FT TECHNOLOGIES

Lightweight **wind sensors for use on drones**

THE WORLD'S TOUGHEST WIND SENSORS

www.fttechnologies.com

Why use a wind sensor on a drone?

Meteorological measurement

FT sensors measure wind speed, wind direction and acoustic air temperature. These measurements can be used as part of a mobile drone weather station: maybe used for environmental monitoring, atmospheric measurements, pollution monitoring, precision agriculture etc. The wind input can be used to normalize or provide a reference point for the other measurement sensors on a drone, e.g. in methane detection or CBRNe applications where consistent quantitative concentration results are required, but the wind at the measurement location may be changing from day to day and affecting the concentration profile.

Flight range estimation

If it has to return against a headwind, there is a risk of a rotor UAV not making it back to base before running out of power. A wind sensor can help calculate the safe operating flight range in that case. FT UAV sensors all incorporate an integrated compass, so that true wind can be separated from apparent wind, and true wind measurements can therefore be taken from a moving UAV.

Flight control system

Drones that operate around, or close to, large structures such as wind turbines, transmission towers or buildings, are prone to a lot of unexpected wind gusts and turbulence. Using a wind sensor as part of a Dynamic Positioning System can help to protect the public, the UAV and surrounding objects from collision, injury and damage. For example, in the case of wind turbine inspection, you want the drone to be close enough to the turbine to capture enough detail, but the closer you are, the more responsive a control system is required.

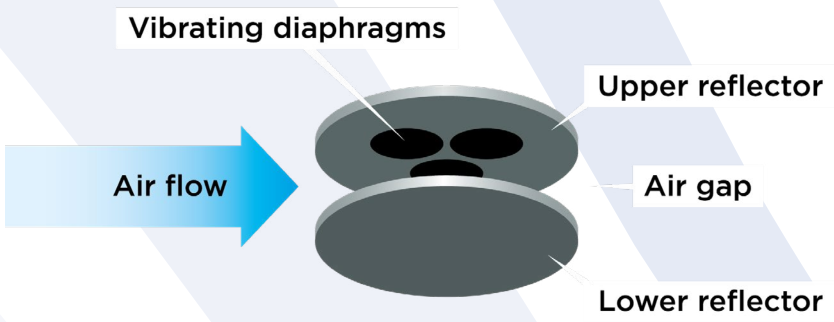
Replace or augment pitot tube

Pitot tubes are an established technology but can suffer from two main issues: inaccurate low air speed measurement, and inherent one-dimensional direction reporting. FT sensors accurately measure the air speed range from 0-145 knots (0-75m/s) in a full 360 degrees. This opens up opportunities in rotor UAVs where the absence of a pilot causes difficulty with drift detection and compensation during hovering and landing.

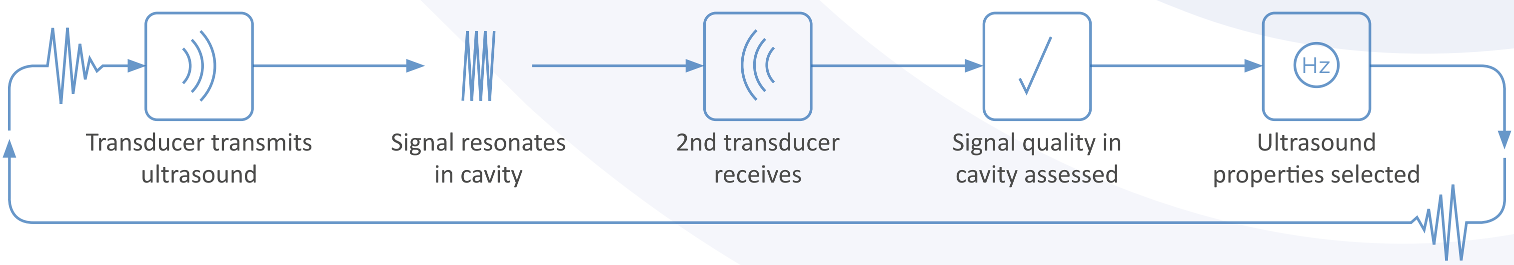
What makes Acu-Res® Technology ideal for drone use?

FT Technologies is a leading manufacturer of rugged wind sensors for UAVs and SWaP applications.

FT sensors are unique in the marketplace in that we use acoustic resonance to measure wind speed, direction and acoustic air temperature. Acu-Res® Technology provides a superior signal/noise ratio, which enables high levels of data availability and accuracy in acoustically and vibrationally noisy environments. FT sensors are designed to withstand shock and vibration and have passed all our HALT tests at 60G. This may sound like overkill, but some fixed wing drones are launched by catapult, and this can place enormous mechanical stress on sensors, so we are confident that our sensors are tough. In addition, since UAVs are essentially mobile radio transmitters/receivers, FT sensors are designed to be immune to Radio Frequency Interference, and to have low enough emissions that they will not affect neighbouring sensors on the drone.



