Microwave Autodyne Vibrosensor in Aeroengine Diagnostics

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The sensor is designed for in-flight aeroengine turbine blade vibration monitoring. The sensor operation and construction are similar to liquid rocket engine flame parameters sensors, which were presented on 20th EFTF.

Sensor represents an antenna-oscillator module. It excites electromagnetic field in “diagnostic chamber” being (that is itself) a section of air flow duct, bounded by stator and rotor parts surfaces. Currently existing engine “diagnostic chamber” can be accessed through operational inspection port from 6 to 12 mm in diameter, where flush-mounted antenna is installed. Unlike mentioned prototypes this sensor is an open-ended circular waveguide.

3D EM field structure and its fluctuation depending on regular, vibrating and damaged blade travel states have been researched in quasi-static approximation. Probing frequency varied from 4 to 40 GHz, and range from 28 to 37 GHz was accepted as preferable. Field structure impact on antenna current flow, its vector admittance, and reflectivity have been found out. Furthermore, Computational electromagnetic simulation by FEKO software tool was applied. Then autodyne frequency response form was found out.

During regular turbine rotation RF spectrum is sampled. Sampling rate F is multiplication of rotation frequency (hundreds of hertz) to number of blades (approx. one hundred hertz). Estimated samples amplitudes are stipulated by response form and modulated by vibration process.

Damage of a blade causes sample component occurrence in RF spectrum and corresponds to rotation frequency. Final part of diagnostic operation includes two-step detection of frequency and amplitude of the signal received. At the end, evaluated spectrum is compared with reference spectrum, while secondary processing of signal is being performed.

According to data vibration process spectrum (received after second detection in two-step detection process) is quite meaningful and, particularly, allows revealing more than ten malfunctions in eight aeroengine components at pre-emergency state.