IC-1
INFORMATION SHEET

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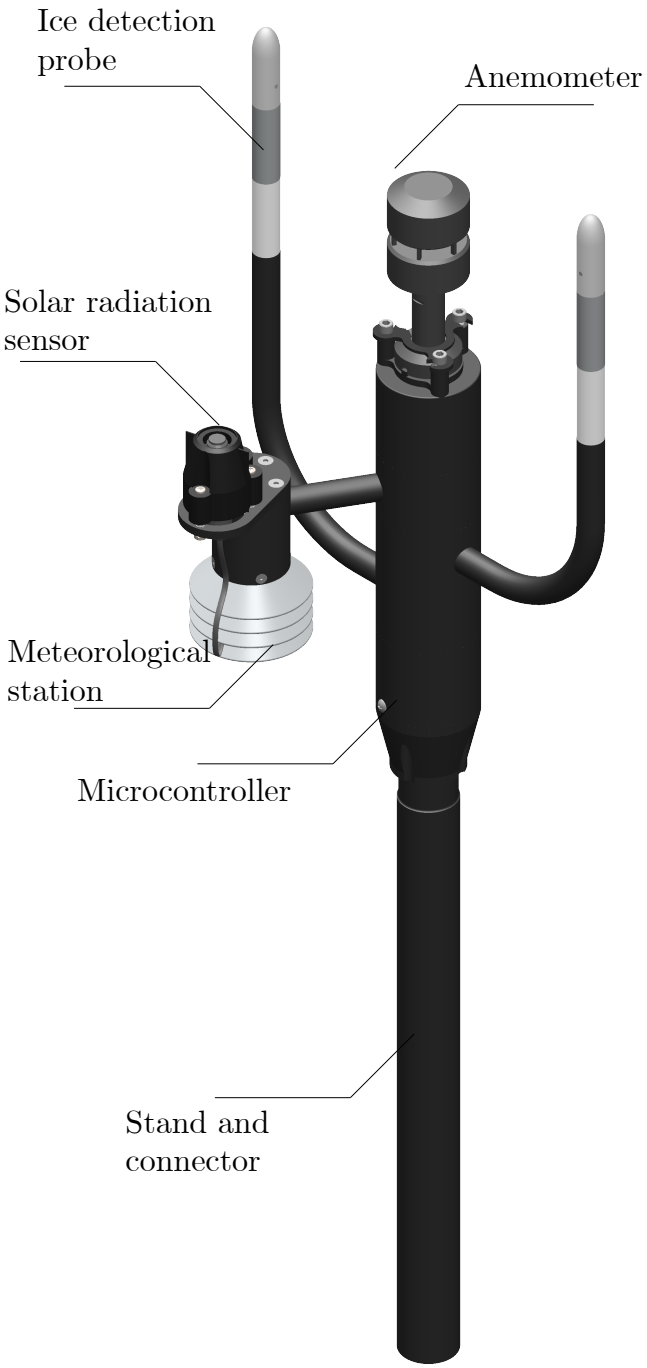
IC-1

The IC-1 Ice Condition Monitoring System is an instrument used to detect and quantify ice formation events. It also allows quantifying various meteorological characteristics necessary to obtain a comprehensive understanding of icing events. The IC-1 is designed to be installed on the nacelle of a wind turbine and on meteorological masts. Its measurements enable operators to better manage their assets by guiding their decisions based on field measurements and automating certain actions. It can be used to trigger blade heating systems or as a decision-making aid for alternative operational strategies to minimize production losses caused by ice accumulation. It is a robust instrument suited to the reality of conditions observed in cold climate wind farms.



Anemometer. The IC-1 is equipped with an FT Technologies ultrasonic anemometer to measure wind speed. This anemometer has proven its reliability over the years in the most arid environments.

Ice detection probes The heating probes allow the detection of conditions that lead to ice accumulation. Their increased sensitivity provides the opportunity to detect the onset of icing events at the earliest signs.

Solar radiation sensor. It provides measurements of solar radiation as well as cloud coverage.

