Low-cost Packaging Inspection System Based on Millimeter-Wave Stepped Frequency Radar

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The exponential growth of e-commerce in conjunction with threats pertaining to the drug trade and terrorism are creating a significant need for inspection sites (postal processing centers, airports, seaports, and etc.) to upgrade and expand their capabilities. It is important to prevent hazardous and explosive materials, and illegal drugs transportation across international borders.

As compared to the other parts of spectrum, namely infrared, visible light, ultraviolet, X-ray or radio-wave radiations, the millimeter-wave radiations are more suitable for the packaging inspection. This is particularly the case due to the fact that the visible and infrared radiation cannot penetrate inside the package. X-ray and ultraviolet radiation penetrates inside the package and can be used for imaging high-contrast materials but is not suitable for the low-contrast materials.

We are going to implement a low-cost millimeter-wave packaging inspection (MMPI) system using the Millimeter-wave Integrated Circuit (MMIC) to lower the implementation cost of the stepped frequency CW Radar. The synthetic aperture focusing (SAF) technique will be employed for reconstructing the internal sectional image inside packaging under test (PUT) using the electric fields measured outside the PUT. The proposed MMPI system has two main advantages over the X-ray Packaging Inspection systems. On one hand, the proposed MMPI system can be used to detect a concealed object from a low-contrast background (i.e. detecting a ceramic knife or a plastic gun from a low-contrast background) while the X-ray inspection systems cannot. On the other hand, the MMPI system will be able to estimate the electromagnetic properties of materials within PUT while the X-ray systems will not be able to do so.

We are going to present our experimental results for packaging inspection system development: 1) Design, analysis, and optimization of the 3D millimeter-wave imaging system using low-cost commercial components and MMICs commercially available in the market, 2) Prototype development and implementation, and 3) System test and verification.