Compact Reflectometers for a Wideband Microwave Breast Cancer Detection System

Marek E. Bialkowski, *Fellow, IEEE,* Norhudah Seman, *Student Member, IEEE,* Amin Abbosh and Wee Chang Khor, *Student Member, IEEE*
School of Information Technology and Electrical Engineering, The University of Queensland, St Lucia, QLD, 4067 Australia

***Abstract*—The design of compact wideband microwave reflectometers for the purpose of inclusion in a breast cancer detection system is presented. In this system, a wideband frequency source is used to synthesize a narrow pulse via the step-frequency synthesis method. The reflectometer undertakes measurements in the frequency domain and the collected data is transformed to the time/space domain using IFFT. In order to accomplish reflection coefficient measurements over a large frequency band, compact wideband couplers and power dividers are used to form the reflectometer. Two compact six-port reflectometer configurations are investigated. One uses the Lange coupler and the Gysel power divider and the other one employs a 3dB slot-coupled microstrip coupler and a 2-stage Wilkinson power divider. The reflectometer employing the slot-coupled coupler and the Wilkinson divider provides a wider operational bandwidth, as shown by simulation results performed with Agilent ADS.**

***Index Terms*—Cancer detection, microwave imaging, experimental verification, near field.**

I. INTRODUCTION

Breast cancer is the most common cancer diagnosed in women in various parts of the world. In Australia alone, it is estimated that one in eleven Australian women will develop breast cancer at some stage in their life [1].

Early detection and effective treatment is the only way to reduce the mortality rate due to breast cancer. Currently the primary method for breast screening is X-ray mammography [2], [3].

X-ray mammography has saved many lives, but the technology still produces a relativity high number of false negative and false positive diagnoses. There is also health concern related to exposure to ionizing radiation [3]. These factors have generated interest in alternative approaches of breast cancer detection that feature various degree of success. For example ultrasound is used clinically to discover whether a lesion detected in a mammogram is a liquid cyst or a solid tumour [2]. In addition, Magnetic Resonance Imaging has been shown to be a very useful screening tool, but is very expensive and not portable [4].

Recently, microwave imaging has been proposed as a viable alternative to X-ray mammography. Microwave imaging system is essentially "breast tissue radar". It involves an application of very low levels (1000 times less than a mobile phone) of microwave energy through the breast tissue. The foundation for tumour detection is a difference between the electrical properties of normal and malignant breast tissue. Normal breast tissue is largely transparent to microwave radiation while lesions, which contain more water and blood, scatters microwaves back towards the microwave source. The antenna picks up these reflected signals and they are analysed using a computer. A three dimensional image showing the location of the cancerous tissue can be obtained as the outcome of this signal processing [3].

Several research groups, including the University of Wisconsin-Madison and Dartmouth Collage of the US, University of Calgary in Canada, Technical University Denmark and others are currently doing research in this new area [2], [3], [5]. Similar activities have also been undertaken at the University of Queensland in Australia.

The majority of the developed microwave breast cancer detection prototypes are based on the synthesized pulse technique, in which a narrow pulse is generated in the frequency domain [6]. This synthesized signal is launched and received by an antenna which can be moved in small steps across a planar or curved area in front of an imaged object. At each location of the probe antenna, the received signal is processed with a Vector Network Analyser (VNA) which, by using its time domain capability, provides a suitable signal transformation from frequency to time or space domain. The measurement system is controlled from a PC. The collected data is gathered and processed by the PC to obtain a visual insight.

The conventional VNA with time-domain processing capability is handy to test and proof the concept of the microwave breast cancer detection system. However, because of its large size and high cost it may be precluded in a commercial breast cancer detection system.

The purpose of the work presented in this paper is to replace the conventional VNA by a low-cost alternative in the form of a wideband microwave six-port reflectometer. This paper is organised as follows, Section II, describes the experimental setup required for a microwave breast cancer detection system and provides results obtained using the conventional VNA with time-domain processing capability. Section III describes the design of a wideband

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