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Orthogonally Coded Antenna Array for Millimeter-Wave Imaging

Matthew Caron, Matthew Dvorsky, Mohammed Tayeb Al Qaseer, and Reza Zoughi

Center for nondestructive Evaluation (CNDE)
Electrical and Computer Engineering Department
Iowa State University
caronm25@iastate.edu

ABSTRACT

Imaging applications requiring non-contact and real-time imaging (e.g., production environments and imaging through thick honeycomb composites) can greatly benefit from real-time millimeter-wave imaging systems. The latest designs of millimeter wave imaging arrays are often multi-static, where there are multiple receive and transmit antennas, each of which can be individually switched on or off. This configuration allows independent measurements to be made using many different pairs of transmit and receive antennas, which in turn provides for improved image quality (i.e., improved SNR) when compared to mono-static configurations. However, most multi-static arrays use a multiplexed feed structures, which only allows operation of one pair at a time. Thus, there is a significant compromise between increasing data acquisition time and reducing SNR. This paper introduces a new multi-static imaging methodology, relying on binary phase shift keying (BPSK) modulation, that can simultaneously transmit and receive without sacrificing data acquisition time or imaging quality. To demonstrate this new methodology, a multi-static millimeter-wave imaging array with 8 transmitters and 8 receivers was developed operating at Ka-band (26.5-40 GHz).

Temporal orthogonality allows multiple signals to be simultaneously transmitted through the same channel and recovered via demodulation. Utilizing this technique allows an imaging array to irradiate a sample under test (SUT) using multiple transmitters at the same time while still allowing the signal from each transmitter to be distinguished. In this work, we utilize BPSK modulation to modulate each transmitter with a temporally orthogonal signal using Ka-band microwave up-converters. The receivers, which can all operate simultaneously, then each capture the scattered signal off the structure under test, which are subsequently down-converted and digitized. Then, in post-processing, the received signals can be demodulated to recover the signal resulting from each transmitter/receiver pair.

This approach enables the device to simultaneously measure the magnitude and phase of the signal scattered by the structure under test for pair of the transmit and receive antennas. The proposed method significantly improves the contrast for objects with weakly scattering targets, without a dramatic increase to measurement times. The design of the system will be presented along with imaging few imaging experiments that demonstrate the efficacy of the system.

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