

Airplane Ice Detector Based on a Microwave Transmission Line

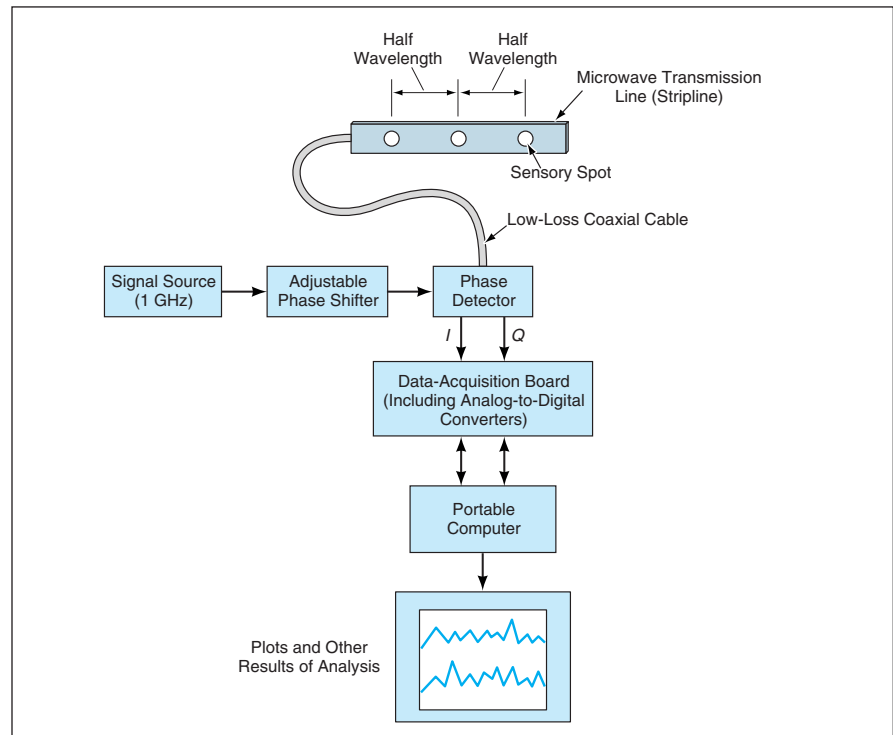
Electrical measurements are affected by thawing, freezing, and the presence or absence of water.

Lyndon B. Johnson Space Center, Houston, Texas

An electronic instrument that could detect the potentially dangerous buildup of ice on an airplane wing is undergoing development. The instrument is based on a microwave transmission line configured as a capacitance probe: at selected spots, the transmission-line conductors are partly exposed to allow any ice and/or liquid water present at those spots to act as predominantly capacitive electrical loads on the transmission line. These loads change the input impedance of the transmission line, as measured at a suitable excitation frequency. Thus, it should be possible to infer the presence of ice and/or liquid water from measurements of the input impedance and/or electrical parameters related to the input impedance.

The sensory transmission line is of the microstrip type and thus thin enough to be placed on an airplane wing without unduly disturbing airflow in flight. The sensory spots are small areas from which the upper layer of the microstrip has been removed to allow any liquid water or ice on the surface to reach the transmission line. The sensory spots are spaced at nominal open-circuit points, which are at intervals of a half wavelength (in the transmission line, not in air) at the excitation frequency. The excitation frequency used in the experiments has been 1 GHz, for which a half wavelength in the transmission line is ≈ 4 in. (≈ 10 cm).

The figure depicts a laboratory prototype of the instrument. The impedance-related quantities chosen for use in this version of the instrument are the magnitude and phase of the scattering parameter S_{11} as manifested in the in-phase (I) and quadrature (Q) outputs of the phase detector. By careful layout of the transmission line (including the half-wavelength sensor spacing), one can ensure that the amplitude and phase of the input to the phase detector keep shifting



The I and Q Outputs of the Phase Shifter are affected by the presence or absence of liquid water or ice on the sensory spots on the microwave transmission line.

in the same direction as ice forms on one or more of the sensor areas. Although only one transmission-line sensor strip is used in the laboratory version, in a practical application, it could be desirable to install multiple strips on different areas to detect localized icing. In that case, a multiplexer should be used to connect the various strips to the phase detector for sequential measurements.

Experiments have been performed with freezing and thawing of water and of water/glycol mixtures. The experiments have shown that, whether or not glycol is present, it is possible to distinguish between liquid water and ice via the I and Q outputs; in particular, the equipment can

be adjusted so that when water freezes, I decreases and Q increases. With respect to the operation of this instrument, the main effect of glycol is to increase the freezing or thawing time.

This work was done by G. Dickey Arndt and Phong Ngo of Johnson Space Center and James R. Carl of Lockheed Martin. For further information, contact G. Dickey Arndt at g.d.arndt@nasa.gov.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23118.

Microwave/Sonic Apparatus Measures Flow and Density in Pipe

The entire flow, rather than a small diverted sample flow, is probed.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus for measuring the rate of flow and the mass density of a liquid or slurry includes a special section of pipe instrumented with microwave and sonic

sensors, and a computer that processes digitized readings taken by the sensors. The apparatus was conceived specifically for monitoring a flow of oil-well-drilling

mud, but the basic principles of its design and operation are also applicable to monitoring flows of other liquids and slurries.

In one configuration, a special section