MiniSODAR: High Resolution Wind Profiling

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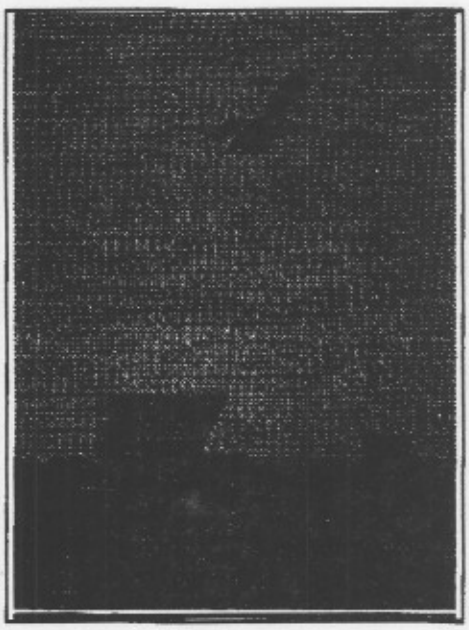
MiniSODAR



The miniSODAR is a high-frequency Doppler sodar system that was designed to measure the atmospheric wind profile from 15 meters to 200 meters in 5 meter increments. It operates by generating a short burst at 4500 Hz and monitoring the signal echoed by the atmosphere. This signal is processed in realtime for its frequency content which is directly related to the radial motion with respect to the miniSODAR antenna (see Figure 1).

The miniSODAR samples the atmosphere in three independent directions. It combines the data from these directions and utilizes the system geometry to profile the horizontal and vertical wind field above the antenna.

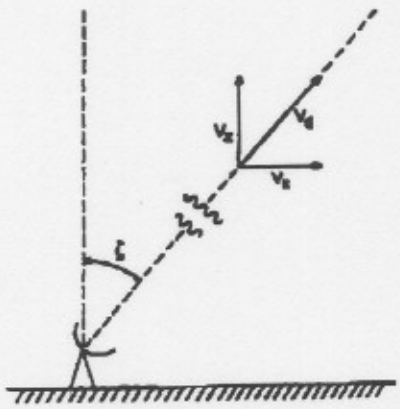


FIGURE 1

The miniSODAR is comprised of three components:

1. the model 4000 antenna and enclosure
2. the acoustic signal processor (ASP)
3. a PC type microcomputer

The system is supplied with the DOPLMAIN^{++} interface software which enables the PC microcomputer to become the user interface to the ASP, store the wind profile data produced by the miniSODAR, graphically display the miniSODAR data and provide an ASCII based remote user interface to the miniSODAR system. DOPLMAIN^{++}, using its split screen display, is able to display the wind and turbulence data both graphically and in tabular form for quick review. The Digital Facsimile Data (optional feature) can also be displayed in one of its split screen windows. The facsimile data is color encoded in terms of the received signal intensity (decibel scaling). It is corrected for the spherical spreading of the acoustic wave to present a relative picture of the atmospheric thermal turbulence intensity. Spectral data from a single altitude and beam can also be plotted in realtime as a system diagnostic feature. The wind and spectral data are stored in ASCII format and the facsimile data in binary format.

For more information contact:
AeroVironment Inc. • 222 E. Huntington Drive • Monrovia, CA 91016
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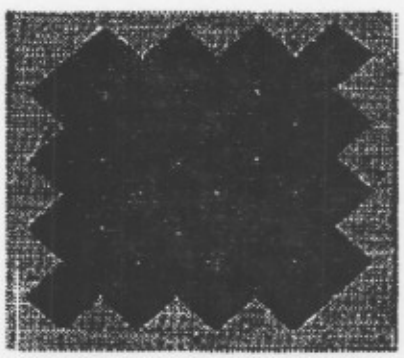
The following table lists the performance specifications of the AeroVironment model 4000 miniSODAR system.