Meteorological station. This station is used to accurately measure ambient temperature, atmospheric pressure, and relative humidity.

Microcontroller. The signals are analyzed locally, and no external measurements are required to determine the weather conditions and icing conditions. Communication protocol: serial 485 full-duplex.

Stand and connector. A versatile support that can be adapted to a variety of configurations is an integral part of the IC-1.

Operation

The IC-1 is equipped with two constantly heated probes to prevent them from being completely covered by ice. The patented detection principle [1, 2] utilizes heat transfer to detect the presence of water droplets in the air. When these droplets strike the surface of the heated probes, the heat transfer is amplified compared to what would be expected based on wind speed and measured surface temperature. From this additional heat extracted from the probe surface, it is possible to estimate the liquid water content (LWC) present in the air. This direct detection method provides the system with increased sensitivity compared to methods based on ice accumulation on surfaces. [1]

Control panel

Each instrument is supplied with a control electrical cabinet installed in the wind turbine nacelle. This cabinet, powered by 115/230V AC, serves as the interface between the signals measured by the IC-1 system and the wind farm control station. The electrical cabinet includes all the necessary equipment for the operation of the IC-1, including surge protectors and an edge device for control purposes. The cabinet complies with CSA22.2-286-17 and UL508a standards.

Controlling device

The IC-1 is delivered with its control intermediary (edge device) for the integration of signals into the computer network. This device provides an intuitive and user-friendly interface for monitoring and managing the data collected by the IC-1. With Internet connectivity, the data is easily accessible remotely. The flexible architecture of the interface can be adapted according to specific needs.

Communication protocols

The information from the IC-1 is routed to the network through the control device. This device hosts a Modbus TCP server that other devices can easily connect to. Custom programs are also available to directly send the data to servers using other protocols such as SQL or FTP.

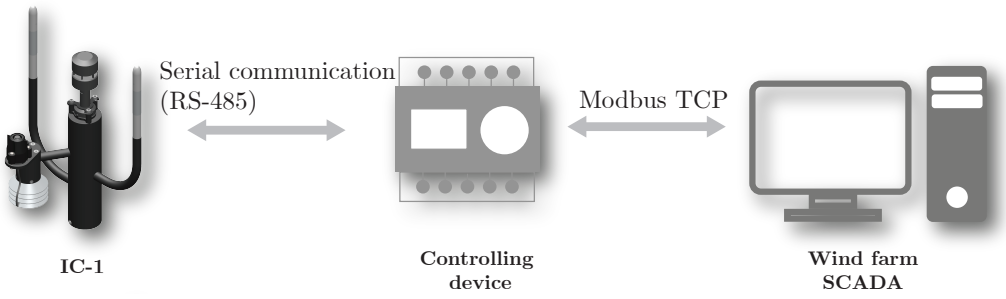


Figure 1: Communication diagram

[1] The validity of the measurements is confirmed for an instrument orientation of plus or minus 60 degrees from the wind direction.

Physical dimensions (in mm).

