Jorma Islander, product manager, Vaisala

WHATEVER THE WEATHER

Heating weather station components is fine with mains power but poses an entirely different problem for the most remote setups

Arctic environments are extremely challenging for sensors, with temperatures falling to -60°C (-76°F)

Weather stations need to be tough enough to withstand windspeeds of up to 75m/s (246ft/s)

A durable design is key when creating an automatic weather station for demanding environments

Extreme weather conditions pose a tough challenge for weather station equipment, which has to deliver accurate and reliable measurements in environments where temperatures drop below -60°C (-76°F) or reach over +50°C (122°F), or where windspeeds can exceed 100m/s (328ft/s).

These challenging conditions typically occur in remote areas with sparse populations and a lack of infrastructure. The toughest environments for weather station equipment are arctic regions, where the annual temperature variation can be as great as 100°C (212°F) and temperatures can fall below -60°C. Global warming has made it more important than ever to gather accurate weather information from these areas.

ROBUST COMPONENTS AND A SOUND STRUCTURE

A weather station is typically made up of several different components, including the main processing unit, power supply system and telemetry systems. Although the main processing unit is referred to as the datalogger, its key functions are to perform analog measurements, collect data from the sensors, control the power management and integrate the communication network. It is the most critical component in a weather station and must be able to operate in all temperatures. When components are not guaranteed to operate reliably at extremely low temperatures, the only way to ensure operation is to thoroughly test each unit during the manufacturing process.

The wide range of temperatures the equipment is exposed to is not the only challenge in weather station design. The equipment must also be mechanically sound and able to operate in any environment, from coastal regions to mountainous areas. This requires a robust structure that can withstand windspeeds of up to 75m/s (246ft/s) and additional load from icing. The structure should also have sufficient corrosion resistance to allow it to remain standing for a long period of time – ideally at least 10 years.

SECURING A RELIABLE POWER SUPPLY

In arctic regions, the main challenge for automatic weather stations is power. When mains power is available the electronics and sensors can be kept warm, but when it isn't, the components need to be robust enough to provide accurate measurements even at extremely low temperatures. The industrial temperature limit for electronic components is -40°C/°F, meaning that manufacturers do not guarantee operation below that temperature. Designing a weather station to operate reliably below this temperature requires careful component selection, knowledge of which parts of the design are most critical, and thorough and precise design testing.

Solar panels provide an easy way to secure electricity to power the equipment in areas where there is sufficient sunlight throughout the year, but heating the components requires a large number of solar panels and batteries. Even in areas where mains power is available, providing a connection to the weather station may be costly, and a battery backup will still be required to enable the equipment to operate during power outages. Using an intelligent power control system is beneficial because when power is not available the weather station can shut down the heating system, change the measuring and reporting interval, and generate an alarm if the power doesn't return. Battery selection depends on the temperature range: high temperatures can reduce battery lifetime while low temperatures can significantly cut capacity.

SELECTING OPTIMAL SENSORS

Sensor selection is always a compromise. In cold environments heated sensors are preferred, but if power for heating is not available then a non-heated model or one with limited heating capability has to be used. Selecting a wind sensor that will operate reliably at low temperatures can be challenging. Without heating, ultrasonic wind sensors will not work in icing conditions, while mechanical sensors do not provide accurate readings. Furthermore, ultrasonic wind sensor performance can be affected by temperature even if the sensor is heated, and calibration cannot be performed for the full temperature range as wind tunnels can only operate at ambient temperature – it is not possible to control the temperature in the tunnel. Typically, the temperature testing performed on these sensors verifies only that they are functional and does not cover zero wind measurement.

COMMUNICATION NETWORKS AND DATA AVAILABILITY

To serve weather forecasters and forecasting models, it is important to be able to collect accurate weather data in real time. Several types of communication network are suitable for real-time collection, but their effectiveness and reliability will vary according to location. When selecting a communication network, it is important to consider the amount of observation data that will be collected.

