THE DEVELOPMENT OF A SPECTROMETER FOR PORTABLE NMR SYSTEMS

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Physics at Massey University

Robin Dykstra

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Appendix D

MASSEY UNIVERSITY
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Dedicated to the memory of my late father,
Michiel Dykstra,
who passed away during the preparation of this thesis.

Abstract

Nuclear Magnetic Resonance (NMR) is a relatively complex technique and normally requires expensive equipment. However, with advances in computing, electronics and permanent magnet technologies, NMR is becoming more feasible as a non-invasive tool for industry. The strength of NMR is its ability to probe at the molecular level and hence gain information about molecular structure, organisation, abundance and orientation. This thesis describes the development of an instrumentation platform technology that is compact and therefore portable. It has been produced to aid the development of NMR based tools or sensors for research and industry and will lead to a series of low cost, portable NMR systems for the non-destructive testing of materials such as polymer composites, rubber, timber, bricks and concrete.

The instrumentation is largely electronics based and consists of a series of modules that can be interconnected to produce a solution. The first of two main modules is called the system core. What is common to all NMR applications is the generation of precisely timed signals, the capturing of signals and the processing/display of data. This has been implemented by developing a general purpose Digital Signal Processor (DSP) based instrumentation and control module that uses a Universal Serial Bus interface to communicate with a host computer. A graphical user interface is provided by an application running under Windows® XP.

The second main module is a radio frequency transceiver that has been developed using digital receiver technology. The signals, after some amplification, are digitized with a 14-bit, 62.5 MHz analogue to digital converter. The sampled signal is then mixed digitally with synthesized sine and cosine functions to generate lower frequency quadrature outputs which are then digitally filtered and decimated before being passed onto the DSP for further processing and storage. A direct digital synthesizer with an analogue output is used to generate any required excitation signals. All synthesizers have phase and frequency hopping capabilities and are phase locked to each other and the DSP.

The system was designed to interface to a range of NMR probes. The type of probe is determined by the intended application and each probe has specific requirements such as the type of radio frequency power amplifier, duplexer and preamplifier needed. This results in a number of instrumentation variations and a modular instrument enclosure was used to cater for these variations. The instrument was first configured for an NMR probe called the NMR-MOUSE. Tests were performed with this probe to verify the correct operation and performance of the instrument. The instrument was then reconfigured for a new probe called the NMR-MOLE and further testing was performed. This probe was still undergoing development and had not been previously tested. Finally, a dedicated compact instrument measuring 360 x 240 x 55 mm and weighing 3.6 kg was developed for the NMR-MOUSE probe.

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Contents