Vaisala WINDCAP® Ultrasonic Sensor Technology

Vaisala WINDCAP® Ultrasonic Wind Sensor Technology uses ultrasound to determine horizontal wind speed and direction. WINDCAP® sensors have no moving parts so they are free from the challenges posed by conventional mechanical wind sensors (friction, inertia, time constant, over-speeding, starting threshold). The unique triangular design of the WINDCAP® array assures accurate measurement of wind from all directions. WINDCAP® sensors can be heated for use in cold climates. Finally, WINDCAP® sensors are maintenance-free and do not require field calibration.

WINDCAP® Theory of Operation

WINDCAP® sensors use an array of three ultrasonic transducers oriented so that the paths between the transducers form an equilateral triangle. Wind measurement is based on time of flight (TOF), the time it takes for an ultrasonic signal to travel from one transducer to another. TOF is measured in both directions for each pair of transducer heads. The parallel component of wind velocity can be determined for each transducer pair by comparing the TOF of ultrasonic signals in opposing directions. In zero wind, TOF for all ultrasonic signals is the same. As wind increases, disrupting the medium through which the ultrasonic signal travels, TOF values begin to diverge. The processing of these TOF values enables accurate calculation of wind speed and direction.

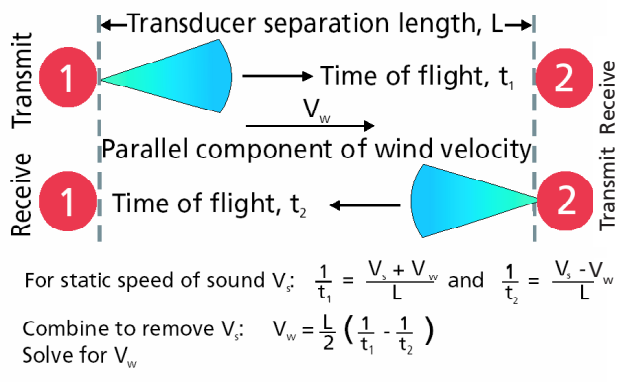

Figure 1.
Time-of-flight for a sonic impulse from the transmit transducer to the receive transducer is determined for both directions. Simple algebra allows solving for the parallel component of wind velocity independently of the static speed of sound.

WINDCAP® ultrasonic transducers operate at approximately 100 kHz or 300 kHz, depending on the type of wind instrument. A measurement cycle consists of each transducer sending 16 ultrasonic pulses to the other two transducers, resulting in 96 TOF measurements. As many as four measurement cycles can be completed in one second, depending on the type and configuration of wind instrument. Although atmospheric conditions affect the speed of sound and therefore the TOF, the speed of sound at any given moment is static and its effect is cancelled algebraically when calculating parallel component of wind for each pair of transducers.

The triangular configuration of the WINDCAP® sensor and the bi-directional TOF measurements for each pair of transducers provides three sets of basis vectors. Only two basis sets are necessary to determine windspeed and direction. The WINDCAP™ measurement strategy is to evaluate the quality of each basis set and select the two best basis sets to be used for calculation. The quality of a basis set is determined by statistical analysis of TOF data.

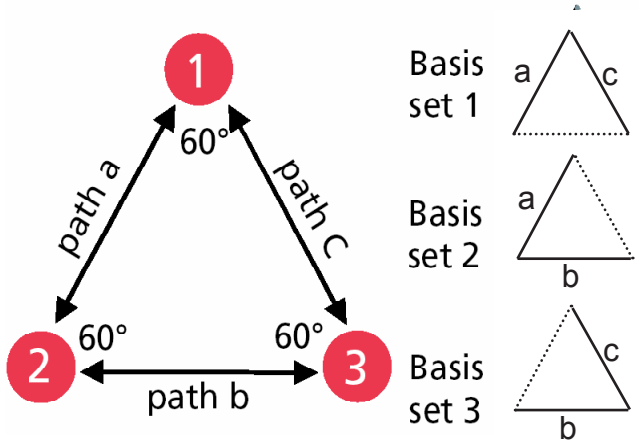

Figure 2.
The equilateral triangle configuration of the three transducers provides three possible sets of basis vectors. The combinations yield bi-directional measurements on the paths labeled a, b and c. These measurements are used to determine the wind velocity components parallel to each of the three paths.

Quality criteria include the number of successful measurements for each measurement path, the standard deviation of TOF values for each path, and the TOF average values for each path.

The triangular configuration of WINDCAP® transducers assures that two good basis sets are always available for any set of wind conditions. If wind direction is exactly parallel to one set of transducers, turbulence will distort the TOF measurements and create a flawed basis set, but data from the remaining two sets of transducers will be valid.

Vaisala Equilateral Triangle Design versus Orthogonal Design:

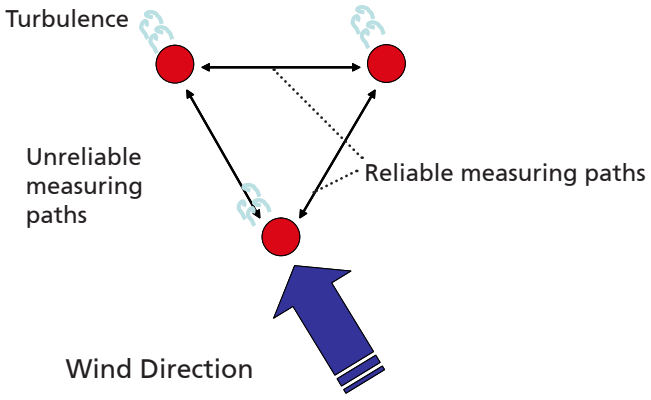

Figure 3.
Vaisala proprietary equilateral triangle design assures two good basis sets in all wind conditions.

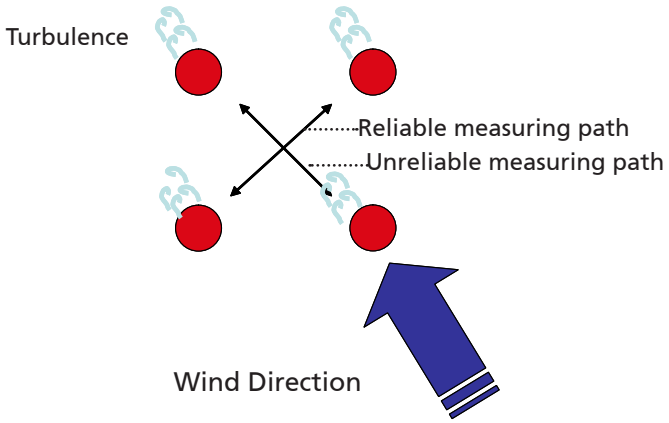

Figure 4.
Orthogonal design.

Vaisala WINDCAP® Ultrasonic Wind Sensor WMT52

http://www.vaisala.com/instruments/products/wind/WMT52

Vaisala Ultrasonic Wind Sensor WS425

http://www.vaisala.com/instruments/products/wind/ws425

Vaisala Multi-Weather Transmitter WXT520

http://www.vaisala.com/instruments/products/weathermulti-sensor