While cellular networks are capable of transferring large amounts of data at a low cost, the network coverage is restricted to inhabited areas. Satellite communication systems have the advantage of global availability but transferring large amounts

The Vaisala AWS310 weather station comprises several components, the most important of which is the main processing unit

"Reliable and flexible software is just as important as a robust electrical and mechanical design"

of data may be costly or even impossible, depending on the system.

Weather satellites offer a cost-effective way to transfer weather data, but may present challenges in terms of availability or data capability. Geostationary weather satellites are continuously available but cannot be reached from arctic regions, while arctic-orbiting weather satellites are only available a few times a day. Geostationary operational environmental satellites (GOES), widely used in North and South America, offer a low-cost method for transferring data but have a limited data capacity, with a five- or 10-second transfer window at low speed once an hour.

Use of geostationary weather satellites requires precise alignment of the transmission antenna and precise time synchronization for the weather station.

Weather satellites can only be used to collect data from the weather station; there is no communication from the data collection system to the weather station. Commercial telecommunication satellite systems can provide bidirectional broadband communication, but at a high cost.

Some commercial systems also provide low-cost packet data services. Two satellite constellations, Iridium and Argos, provide global coverage, but only the Iridium constellation has enough satellites to enable real-time data collection. Iridium offers a specific short burst data (SBD) communication mode where the data is in small packages that the weather station can read during the data transmission from the mailbox in the satellite.

Full integration between the weather station and the database is just as important as a reliable and robust communication network. The network management system has to be able to collect the data using different communication systems, control the weather stations and ensure data quality.

THE KEY ROLE OF SOFTWARE

Reliable and flexible software is just as important as a robust electrical and mechanical design. Weather station software is used to validate measurements, perform calculations, control telemetry devices, run continuous hardware testing, and generate reports for data collection. For analog measurements, the weather station needs to ensure that values are in range and also recognize sensor connections and possible failures.

Digital sensors come with their own software and validation, and it is important that the weather station can use the status information they provide for its own validation. The weather station software must be able to calculate short-term statistics from measurement values and perform validation between parameters. It also needs to be able to generate alarms for weather conditions as well as modifying its own operation based on the measured values. Continuous sensor development requires flexibility and easy integration for new protocols. New communication protocols enable a larger data transfer capacity, but when communicating over an open network ensuring communication security is more important than increasing the transfer capacity. In terms of maintenance requirements, the software should support easy remote operations, system validation, parameter setting adjustment and remote software updates.

A WEATHER STATION FOR THE MOST EXTREME CONDITIONS

Vaisala has more than 30 years' experience of designing weather stations for every weather and climate extreme on Earth, from the harsh temperatures of arctic regions to the hot and humid conditions of the tropics, and from exposed coastal areas to the top of the highest mountains. The Vaisala AWS310 weather station includes the main processing unit, with power supply, communication system and sensors. The entire system has been subjected to rigorous environmental and electrical testing, the mechanical structures have passed the relevant corrosion tests, and wind-load calculations have been performed to ensure mechanical strength. The Vaisala AWS310 software controls the sensor measurements, provides metadata from the system, and allows operation to be adjusted according to power availability.

The Vaisala AWS310 weather station also has a factory-tested software configuration with flexibility built in. The user can select sensors, devices and reporting format using the standard software. In addition, the Lizard configuration program can be used to modify the software or to write custom procedures. For network maintenance, the AWS310 has an automatic configuration update functionality that requires a cellular or LAN connection. This allows the network configuration to be updated without connecting to each individual weather station separately.

The most important factors in automatic weather station lifetime costs are maintenance needs and system reliability. A single annual maintenance visit should be sufficient to ensure that the station continues to provide accurate measurements. Additional maintenance visits can easily cost more than the station itself, so it's essential that accurate status information has already been accessed remotely before the visit. With well-documented and thorough testing before installation, your weather station should operate accurately and reliably, whatever the conditions. ∎