range
- < 1 micro g accuracy
- z axis, high impact sensor
- +/- 1000 g range
- < 0.1 g accuracy

Gyroscopes:
- +/- 300 degree/sec range
- < 0.03 degree/sec accuracy (< 0.5 mrad/sec)
- Pressure / Temperature Boom -
- Pressure Sensor Implementation -

- Pressure manifold holds pressure transducers with three ranges cover pressure range
  - 0.01 to 1 bar
  - 0.1 to 10 bar
  - 1 to 100 bar

- Fully redundant system
  - Provides method to measure pressure offset and gain drifts

- Micromachined capacitive aneroid barometers used
  - MVACS/HASI heritage
  - No new technology, but modifications needed for high temperature operation
- Temperature Sensor Implementation -

Schematic of an atmospheric temperature TC sense junction and reference junction on the isothermal block

- Thin-wire thermocouple (TC) assemblies deployed on 2 fixed booms
- Reference junctions are located on an isothermal block inside probe body
  - temperature monitored by a precision platinum resistance thermometer (PRT)
- Accuracy: ±1 °C, 150 ≤ T ≤ 750 °C  
  Precision: ~0.01 °C (14-bit)
- Time Constant: <1 sec
- Wind / Temperature Boom -
- Directional Pitostatic Anemometer -

- 1-cm diameter sphere with six pressure ports equally spaced around its equator and two additional pressure ports located at its fore and aft poles.

- Speed and direction can be derived from pressure differences measured at these eight ports.

- During decent the fall speed will be derived from the wind sensor and used to adjust pressure measurements for dynamic effects.

- Surface winds measured to < 0.05 m sec^{-1}
- SYSTEM ARCHITECTURE -

JPL Daughter Board

- Pressure
- Temperature
- Wind Speed

+5V, +/-12V
I/O LINES, TTL

Temp. Thermal couples Interface

Magnetometers Interface

Payload Power/data link

Main power
CMD/DATA TRANSFER

Z-Axis, Impact Accelerometer Interface
Z-Axis, Accelerometer Interface
Y-Axis, Accelerometer Interface
X-Axis, Accelerometer Interface
X-Axis, Gyro Interface
Y-Axis, Gyro Interface
Z-Axis, Gyro Interface

Motherboard

- SYSTEM ARCHITECTURE -
- Future ASI Development -

High Pressure and Temperature, Miniaturized Sensors

• AlGaN/GaN-based microsensors (Kyung-ah Son, JPL)
  Small: ~ 1 cm$^3$
  Low mass: <5g
  Low power: < 10 mW

• Broad Operational range
  Temperature: 4 K-1000 K (0.1 °C)
  Pressure: 0-10 kbar (<5%)

Highly Integrated Systems

• Integrated power, com., C&DH, and structure