Maximum Altitude	200 meters
Minimum Altitude	15 meters
Height Resolution	5 meters
Transmit Frequency (approximate)	4500 Hz
Averaging Interval	1 to 60 minutes (variable)
Wind Speed Range	0 to 45 meters / second
Wind Speed Accuracy	< 0.25 meters / second
Wind Direction Accuracy	+ 2 degrees
Weight	255 lbs (116 kg)
Antenna Height	4 ft (1.2 meter)
Antenna Width	4 ft (1.2 meter)
Antenna Length	5 ft (1.5 meter)

Model 4000 Antenna

The model 4000 antenna utilizes a single, electrically-steered (phased array) speaker array to create three independent orthogonal beam patterns. The antenna consists of 32 piezoceramic acoustic transducers excited with phase-controlled electronics to provide the appropriate beam steering. A pulse of acoustic energy is generated for each beam. The pulse has a duration of 30 (default) milliseconds. The corresponding depth of the pulse is 5 meters. This pulse propagates through the atmosphere at approximately 340 meters per second. However, the round trip propagation speed of the acoustic pulse is approximately 170 meters per second.



A backscattered signal is produced by the interaction of the transmitted acoustic steered pulse with small scale atmospheric turbulence. This signal is received by the speaker array. It is analyzed both for energy and frequency content using spectral processing techniques. The energy in the scattered portion of the detected signal is related to the strength of the inhomogeneities. The received frequency is related to the radial motion of the scatters relative to the antenna.

In the transmit mode, two complementary outputs (sine and cosine) supplied by the audio power amplifier, are input to an opto-isolated triac switching board located on the back of the antenna. Three transmit-axis logic signals are used to turn on the corresponding set of triacs for each transducer group. This forms the three transmit beams.

In the receive mode, individual transducer signals within each of the eight groups are first summed, and then appropriately phase shifted using op-amp integrator circuits and applied to a final differential input amplifier for each axis. All three receive signals are thus generated simultaneously, though only one at a time is used by the analog computer electronics.

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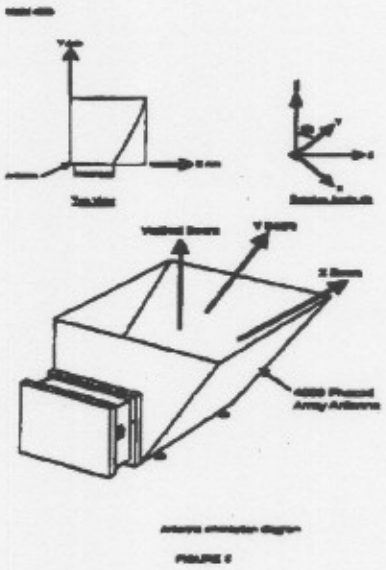


The phased-array is enclosed in a box-like structure approximately 28 inches square. This enclosure provides mechanical support and structure for wiring and the two on-board circuit cards.

Acoustic Enclosure Description

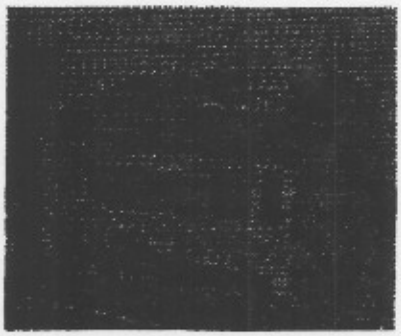
The model 4000 acoustic enclosure is basically an open structure with a reflector surface for the acoustic signals. This structure serves three fundamental purposes: (1) it shields the antenna from external noise sources, (2) it provides acoustic damping of the transmitted signal in the region surrounding the unit, and (3) it permits the model 4000 antenna to be mounted in a weather-resistant manner.

The main reflecting surface is tilted at a 45 degree angle from the vertical, and is sized to allow all three monostatic beams to be transmitted with minimal interference. An optional area heater, which covers the surface of the reflector panel, is available for regions with significant snowfall during winter months. The other three sides to the antenna assembly are covered with acoustic absorbing foam to dampen spurious noise from the immediate surroundings, and to reduce the noise level in the neighborhood of the unit. A drain panel is provided at the bottom of the assembly, which can be lifted for debris removal.

Acoustic Signal Processor

The acoustic signal processor (ASP) is an integrated electronics package, which performs the following functions:

- Generation of transmit signal pulse stream
- Amplification of transmit signal pulse stream
- Selective filtering of receive signal data
- Digital sampling of receive signal data
- Multiple gated Fast Fourier Transform (FFT) of receive signal
- Data analysis and reduction
- System control and data routing
- Data storage (optional)



A functional block diagram of the ASP is given in Figure 3. A brief description of each major component is provided below.

