Remote Monitoring of Ice Formation over a Runway Surface

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Presentation outline

- The innovative ice sensor
- The monitoring system
- Presentation of the data
- Conclusions
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Applications

- Airports
- Roads
- Aircrafts
- Walkways
- Seas
Relative permittivity of water and ice

Water

Relative permittivity of air is about 1 for the whole range of frequencies and temperatures of interest
Multi-frequency measurement

Low frequencies (<1kHz). Distinction between water and ice is not possible, only air can be identified.

High frequencies (>100kHz). Distinction between air and ice is not possible, only water can be identified.

It is possible to distinguish between water, ice, and air by two measurements, at low (200Hz) and high (20MHz) frequencies.
Geometrical configuration and dimension of the electrodes

- Independent of the orientation of electrodes
- Independent of the position of raindrops or pieces of ice with respect to electrodes

Concentric electrodes

- External maximum ring dimension imposed by the box
- External minimum ring and internal circle dimensions in order to explore a largest area between the 2 electrodes, but still large enough to get a measurable value of capacitance
The capacitance measurement circuit

- $C_X$ is the capacitance of the electrode assembly and the material placed over the sensor.
- $V_R$ and $C_S$ are the reference voltage and capacitance.
- Since $C_X \ll C_S$, nearly all charge in $C_X$ is transferred to $C_S$ when $S_2$ is closed.
- $V_S$ is measured by an ADC.
- $S_3$ is used to discharge $C_S$.

Repeating the transfer process for $n$ times:

$$C_X = \frac{C_S V_S}{n V_R}$$
Final prototype
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Sensors at the Turin-Caselle airport

Three sensors were embedded at the Turin-Caselle airport in order to detect formation of ice at the beginning, ending and in the middle of the runway, and increase safety during take off and landing of the aircrafts.
Wireless sensor network

- Sensor
- Monitoring system
- Control station

Using cable: 3450m of cable

Using a wireless monitoring system: 300m of cable
Wireless sensor network

GPRS was chosen since:

- cover a large area without using repeaters
- secure (using encryption algorithms)
- be manageable via Internet
The monitoring system

Data acquisition board

GPRS board
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Presentation in a web site: current state

RUNWAY D-ICE SENSORS: CURRENT DATA

Torino-Caselle Airport

Last update: 14:24:20 04/05/2012
Presentation in a web site: last 24h state

www.neuronica.polito.it
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Conclusions

- An innovative system to monitor the data collected by sensors at the Turin-Caselle airport was presented.
- The data are presented on web pages for simple access.
- The GPRS based monitoring system was installed more than one year ago showing correct working and automatic reactivation after malfunctions without any external help.
The end

Thank you for your attention!

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