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OUTILS ET MÉTHODES INTELLIGENTES POUR LES RADIO-SCIENCES

Terahertz imaging and sensing with open waveguides : Advantages, challenges and opportunities

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Terahertz (THz) imaging provides non-ionizing, contactless inspection with sensitivity to dielectric contrast and, in many materials, partial transparency to sub-surface features [1]. These properties make THz methods attractive for non-destructive testing (NDT), quality control, and diagnostics of polymers, foams, coatings, and composites. However, conventional far-field THz imaging is limited by diffraction-limited resolution, strong sensitivity to alignment, and significant propagation and coupling losses that require bulky quasi-optical benches. In reflection mode, weak backscattered signals and parasitic multipath/standing-wave effects further degrade robustness and complicate deployment outside controlled laboratory environments.

Open waveguides provide an alternative by transporting the THz/mm-wave field directly to the region of interest, reducing free-space path loss and easing alignment. A single guiding structure can both deliver and collect the signal, enabling compact reflection-mode probes and access to confined geometries. This approach also supports cleaner system integration and, when combined with appropriate processing, can help separate useful echoes from unwanted reflections generated along the measurement chain. The feasibility of guided reflectometry imaging has been demonstrated with broadband impulsive systems using an optics-free photoconductive transceiver coupled to a hollow-core waveguide, enabling reflection imaging after guided propagation [2]. It has also been demonstrated with FMCW radar [3], where range processing enables discrimination of parasitic reflections from the reflection at the probe end, supporting practical raster-scan imaging with compact mm-wave hardware.

In this work, we propose to present these two complementary approaches—pulsed guided THz reflectometry and guided FMCW radar reflectometry—and introduce FMCW imaging results for NDT using plastic open waveguides. The focus is on compact, low-cost probes for industrial inspection, with emphasis on coupling strategies, artefact mitigation, and distance-gated processing to enable robust imaging in realistic deployment conditions, with FDTD simulation and experiments with D-Band FMCW radar.

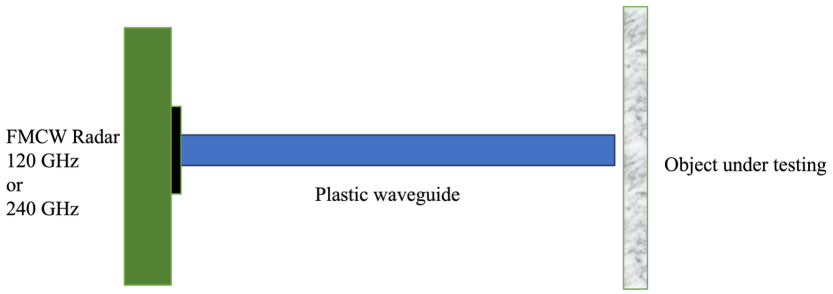

Figure 1: Reflectometry setup with plastic waveguide

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