Feasibility Study for Microwave Doppler Vector Flowmetry

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We propose a feasibility study for Microwave Doppler Vector Flowmetry, where the goal is to determine if microwaves may be applied to measure the velocity vector of a liquid within a dielectric pipe. Non-invasive flow measurement of liquids inside a pipe have several interesting applications ranging from industrial monitoring of conduits content to medical sensing of vital signs. Many techniques have been developed throughout the years, including, for example Optical Coherence Tomography (OCT) and its Doppler version, Electrical Impedance Tomography (EIT) and Doppler Ultrasound Flowmetry [1-4].

The proposed approach is stimulated by the technique described in [5], valid in the case of ultrasounds, to the microwave spectrum. Microwaves are considered because of their potential to penetrate through materials that are not suitable for the use of ultrasounds. The measurement system consists of a hydraulic circuit, in which the flow through the pipe under investigation (PUT) is known. The PUT is radiated by a transmitter operating at a given carrier frequency. Three receiving antennas are located around the PUT to collect the signal scattered by the flowing liquid. The scattered signal will be processed to retrieve the Doppler components along three orthogonal directions and to compute the velocity vector associated with the flux. To avoid complications due to coupling among antennas, measurements will be repeated at different time instants for each pair transmitter-receiver; then, synthetic reconstruction under the same operating conditions will be used to compute the 3D components of the average flow vector. By choosing adequate carrier frequencies for the dielectrics in the setup, one expects to find a suitable compromise between resolution and penetration. For example, with OCT high resolution is obtained with low penetration, while with EIT measurements are limited by resolution constraints. Experiments will be carried out in the anechoic room of the Andrew Electromagnetics Laboratory using simple straight cylindrical pipes as well as realistic phantoms of human vessels manufactured by the Biofluids Laboratory [6].

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