ULTRASOUND DEVICE TESTER

MURNI NORESTRI BINTI MOHD NORDIN

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Faculty of Computer Science and Information Systems
Universiti Teknologi Malaysia

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ABSTRAK

Pada masa ini, teknologi ultrabunyi telah digunakan secara meluas untuk tujuan perubatan, industri, keselamatan, automotif dan pendidikan. Dalam kebanyakan applikasi seperti terapi perubatan, diagnostik perubatan dan pengujian kerosakan, kuasa yang tepat yang dijanakan oleh transduser ultrabunyi amatlah penting. Jika kuasa yang dijanakan itu tidak tepat untuk applikasi tersebut, masalah yang timbul menyebabkan bahaya kepada pesakit. Satu kajian menunjukkan lebih kurang 10,000 mesin ultrabunyi di United Kingdom gagal menjanakan kuasa sekurang- kurangnya 30 % daripada kuasa yang tepat. Untuk mengurangkan risiko ini, mesin ultrasound haruslah diuji secara berkala dan kerap. Salah satu cara untuk menguji mesin ini ialah dengan menggunakan meter kuasa ultrasound. Dalam projek ini, satu prototaip Penguji Alat Ultrabunyi akan dibangunkan di mana ia adalah alat untuk mengukur kuasa ultrabunyi yang dijanakan oleh mesin ultrabunyi diagnostik dan terapi. Ia terdiri daripada bahagian perkakasan dan perisian. Ia menggunakan Rajah Kes Guna untuk membangunkan bahagian perisian dan pengesan polimer sebagai teknologi pengukuran. Beberapa ujian telah dilakukan untuk melihat sama ada prototaip ini berfungsi dengan baik atau tidak dan ia selamat digunakan. Kesimpulannya, prototaip ini telah berjaya dibangunkan. Untuk menjayakan projek ini, jumlah pembiayaan yang diperlukan ialah sebanyak RM 0.5 juta. RM 0.15 juta diperlukan untuk pembangunan prototaip dan permulaan perniagaan. Lebihan pembiayaan tersebut diperlukan untuk permohonan harta intelek, menjalankan pengujian professional permohonan pensijilan tempatan dan antarabangsa serta pra- komersialan.

ABSTRACT

Nowadays, ultrasound technology is widely used for medical, industry, security, automotive and education purposes. For many application such as medical therapy, medical diagnostic and non destructive testing, accurate value of power generated by ultrasound transducer is very crucial. If the power generated is not accurate for those applications, problems which cause danger to patients might occur. A research shows that most of the 10,000 ultrasound machines in the United Kingdom fail to deliver within 30% of the correct power. To reduce the risk the ultrasound machine must be tested periodically and frequent. One of the approaches to test the machine is using ultrasound power meter. In this project, an Ultrasound Device Tester prototype is developed whereby it is a device to measure ultrasound power generated by ultrasound diagnostic and therapeutic machines. It consists of hardware and software part. Use case model is used to create the software part and polymer sensor is used as the measurement tool. Testing has been done to see whether the prototype is working properly or not and safe to use. As a conclusion, the prototype has been successfully developed. In order to embark on this project, a total funding RM 0.5 million is required. RM 0.15 million of the funding is required which for prototype development and business incorporation. Balance of the funding required is for intellectual property application, perform professional testing, local and international certifications application and pre- commercialization.

TABLE OF CONTENTS

CHAPTER 1

PROJECT OVERVIEW

1.1 Introduction

Ultrasound therapeutic device is used to generate the ultrasound mainly used in the treatment of soft tissue injuries for the acceleration of wound healing. Therapeutic ultrasound can be divided into two classes; at low spatial peak temporal average (SPTA) intensities around 0.125 to 3.0 W/cm^2 at frequency 0.5 to 3.0 MHz. The aim is to produce non- destructive heating or non thermal effect for accelerating normal physiological response to injury. Besides, at higher intensities above 5 W/cm^2, the aim is rather to produce controlled selective destruction of tissues. The first category includes the majority usage for physiotherapeutic whereas beam surgery falls into the second category. The thermal energy from the treatment head will transfer to the exposure tissues with a depth for the treatment of soft tissues injuries, wound healing and treatment of bone and joint injuries.

The ultrasound power meter is a device used to measure and calibrate the output power and intensity of the ultrasound machine. The measurement of the ultrasound power

meter is aimed to ensure the output generated by the ultrasound machine is under the safety condition according to the International Electrotechnical Commission (IEC) standard. The ultrasound power meter used the piezoelectric devices to detect the ultrasound field. The piezoelectric devices have the nature ability to convert the mechanical energy or heat to the electrical energy. Meanwhile, there is variety methods used to construct the ultrasound power meter. The approaches are the radiation force method, calorimetry and hydrophone with polyvinilidene difluoride (PVDF) sensor.

