A 94-GHz Receiver Front End for Passive Millimeter-Wave Imaging

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***Abstract*—We have designed and fabricated the passive millimetre-wave imaging system for receiving radiation energy from the an object and a human body. The lens and front-end of the receiver are important in the system to detect input thermal noise signal. Passive millimetre-wave imaging system required of high sensitivity and wide broadband to detect input thermal noise. The LNA module of the imaging system has gain of 65.8 dB in average linear gain and 11 GHz in bandwidth to enhance sensitivity for thermal noise and to receive it in wide-band width as well. The zero-bias Schottky diode has been used for the detector circuit to convert amplified millimeter-wave signals to DC output.**

I. INTRODUCTION

The area of Millimeter-Wave (MMW) system research and design has become increasingly popular in recent years. Passive millimeter wave (PMMW) imaging is a method of forming images through the passive detection of naturally occurring millimeter wave scene radiation. Recently, this kind of imaging has been paid attention due to its ability to not only image in low visibility conditions, but also because it can detect concealed weapons under clothing. This ability has the potential to improve the general state of societal security through the detection of such weapons that may be missed by current methods. A millimeter-wave imaging system has been developed for personnel screening at airport checkpoints.

Improved weapon detection technologies are critically needed to counter the threat of modern weapons at high-security locations. At this time, public security scanning systems rely heavily on metal detectors and X-ray imaging systems. However, it may not be allowed due to real or perceived health threats of ionizing X-ray radiation [1~2]. In addition, most security imaging for personal privacy issues have recently been seriously considered.

PMMW system requires high sensitivity and wide broadband to detect input thermal noise. In this paper, we designed and fabricated a 94-GHz receiver front end for passive millimetre-wave imaging.

II. DESIGN OF THE IMAGING SYSTEM

In the millimeter-wave regime, there are propagation windows at 35, 94, 140, and 220 GHz, where the attenuation is relatively modest in both clear air and fog. Even taking into account the much higher blackbody radiation at IR and visible frequencies, millimeter waves give the strongest signals in fog when propagated over distances of useful interest [3].

A black body is an idealized object that absorbs all electromagnetic radiation that falls on it. No electromagnetic radiation passes through it and none is reflected. Because no light (visible electromagnetic radiation) is reflected or transmitted, the object appears black when it is cold. However, a black body emits a temperature-dependent spectrum of light. This thermal radiation from a black body is termed black-body radiation [4].

Planck's law states that

$$I(\nu,T)d\nu = \left(\frac{2h\nu^3}{c^2}\right)\frac{1}{e^{\frac{h\nu}{KT}}-1}d\nu$$

where, I(ν,T)dν is the amount of energy per unit surface area per unit time per unit solid angle emitted in the frequency range between ν and ν + dν by a black body at temperature T, h is the Planck constant, c is the speed of light in a vacuum, k is the Boltzmann constant, ν is frequency of electromagnetic radiation and T is the temperature in kelvins.

We designed a receiving front end for passive imaging which contains antennas, 4-stage LNA and diode detectors. A block diagram of the imaging system is shown in Fig. 1.

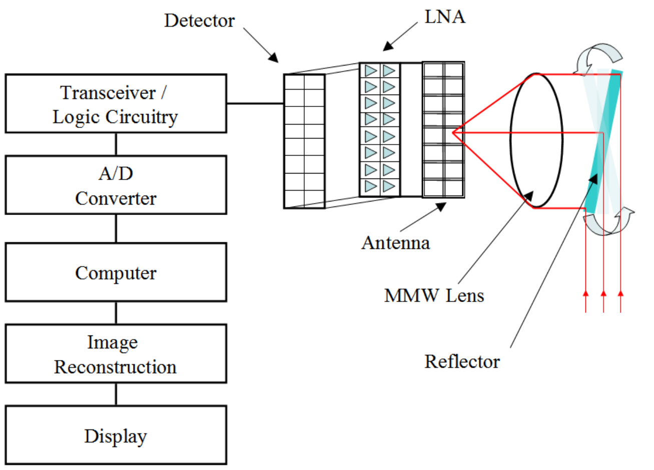

Figure 1. Block-diagram of the PMMW imaging system