The sensor works by creating a resonating ultrasonic signal inside the sensor's measurement cavity. The motion of air is sensed by measuring the phase change in the ultrasonic signal caused by the wind as it passes through the cavity. The sensor has three transducers arranged in an equilateral triangle. The net phase difference between a transmitting and receiving transducer pair is indicative of the airflow along the axis of the pair. Therefore by measuring all three pairs the component vectors of the airflow along the sides of the triangle are determined. These vectors are combined to give the overall speed and direction. The sensor uses complex signal processing and data analysis taking a sequence of multiple measurements to calculate regular wind readings. The sensor inherently compensates for changes in the air's temperature, pressure or humidity. A strong resonating sound wave in a small space provides a large signal that is easy to measure. Acu-Res® has a signal to noise ratio more than 40db stronger than other ultrasonic technologies.



Which wind sensors for which application?

High performance in a light package

The FT205 has been specially designed for drones, and in particular the sub-market of drones which fall under the sUAS category. These vehicles have strict limitations on payload weight, and lighter is obviously better. We have taken our proven Acu-Res® core technology, and packaged it in a body which weighs <100g, but maintains the physical toughness and reliability that FT Technologies is renowned for.

See datasheet on page 10.

Built for use in extreme conditions.

The FT742-SM is the smallest and lightest of FT's "world's toughest" wind sensors range. Small, low power and extremely rugged, it has been integrated into drones, military vehicles, autonomous robots, vehicle-mounted and ship-based meteorological systems. The FT742-SM has a hard-anodized aluminium, corrosion-resistant body with built-in heating. Sealed to IP66/67 standard it also extensively tested and certified for vibration, shock-resistance, and RF immunity.

See datasheet on page 9.

Unmanned seaplane: Japan

Established in 2014, Space Entertainment Laboratory (SELab) is fixed wing drone manufacturing company based in Tokyo. Their latest design, the Hamadori, is an unmanned seaplane due onto the market in early 2021. With a flight time of up to two hours, it is ideal for surveillance and monitoring services both at sea and on land. Early trials of the Hamadori used a pitot tube to collect airspeed data to control the fixed-wing UAV effectively. However, as the Hamadori both takes off and lands on water, they found that the pitot tube was getting blocked by water and therefore causing major malfunctions. Consequently, they were looking for an alternative type of airspeed sensor that would continue to function in seawater environments.

Project

SELab contacted FT Technologies and we provided them with an FT205 lightweight sensor for testing with their prototype. The FT205 sensor was fitted to the nose of the UAV with the datum mark, representing 0deg, facing in.

SELab used a 3D printer to produce a mount for the FT205. They fitted an original cable to the sensor to communicate with the flight controller, as well as powering the sensor with electricity from the UAV's battery. They also programmed a driver for the sensor within the flight controller. In December 2019, the Hamadori, fitted with the FT205 sensor, flew a series of tests at the Docomo 5G Open Laboratory in Guam

Conclusion

SELab were delighted with the successful results. The sensor worked perfectly and delivered accurate airspeed data to the flight control system throughout the tests.

"The FT205 solved our problem just as we had hoped it would. Even when the drone landed on seawater, the data was not affected. The seawater appears to have had no effect on the sensor. Also, the accuracy of the data seemed to be higher than that gathered from a pitot tube, especially at low airspeeds – under 5m/s.

"We will now be using the FT205 as we feel confident that it will show airspeed precisely and constantly in whatever condition our UAVs may encounter in normal operation."

Takenori Hashimoto
Space Entertainment Laboratory

Forest Fire Monitoring: Spain

When trying to predict the progress of a forest fire, one of the most important pieces of information to consider is the intensity and direction of the wind. Armed with this knowledge, it is possible to take preemptive action, such as controlled burning in specific areas to prevent the fire from advancing.

In Andalusia, Spain, forest fires are a regular occurrence during the summer months. Until recently, the only way to predict the wind was by gathering data from low altitude weather stations. Although producing reasonably accurate data, the stations were often located several kilometres from the fire front, usually within the same incident command centres controlling the emergency services.

Background

By day, planes are able to fly above the fire and report its progress. However, at nightfall, all piloted aircraft must stop their operations for safety reasons. The lack of wind data during the night could often have disastrous consequences.

During the summer of 2018, AMAYA and INFOCA (the authority dedicated to the prevention and extinction of forest fires in Andalusia) jointly funded a project to test a new drone specifically designed to fly at night in order to monitor wind speed and direction directly at the fire front. Developed by Dronetools SL, the drone was equipped with an FT205 wind sensor.