Ultrasound power meters which are currently available mostly rely on radiation force balance method. It is balancing the radiation force exerted by and ultrasound wave on a reflector with a restoring force. The restoring force may be provided by an electronic feedback system. The main concept is using the reflecting rather than absorbing targets. The power meter is measuring the entire of the beam ultrasound and the quantity pressure is the main concern parameter to carry out the measurement for the power meter. Then the mostly of the detector sensor using for this power meter is ceramic piezoelectric device.

The calorimetry type of ultrasound power meter is measuring the total beam power and carried out with direct reference to fundamental physical quantities. The calorimetry measurement of the total acoustic power output of a transducer under conditions where the complete beam can be directed into the calorimetry. Measurement of local values of intensities by calorimetry method is rather a different approach and one that is additionally of interest in the assessment of the pattern of temperature rise that occur in tissues exposed to therapeutic sources of ultrasound. Thermocouple is the sensor used in the calorimetry method for the absorption of the heat produced by the ultrasound beam. The measurement is due to the temperature as reference set value.

The development of Ultrasound Device Tester (***UDevT***) for medical application have been reached the point of formal international agreement on

recommended method to measure the power and intensity for the ultrasound machine. It consists of hardware part called Ultrasound Tester (***UTest***) and software part called Smart Measurement (***SMeas***). The hydrophone is a water tank and used the water as the propagation medium for the ultrasound sources with the sensor. Then a piezoelectric polymer sensor place inside the water tank to measure the intensity of the sources of the ultrasound. The absorption of the heat of the PVDF sensor will convert to the electrical energy for measurement. The hydrophone power meter with PVDF sensor can utilize for wideband frequencies which is suitable for most of the medical application.

1.2 Problem Statement

Published surveys of ultrasound therapy generators in hospital use have revealed that the calibration supplied by the machine manufacturers may be grossly inaccurate. The machine may exceed the safety regulation and may cause the biological negative effect to the patients. Some researches have been done and the problems have been identified are:

i. 37 devices use in the Ottawa area that were tested, the acoustic output varied from +/ 250 % of the meter reading, with 72 % of the devices giving less than the set value.
ii. Most of the 10,000 ultrasound machines in United Kingdom (UK) fail to deliver within 30 % of the correct power.
iii. 37 treatment head, the ultrasound beam non-uniformity ratio was normally found to be in the range 3 to 7 W/cm^2, but 8 heads had values above 8 W/cm^2.

1.3 Background of Study

Ultrasound is one of the most popular and productive non-invasive therapeutic and diagnostic tools in medicine. Ultrasound with frequencies 1 to 10 MHz for diagnostic usage is most frequently used, as high frequency allows good resolution to be obtained. For the ultrasound therapeutic devices, the safety intensity emission is 3 W/cm^2 and the frequency response is 1.5 to 3.5 MHz. Increases in transmitted ultrasound power improve the signal to noise ratio of the image and the biomedical usage. However ultrasound absorption in the body causes heating which may be harmful in excess. Therefore, it is important to keep the overall power to a minimum but sufficient to produce the desired information.

Due to the significance of the ultrasound devices to generate safety acoustic wave for medical usage, there are currently available products which are able to measure it accurately to ensure the correct operation and safe use of ultrasound for specify application. Monitoring of output power levels also provides a means of monitoring the performance of the equipment. The products are the ultrasound power meter. It comes with different features and sensor used as detection. The features of these products vary from low cost to high cost with different specifications. Meanwhile, the power meter's measurement methods used are the radiation force measurement and hydrophone with PVDF sensor in membrane probe and needle.

1.4 Objective

The objectives of this project are:

i. To complete market survey through literature, questionnaire distribution and interviews.
ii. To study basic principal of ultrasound and characteristics of the PVDF sensor through literature.
iii. To create programme codes for data management in processors.
iv. To integrate analogue part and digital part in the ***UTest***.
v. To develop prototype of the ***UDevT***.

1.5 Scope of Project

Scope will be used to bind this project to a certain limit. So, the writer has to concentrate on what really important and related to this project. There are three main scopes that should be covered and it will determine the effectiveness of this project. The scopes are:

i. Design and develop the prototype of ***UTest***.
ii. Design and develop the prototype of ***SMeas***.
iii. ***UDevT*** is developed for testing the ultrasound diagnostic and therapeutic machines.

1.6 Thesis Outline

The thesis consists of seven chapters. Each chapter is described follows.

Chapter 1 serves as an introduction to the report. It includes an overview of ultrasound power meter applications and description, literature review, project objective and scopes of the project.

Chapter 2 discusses the literature review which is relevant for focusing on the basic concept of ultrasound and comparison between several ultrasound power meters available in the market. Then, advantages' using the PVDF sensor rather than ceramic is discussed.

Chapter 3 will describes the methodology taken to complete the entire project. It included the flow diagram and the work breakdown structure about the every process taken to construct the project.

Chapter 4 will guides to the system designed implementation and the description for the hardware and software part of the project.

Chapter 5 shows the result and testing for the project.

Chapter 6 describes the shortcomings experienced and suggestions solution and the conclusion. The recommendation of the project will also be discussed.

At the end of this thesis, a business plan for this project will be presented.