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Minor Research Project

On

STUDY ON MODELING AND SIMULATION OF MEDICAL ULTRASONIC SYSTEM

By

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Summary of Findings:

- In this project circuit simulator models of complete ultrasonic systems are used to design custom integrated circuits. These circuits are optimized for low power consumption and small size. The models that are used to predict the acoustic behavior of an ultrasonic system in a simulated measurement situation. This allows the design of integrated electronics to be customized to a specific measurement application, where performance can be validated, in one tool only.
- This work was intended as a primer on various issues pertinent to modeling of ultrasonic transducers. The attempt was made to review the basic algorithmic background and practical modeling issues to the extent they affect simulation strategies and capabilities.
- The work also tried to convey the idea that modeling is not an exercise independent of experimentation, whether to determine the requisite material properties or to develop intuitive understanding of the transducer's operational parameters. Much can be done to improve the accessibility of advanced simulation techniques; through intuitive graphical interfaces standardized design, and robust algorithms that require less interaction between the end-user and the numeric.
- The software model provides flexibility it can be modified for different digital signal processing methods, algorithms and signals. Therefore, the proposed method and model are applicable for the design of other ultrasonic measurement systems.
- Simulation of ultrasonic systems based on mathematical models can predict the response of the systems to different inputs. These models can also take the form of analogous or equivalent electrical systems because they also simulate wave propagation.
- Ultimately simulations are used to predict the response of a system without to build it. From a management point of view, it is done to save time and money as preliminary designs have flaws. In the case of ultrasound, a mathematical model makes much more sense.
- The ultrasonic velocity and attenuation measurement system designed and built for this research project is generally successful for liquids, solids and binary liquid mixtures. The system is highly reliable and accurate to within its range. These initial tests served to validate the system and future tests using same equipment will be suitable for the intended ultrasonic research.
- One of the difficulties of establishing a comprehensive body of information with respect to the biological and health effects of ultrasound has been the lack of adequate instrumentation to measure the various exposure parameters. However, reliable methods for the measurement of ultrasound field parameters, such as total power, and various intensities in the ultrasound field, are now available in a few national or research institutions. Most devices used to measure ultrasound power and various temporal and spatial intensity parameters for liquid-born ultrasound are not suitable for routine surveys in the work place. There is a need

for the development of portable, rugged instrumentation that will measure accurately both total power and the relevant intensity parameters. Furthermore, a substantial research effort is still needed to develop a system of dosimetric variables relevant to the production of and protection against adverse effects of ultrasound in medical and industrial applications.

- Experimental setup fabricated is used for precise measurement of ultrasonic velocity and attenuation from room temperature to 60^{o}C.
- The RF pulse generator circuit designed with TTL integrated circuit and 10 MHz crystal oscillator with a pulse rise time and fall time lower than 12 ns and 10 ns respectively, 2 to 60 μs pulse width with a 1 KHz PRF provides high axial resolution and a variable frequency inspection with an excellent signal-to-noise ratio. The output voltage amounts to about 20 Volt without load and 18.8 volt with a load of 75 Ω.
- The receiver circuit interfaces to the transducer through preamplifier. The low noise preamplifier, used for ultrasonic transducer, design approach is presented. Optimization is based on noise mode for both electrical and acoustical part of receiver. The extremely low noise amplifier with a maximum amplification of about 40 dB accommodates very small signals. The output of the preamplifier is again amplified with another wideband amplifier to give 50 dB amplification, large bandwidth about 15 MHz and high input impedance of the order of 10.6 KΩ. Output of the amplifier is linear up to 7 V with maximum input of 40 mV .
- The System is completely shielded and therefore receives no noise coming from PC components.
- The data acquisition system and transmit-receive systems is computer controlled via a LAB-VIEW and NI-Data acquisition card. The system comprises of both the software and hardware. The software provides all functions of ultrasonic measurements and a A-scan display. Ultrasonic test application software combines many types of I/O, analysis algorithms, and presentation techniques to form one software interface.
- The virtual aspect of the system is evident in the controlling software. The graphical user interface (front panel) is designed to imitate the control panel of the hardware instrument it replaces, while the computer controls, mouse, keyboard, are used to adjust the on-screen dials and buttons. This may then be modified to any suitable configuration for the user and simplified depending on the needs of the application.
- GUI provides general data representation. In GUI it is possible to change almost all parameters of measured signal and parameters of signal processing.
- The resolution of transit time measurement is within 1 ns and pulse amplitude is within 1.221mV.
- The accuracy of ultrasonic velocity measurement is within 0.025 % and attenuation measurement is within 2 %.