Before testing the sensor on real fires, field tests were carried out 15 metres above the ground in order to compare the results with a weather station and confirm that the sensor's data was correct.

Conclusion

Throughout the summer, the drone equipped with the FT205 wind sensor was tested in four real forest fire situations. The data produced from the sensor proved critically important to the emergency services as they were able to monitor the spread of the blaze during the night. Measurements were taken at different altitudes to confirm the wind direction.

The valuable data collected by the drone and its sensor was used to complement the existing system of ground weather stations used by the emergency services.

"In the final analysis, the sensor worked accurately in real fire situations. The drone, equipped with the FT205 sensor, was an indispensable tool for predicting the advance of the fire at night."

Javier Prada Delgado
Integration Engineer
Dronetools SL

Urban air mobility: Kosovo

Urban Air Mobility (UAM) represents a new era in air transportation. A community of government, industry and academic partners is working together to research the practicalities before UAM is declared fully viable in populated areas. The goal is to develop a safe and efficient air transportation system where everything from small package delivery drones to passenger-carrying air taxis is able to operate over towns and cities.

Background

Whereas drones are already being used in relatively unpopulated parts of the world, cities offer a very different terrain. The effect of 'urban canyons', such as building-lined streets, needs to be fully understood. For example, as the breeze is funneled into the relatively narrow gap between buildings, wind speed can increase dramatically, and the heat from city surface temperatures can produce unexpected thermals.

To study the effects of urban landscapes on drones, a team from Embry-Riddle Aeronautical University and Gaetz Aerospace Institute took off to Kosovo. The team knew it would have been extremely difficult to get permission to fly in a built-up, densely populated area in the US. Kosovo was identified as a potential location for testing as many of its urban environments are sparsely populated due to the war in the 1990s.

Project

The team flew a small unmanned aerial vehicle (UAV) rigged with special instrumentation, including two FT205 sensors which were mounted orthogonally so as to measure both horizontal and vertical wind fluctuations. The eight-motor 'octocopter' drone (a DJI S1000) also measured the temperature, humidity and air pressure in two cities – Janjeva and Prishtina. Combining the wind speed, direction and temperature information gained from the anemometers with aerial photos taken by the drones, the team were able to generate 3D models showing 3D wind components.

Conclusion

With the help of the FT205 sensors, the team was able to measure the wind turbulence in an urban canopy. This will be hugely helpful to companies looking into urban air mobility as it will help them better understand the environment their aircraft will be placed in.

"The FT205 wind sensors were perfect for our operations. Their light weight and accurate measurement contributed immensely to the success of the project. The sensors have been on the road, traveled halfway round the world and back again, and have stood up well!"

Dr Kevin Adkins
Associate Professor of Aeronautical Science
Embry-Riddle Aeronautical University

UAV measuring wake turbulence: Denmark

Aalborg University, Denmark, is engaged in a research project looking at how to transport spare parts to offshore wind turbines using unmanned aircraft, directly from the service harbour to the wind turbine nacelle. If successful, the new system would replace the transportation of parts by ship, followed by the slow and cumbersome craning to get the parts up to the nacelle. The aim is to greatly reduce costs and disruption to the operation of the wind turbine. Since wind turbines tend to be located where it is windy, and since delivery of spare parts would ideally happen without stopping the turbine, there are many challenges. Aalborg University turned to FT to help assess the safety of operating drones right over the nacelle whilst the blades continue to spin, even in strong and turbulent wind.

Project

To determine the wind conditions right at the location of the unmanned aircraft, Aalborg University acquired an FT742-SM sensor and mounted it first on a “smaller” drone, a DJI Matrice 600, and subsequently on the aircraft that will conduct test deliveries during the research project – a 90kg rotorcraft drone.

The M600 drone was used initially for two reasons. Initially, it was not known exactly what to expect when hovering a few meters over the nacelle of a 100m high 6MW wind turbine, 5 meters behind the rotating blades at wind speeds exceeding 20m/s. So the researchers decided to use a relatively inexpensive drone. Secondly, the multirotor configuration allowed for the wind sensor to be mounted above the rotor wake which would otherwise have influenced the wind measurements. The sensor was placed on a 50cm long aluminium rod, and then flown gradually closer to the nacelle to see the results.

Subsequently, the FT742-SM wind sensor was moved to the T50 aircraft and fitted upside down, below the fuselage. To ensure that the sensor could produce useful data in this position, it was flown a number of times in different wind conditions.

“The FT742-SM has turned out to be useful for wind measurements, including when located below the larger unmanned aircraft. We plan to continue using the sensor for determining the wind speed and direction during future flights, especially on longer flights beyond visual line of sight where it is important not to exceed the specifications of the aircraft when operating in strong wind.”

