Ultrasonic Transducer Driving Module

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Project Motivation

NovusTX Devices aims at treating psychiatric and neurological disorders in a non-invasive manner, via the use of ultrasound energy.

The treatment is done by regulating brain activity using low intensity waves through the intact skull (this is known as LIFU for Low Intensity Focused Ultrasound). The technology is a therapeutic ultrasound transducer where electrical energy is converted into acoustic waves that in turn affect brain tissues.

The commercial system to drive their ultrasound transducers is sufficient for their application, however there are certain features that are required. Also, the current system's arbitrary waveform generation produces a deformation of the output wave when different amplitudes are requested, hence lowering the effect of the transducers [1].

Project Scope

The objective of the project is to develop a 7-channels driving module to drive the ultrasound transducers. Each channel is comprised of 3 separate signals that can be altered. The purpose of this multichannel driving device is to generate a sinusoidal signal burst, where the amplitude and phase of that signal can be controlled independently in each channel, with a maximum power output of 3 W per channel and no distortion at 1 MHz+ PRF.

The software interface portion of the project is driven by the need for a precise and configurable control system for ultrasonic transducers, specifically used in medical settings, where existing solutions fall short in flexibility, integration, and performance tuning. The objective is to develop a system that allows dynamic configuration of transducer arrays, global and individual channel parameter setting, and safe, asynchronous operation with real-time feedback on performance status.

Methods and Materials

The entire project is separated into two parts. The first being the electrical component, i.e., the hardware and the second being the software component. The software component is what the user will be able to use in order to control the entire system using a GUI (Graphical User Interface).

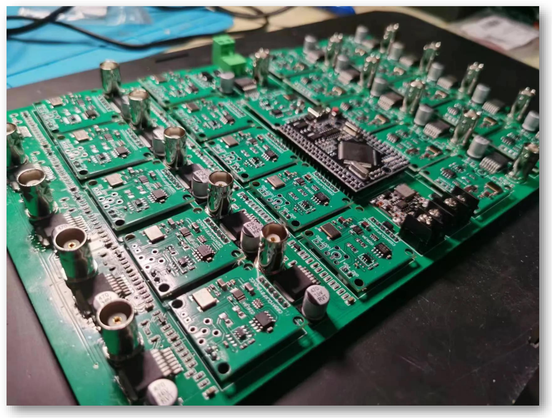
Electrical System:

- The electrical system can be divided into three modules. The first is the "command center" of the system, which is the Arduino Mega Board. The Mega will take the user defined parameters and translate them in a way that the hardware can understand
- The second module is the DDS chip (AD9833 DDS). DDS means Direct Signal Synthesis. This module will be responsible for using the information from the Mega in order to create a sinusoidal pulse as defined by the user.
- The third module is the amplification module. As per the project requirements this will amplify the signal produced be the DDS to a maximum of 3 Watts in order to be output to the transducer. The specific amplifier used to achieve this is the OPA548F/500.

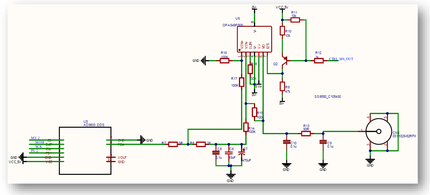
Software System and GUI:

- The GUI for controlling a multichannel power amplifier involves several components for user interaction, including port selection, global and channel-specific parameter configuration, system status updates, and emergency stop functionality.
- Users select communication ports and set global parameters like ultrasound frequency, duty cycle, and pulse repetition frequency. They can also configure individual channel parameters, including signal amplitude and phase for multiple signals per channel.
- Commands are sent to the amplifier through the Arduino Mega microcontroller, leveraging serial communication to transmit JSON-encoded command structures for programming channel parameters, setting global parameters, or stopping the ultrasound output.

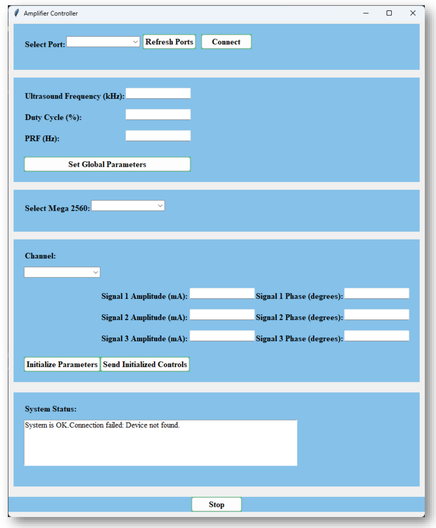
Electrical and Software Systems



7-Channel Driving Module Consisting of Arduino Mega, DDS, Amplifier, and Output Connection for Transducers



Circuit Schematic for Generation of Single Signal (1/3 of a channel)



Graphical User Interface

References

[1] NovusTX. (2023). *Multi Channel Power Amplifier*. Unpublished Internal Document