REMTECH SODAR TECHNICAL DESCRIPTION

1. - SYSTEM OVERVIEW

Our phased array Doppler Sodars continuously and reliably measure wind speed and direction, vertical motions, turbulence, thermal structure, and mixing depth at heights ranging from 15 m up to 1,000 to 5,000 meters depending on the type of antenna.
Briefly, this measurement is accomplished by emitting a strong acoustic pulse in the audio band and detecting the Doppler frequency shift of the received backscattered echo. This backscattered echo signal is due to thermal turbulence in the atmosphere. The signal frequency shift (Doppler shift) and its relative strength are processed in various ways to produce far more information than previously available through conventional methods such as instrumented towers, tethersondes, etc.

All three dimensional REMTECH monostatic Doppler Sodar systems basically consist of one sole antenna (phased array type) and an electronic case. In the electronic case are the computer, transceiver, and power amplifier. Also included are interconnecting cables and a small mount for the antenna.

The system allows for full control of the antenna beams: four of the electronically steered beams are tilted (30° or 15°) or from vertical and turned 90° from each other to provide the horizontal component of wind velocity. The last beam is pointed vertically and provides that component of the wind. The system software controls the sequence and rate of operation for each beam. These are non system parameters which can be changed through keyboard input.

Different antennas are available for different ranges. The table shown on page 2 provides the specifications of the different systems.

A major advantage of the REMTECH Doppler Sodar Systems is their tremendous user flexibility. Virtually all important parameters, such as averaging and sampling times, transmitting power, antenna orientation, range gates, and maximum range, are operator selectable by simple key-in options to the minicomputer.

The exclusive signal to noise detection and comparison techniques developed by REMTECH through several years of research, permit the system to produce reliable data in a noisy environment with comparatively short data averaging times because of the discrete rejection of all spurious signals. Data which are, in fact, considered suspect, due to adverse ambient-noise, are deleted from the system. This prevents users from being misled by erroneous data. No additional data processing is required in order to achieve the system's full accuracy. Data archived can also be directly processed to provide complete statistical data summaries and climatological analyses.

System maintenance is greatly facilitated by special software diagnostic routines. If ever required, repair is accomplished by swapping the complete electronic case, vastly reducing down time.

	PA0	**PA1**	**PA2**	**PA5**
Number of elements	52	52	196	52
Type of elements	Motorola / Remtech	Motorola	Motorola	Eagle
Nominal central operating frequency (Hertz) 9 (up to 15 optional with PA0, PA1 and PA5) frequencies are emitted on each tilted beam during one «beep»	3500	2250	2250	800
Antenna size (meters) (Supporting structure not included)	0.4 x 0.4	0.65 x 0.65	1.3 x 1.3	1.8 x 1.8
Antenna weight including supporting structure	12 Kg	25 Kg	100 Kg	120 Kg
Acoustic Power	1 W	1 W	10 W	60 W
Maximum range	1000 m	2000 m	2000 m	5000 m
Average range in typical conditions	600 m	1300 m	1500 m	3500 m

A. Phased Array Antenna Sodars Unique Advantages

The advantages of steered beam phased array antenna are numerous:

- only one antenna is needed, the steering of the beam is performed by phase control among the antenna elements.

- up to nine beams can be achieved allowing cross checking among wind components.

- no large antenna enclosure is needed due to tapering of the amplitude resulting in a simple flat plate antenna as small as possible.

Moreover, phased array antennas offer tremendous development capabilities.

B. Frequency Coded Transmission

Through software, REMTECH is able to provide a signature to the transmitted pulse. The basic coding consists of transmitting 9 (up to 15 optional) frequencies in the pulse. Upon reception, this coded pulse is easily detected from noise and fixed echoes within the backscattered signal. This is particularly useful for turbulence studies since it allows quicker detection for full analysis on the noise spectrum. The technique has been used for years in radar, REMTECH is still the only company to apply this to SODAR (US Patent No 5,521,883).

C. Automatic Fixed Echo Detection

Though the antenna pattern is optimized relative to fixed echoes, some of these can still be strong enough to spoil the returned signals. In this case the software automatically detects the fixed echoes and, according to the ratio between fixed echo intensity and useful signal, either processes the data with adequate corrections or invalidates them.

D. Unique Noise Subtraction Technique

The frequency transfer function (in phase and amplitude) between the "active antenna" and the "reference antenna" (made of 4 transducers at the 4 antenna corners) allows a very efficient noise subtraction (especially for a fixed noise source such as an air conditioner, an aspirated shield on a meteorological tower close to the sodar). The final acoustic frequency power spectrum can be cleaned by more than 15dB's decrease of the jamming source in the considered frequency zone.

This noise substraction technique is also very efficient to removing spurious frequency peaks which can be generated by electrical and/or magnetic influence.