Anders la Cour-Harbo
Associate Professor, MSc Math, PhD Manager,
Drone Research Lab
Aalborg University (AAU)
Denmark

FT742-SM

Surface mount wind sensor

FT TECHNOLOGIES

The FT742 Surface Mount wind sensor is designed for OEM integration. It has an electronic compass and a thermostatic heater. The sensor has been integrated into UAVs, drones, military vehicles, autonomous robots and handheld weather stations.

The sensor can be installed to ensure alignment with a standard reference, typically Magnetic North, or the integrated compass can calculate this automatically. Small, low power and extremely rugged, the FT742-SM is extensively tested and certified for vibration and shock resistance, and RF immunity.

WIND SPEED

0-75m/s

OPERATING RANGE

-40 to **85**°C

HEIGHT

71.2mm

WEIGHT

252g

WIND SPEED

Range	0-75m/s, 0-270km/h, 0-145.8 knots
Resolution	0.1m/s, 0.1km/h, 0.1knots
Accuracy	±0.3m/s (0-16m/s) ±2% (16-40m/s) ±4% (40-75m/s)

WIND DIRECTION

Range	0 to 360°
Resolution	1°
Accuracy	4° RMS
Compass accuracy	5° RMS

ACOUSTIC TEMPERATURE

Resolution	0.1°C
Accuracy	±2°C

Under the following conditions:

Speed Range	5m/s - 60m/s
Operating Range	-20°C to +60°C
Difference between air and sensor temperature	<10°C

PHYSICAL

Universal M12 8-pole circular I/O connector.

DIGITAL SENSOR

Interface	RS422 (full-duplex) RS485 (half-duplex)
Format encoding	ASCII

SENSOR PERFORMANCE

Measurement principle	Acoustic Resonance
Units of measure	m/s, km/h or knots
Data update rate	Up to 10Hz
Altitude	0-4000m
Humidity	0-100%
Ingress protection	IP66, IP67 (when correctly installed with supplied O-ring)
Heater settings	0° to 55°C

POWER REQUIREMENTS

Supply voltage	6V to 30V DC (24V DC nominal) Supports battery operation with reduced heater capacity.
Supply current heater off	25mA (29mA with compass enabled)
Supply current (heater on)	Up to 2A

POWER CONSUMPTION

With heater disabled - For battery use

Battery supply	Compass disabled	Compass enabled
24V	600mW	696mW
12V	300mW	348mW
9V	225mW	261mW
6V	150mW	174mW

FT205

Lightweight wind sensor for drones

FT TECHNOLOGIES

The FT205 lightweight, low power wind sensor has been specifically designed for use on UAV and SWaP-limited applications. An integrated electronic compass makes it ideal for use on a moving platform.

With low power requirements, and reading up to 75m/s, the FT205 Lightweight Wind Sensor is ideal for UAV flight control systems and environmental monitoring from drones.

WIND SPEED

0-75m/s

OPERATING RANGE

-20 to 70°C

HEIGHT

55.1mm

WEIGHT

100g

WIND SPEED

Range .... 0-75m/s, 0-270km/h, 0-145.8 knots
Resolution 0.1m/s, 0.1km/h, 0.1knots
Accuracy .... ±0.3m/s (0-16m/s)
±2% (16-40m/s)
±4% (40-75m/s)

WIND DIRECTION

Range .... 0 to 360°
Resolution .... 1°
Accuracy .... 4° RMS
Compass accuracy .... 5° RMS

ACOUSTIC TEMPERATURE

Resolution .... 0.1°C
Accuracy .... ±2°C
Under the following conditions:
Speed Range .... 5m/s - 60m/s
Operating Range .... -20°C to +60°C
Difference between air and sensor temperature .... <10°C

SENSOR PERFORMANCE

Measurement principle .... Acoustic Resonance
Units of measure .... m/s, km/h or knots
Data update rate .... Up to 10Hz
Altitude 0-4000m
Humidity 0-100%

POWER REQUIREMENTS

Supply voltage .... 6V to 30V DC
Supply current 30mA

PHYSICAL

Molex CLIK-Mate I/O connector and cable
Sensor made of 3D printed graphite and nylon composite
Surface-Mount with compressed gasket and 3x screw fit. An adaptor is provided for pole-mounting (pole not supplied).

DIGITAL SENSOR

Interface .... RS422 (full-duplex)
RS485 (half-duplex)
UART (full-duplex, 3V & 5V)
Format encoding .... ASCII

Gordon Bease - Director Global Accounts
12600 Hill Country Blvd, Suite R-275
Bee Cave, TX 78738, USA
T: +1 337-254-6336
gordon.bease@fttechnologies.com

THE WORLD'S TOUGHEST WIND SENSORS
www.fttechnologies.com

FT Technologies Ltd
Sunbury House, Brooklands Close
Sunbury on Thames, TW16 7DX, UK
T: +44 (0)20 8943 0801
info@fttechnologies.com