miniSODAR™

The miniSODAR™ is a high-frequency Doppler sodar system that was designed to measure the atmospheric wind profile from 15 meters to 150/200 meters (data is often available to 250 meters) in 5-meter increments. It operates by generating a short tone burst (30 ms to 100 ms) in the frequency range of 4 kHz to 6 kHz. It monitors the low-level acoustic signal echoed by the atmosphere. The echo is processed with for its frequency content. The shift in the received frequency with respect to the transmitted frequency is called the Doppler shift, which is directly related to the radial motion of the echo volume with respect to the miniSODAR™ acoustic antenna (see Figure 1).

The miniSODAR™ samples the atmosphere in three independent directions. These data are combined using geometry to deduce the horizontal and vertical wind profile directly above the antenna.

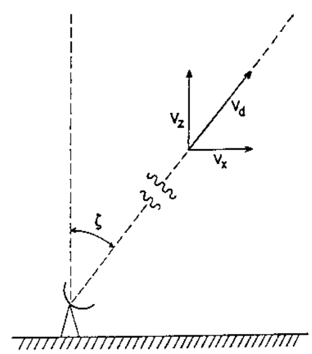


FIGURE 1

The miniSODAR™ system consists of three components:

1. 32 element speaker antenna and fiberglass acoustic enclosure;
2. Acoustic signal processor (ASP);
3. Audio power amplifier;

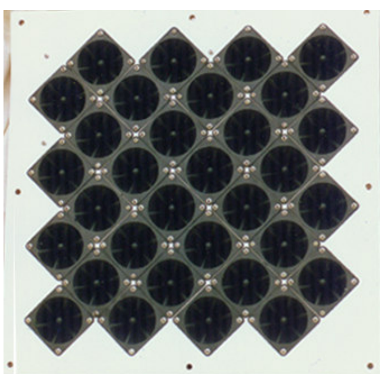
The system is supplied with the SodarPro™ interface software package which is the user interface to the ASP, store the wind profile data produced by the miniSODAR™, graphically display the miniSODAR™ data and provide an ASCII based remote user interface to the miniSODAR™ system. SodarPro™, using its 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 can also be displayed in one of its split screen windows. These data are viewed and plotted offline with the DFSview software package. The facsimile data are color encoded according to the received signal intensity (decibel scaling). They are 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 are also available as part of SodarPro™. The wind and spectral data are stored in ASCII format and the facsimile data in binary format.

The following table lists the performance specifications of the AeroVironment model 4000 miniSODAR™ system.

Maximum Sampling Altitude	250 meters
Minimum Sampling Altitude	10 meters
Height Resolution	5 meters
Transmit Frequency (approximate)	4500 Hz
Averaging Interval	1 to 60 minutes (selectable)
Wind Speed Range	0 to 45 meters / second
Wind Speed Accuracy	< 0.5 meters / second
Wind Direction Accuracy	± 5 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 piezo-ceramic 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 back-scattered 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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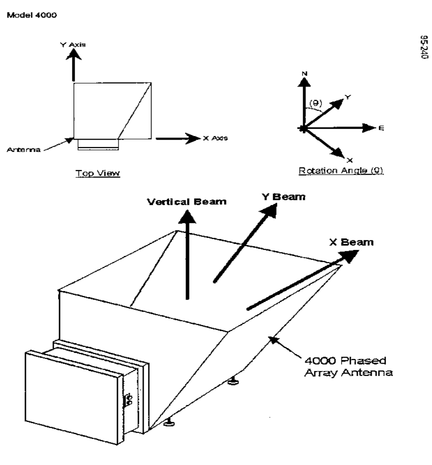
The phased-array is enclosed in a box-like structure approximately 28 inches square. This enclosure provides mechanical support and structure for wiring and the two on-board circuit cards.

Acoustic Enclosure

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.



Antenna orientation diagram

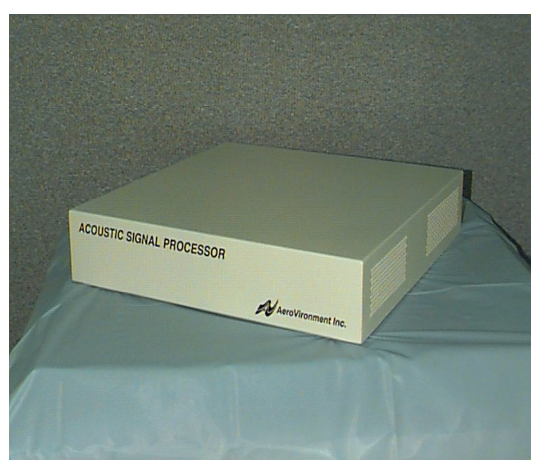
FIGURE 2

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 received 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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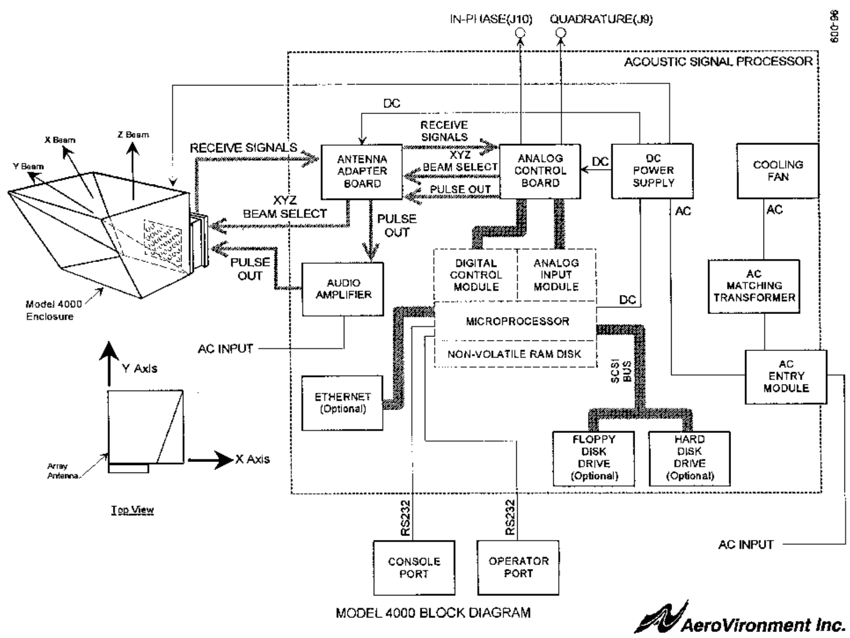
ASP Microprocessor System

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.



MODEL 4000 BLOCK DIAGRAM

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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