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ASP Microprocessor System

The Motorola 68040 based microprocessor system is designed to interface to the 32-bit VME data bus. It serves as the computational heart of the ASP. Digital data is processed via Fast Fourier Transform based algorithms to extract the Doppler shift and intensity of the received signal. These data are processed into wind and turbulence information and formed into data packets, which are transferred to DOPLMAIN** for the creation of wind tables.

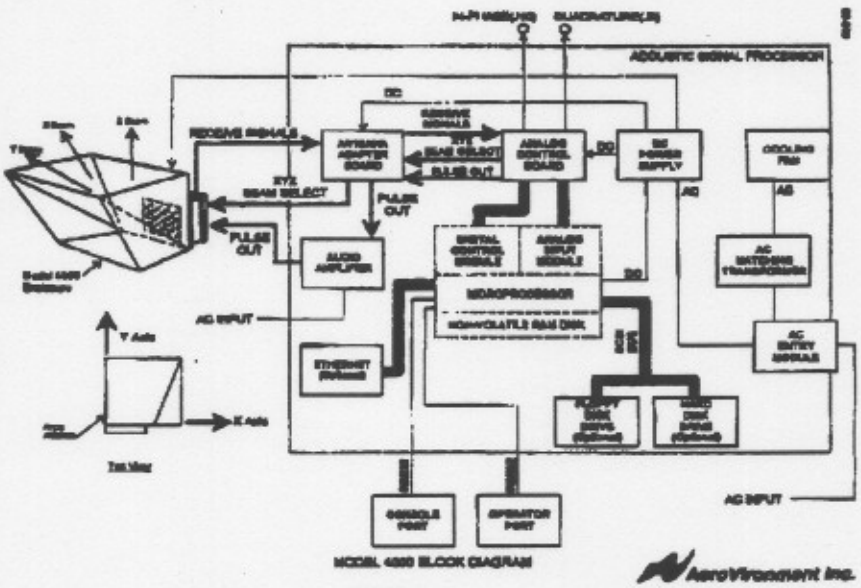

FIGURE 3

Data Acquisition Board

The data acquisition boards consist of two daughter modules that are installed on the Motorola MVME162-201 processor board. The module in port A is an eight channel, 12 bit, A/D converter. The module in port B is a 48 channel digital I/O.

Analog Control Board

The analog control board performs the following operations: (1) enables the active beam, (2) generates the transmit signal and (3) processes and filters the received signals. The analog control board is designed to allow computer control of both frequency and amplitude of the transmit signal and the low pass filter bandwidth used to condition the received signal before it is digitized by the analog-to-digital converter. Located on the front panel of the board is a 10 position rotary switch labeled ramp rate.

Audio Power Amplifier

The audio power amplifier selected for the model 4000 sodar is a high performance, stereo commercial unit. The amplifier has very low distortion, and is very robust under field conditions. The audio power amplifier is mounted inside the ASP enclosure. It performs the function of in-line amplification of the pulse signals generated by the analog card control board.

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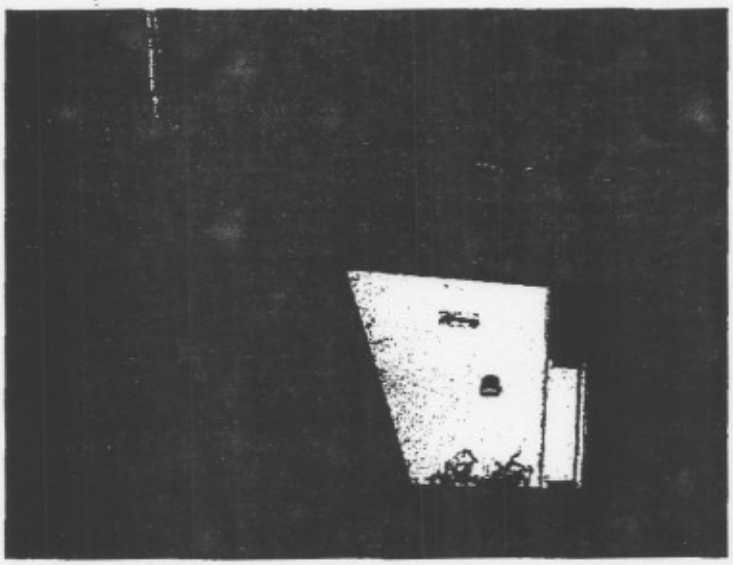
AeroVironment miniSODAR

The 150 meter *"Wind Tower"* that's ....



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