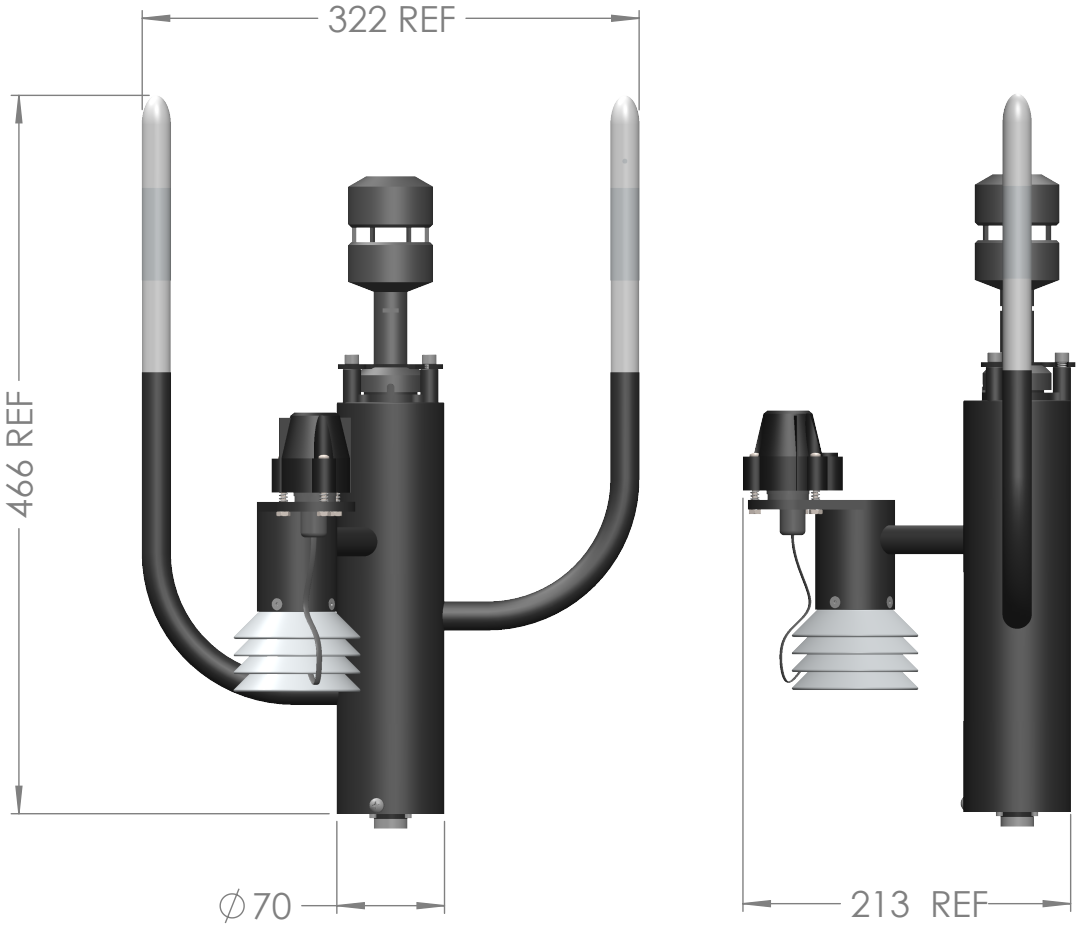


Figure 2: Physical dimensions of the IC-1 Ice Condition Monitoring System in mm. The instrument has a mass of 3300 g.

Technical specifications

The detailed technical specifications of the IC-1 sensor are listed, providing a comprehensive overview of its capabilities and performance.

Available signals		
Wind speed	0 to 50 m/s	±0.3 m/s (0 to 16 m/s) ± 2% (16 to 40 m/s) ± 4% (40 to 50 m/s)
Wind direction	0 to 360°	± 4°
Ambient temperature	-40 to 70°C	± 0.1°C (-20 to 30°C)
Humidité relative	10 to 100 %	± 3% RH
Barometric pressure	30 to 110 kPa	± 1 kPa
Solar radiation	0 to 1800 W/m^2	± 5%
Liquid water content[1]*	Typ. 0 to 1 g/m^3	
Severity[2]*	Typ. 0 to 6 g/(sm^2)	
Ice accretion*	mm	
Ice type*	Glaze	
(ISO 12494)	Hard rime	
	Soft rime	
Precipitation	yes/no	
Meteorological icing	yes/no	
Instrumental icing	yes/no	

Table 1: Available signals from the IC-1 instrument.

[1] Effective liquid water content
[2] Severity is the density of droplets that impact a surface per unit of time.
* Estimated values

Table 2: Historic of versions

Date	Revision	Author	Changes
June 2023	0	Philippe Guay	initial version

References

[1] André Bégin-Drolet, Jean Ruel, and Jean Lemay. Method and apparatus for determining an icing condition status of an environment, December 19 2017. US Patent 9,846,261 (CA 2,908,128).

[2] André Bégin-Drolet, Jean Ruel, and Jean Lemay. System and method for determining an icing condition status of an environment, July 14 2020. US Patent 10,712,301 (CA 3,012,392).