2. - STANDARD SOFTWARE

The raw acoustic spectra are computed using a Fast Fourier Transform (FFT).

Most of the processing is done by software thus dramatically reducing the amount of transceiver hardware.

The software also handles the transceiver relays which are connected to the different transducers of the antenna and perform the beamforming along the 5 (up to 9) axes (1 vertical, 4 -up to 8- tilted).

In the receive mode, the backscattered signal is first processed through 1024 frequency point FFT's.

All REMTECH Doppler Sodar systems are provided with the following features :

- Frequency Coded Transmission
- Fast Fourier Transform Doppler Detection by software
- Automatic Fixed Echo Detection
- Data output on hard disk, floppy disk, CRT, printer and modem
- Automatic real-time data validation
- Standard display and recording of:
  - . echo strength
  - . wind speed
  - . wind direction
  - . vertical speed.

3. - SOME SOFTWARE OPTIONS

. Sigma W Software

Computes the vertical wind speed standard deviation in real time. Sigma w is corrected for individual measurement error using the frequency coding approach.

. Sigma Theta Software

The standard deviation of horizontal wind direction is computed in real time.

. Automatic Inversion Detection Routine

This routine uses pattern recognition algorithms which are applied to backscattered signal, wind components and turbulence vertical profiles. The output is a direct read-out of inversion height accomplished in real time. A success rate greater than 90% is experienced at most sites. This routine requires sigma w and sigma theta software options to function.

. Automatic Mixing Height Calculation

Provides an estimation of the mixing height in real time by using a spectral analysis of the vertical component time series at different levels.
Needs sigma w and sigma theta routines.

. Automatic Stability Classification Routine

This is a real time direct determination of stable/neutral/unstable categories as a function of height and time. Pattern recognition algorithms using echo profiles, wind, wind shear (pseudo "Bulk Richardson" approach).
Needs sigma w, sigma theta and automatic inversion detection routines.

. Temperature Lapse Rate Estimation

Provides an estimation of the temperature lapse rate in real time. Requires sigma w, sigma theta, and automatic inversion detection routines.

4. - SPECIFICATIONS

. Receiver gain	100 dB
. Number of range gates * (selectable)	Up to 300
. Thickness of each gate*	10 to 200 meters, in 1 meter layer increments
. Averaging period*	2 mn (1mn optional) to 1 hour
. Receiver filter type	Sixth order Cauer
. Initial processing	1024 frequency point FFT's by software
. Background noise correction	Signal/noise ratio continuously measured and used for validation of data vs. background noise.
. Horizontal wind speed range	0 to 30 m/sec (0 to 50 m/s for PA0, PA1 and PA5)
. Horizontal speed accuracy	Better than 0.2 m/sec or 3 % for wind speed over 6 m/sec
. Vertical speed range	- 4 to + 4 m/sec (± 12 m/s optional)
. Vertical speed accuracy	5 cm/sec or better
. Horizontal direction accuracy	3° or better for winds faster than 2 m/s.

* Parameters easily changed by key-in command.

Accuracies correspond to the limits of our validation criteria, therefore accuracies are usually better.

Operating conditions

Antenna:

. Temperature -40° C to + 60° C

. Humidity 10 - 100%

Electronic case:

. Temperature 5° C to 40° C (-10° C to 50° C for PA0)

For wider range, please consult REMTECH.

. Humidity 20 to 80% non-condensing

Power consumption

	Without antenna heating	**With antenna heating**
PA0	15 W	100 W*
PA1	25 W	250 W
PA2	50 W	1100 W
PA5	190 W	1150 W
RASS	200 W	N/A
SONAR	500 W	N/A

* optional

APPLICATIONS

The REMTECH sodar can be used in a variety of meteorological monitoring applications. Several of these are listed below.

. Regional wind studies for pollutant dispersion analysis

. Diffusion in complex terrain

. Power plant siting studies

. Environmental impact analyses

. Building downwash studies

. Mountain valley flows and their impacts

. Land and sea breezes

. Urban heat island circulations

. Topographically induced flows

. Nocturnal inversion formation and decay

. Planetary boundary layer research

. Transport of elevated pollutant plumes

. Wind shear research, both speed and direction

. Clear air turbulence studies

. Thunderstorm outflows

. Vertical temperature structure

. Dose calculation forecasts of nuclear accidents

. Toxic chemical spill response training

. Wind energy site assessment

CONCLUSION

The REMTECH Doppler Sodar System is clearly the most advanced system available in the world today. It has been designed with the flexibility to meet the growing research and operational requirements of the meteorological community.

NOTE :

The information in this document is subject to change without notice and should not be construed as a commitment by REMTECH.

REMTECH assumes no responsability for any errors that may appear in this document.

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