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Compact phase delay control module for HIFU therapy
HIFU 用多チャンネル位相制御モジュールの開発

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1. Introduction

High-intensity focused ultrasound (HIFU) is widely used for therapeutic applications because it is an attractive and non-invasive tool by which to provide thermal therapy [1]. The sound pressure at the focal point reaches hundreds of megapascals, resulting in an increase in temperature, which necrotizes cells. Although HIFU treatment has been applied to limited regions. It is difficult to treat targets that lie behind bone (e.g., brain tumors) or that lie deep inside the body (e.g., liver tumors), because the ultrasound beam is reflected, refracted, and attenuated by the intervening tissue and/or bone [2-3]. In order to resolve this problem, phased array HIFU has been developed [4]. Focus position control of HIFU by multi-elements phase control is very popular in clinical application. However, multi-elements driving amplifier are very large size like a large refrigerator. So, previous study, we adopted a direct drive amplifier system for the multi-elements transducer [5]. This system has an advantage of reducing the energy loss of the connecting cable between the transducer element and the amplifier. So, we make the very compact multi-elements transducer system combined with multi-elements amplifier. Also, we need a phase delay control system. So we develop name card size multi-channel phase delay generator system for the compaction of the modular HIFU system. Figure 1 shows an image of multi-elements module transducer.

2. Method

In this study, we evaluated the specification and system design of the first prototype module phase delay generator. We discussed the requirement of the specification as follows.

- Number of channels: 88
- Pattern: pulse mode (1-8) and continuous mode
- Minimum delay time: 6.25 nano-Sec (@2MHz)
- 5V driving
- Emergency stop button
- Preset phase delay pattern (256set)
- Synchronous control for each delay generator

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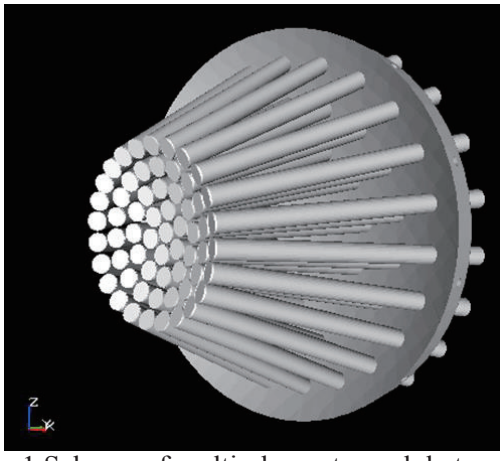

Fig.1 Schema of multi-elements module transducer

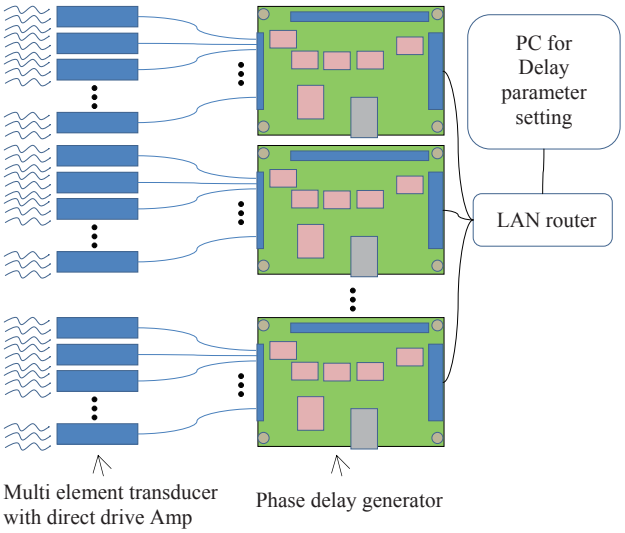

Fig.2 Schematic view of the module system

Figure 2 shows the schematic view of the module system. The phase delay generator has multiple synchronous drive system. PC uses only for the phase delay parameter upload to the module delay generator. The generator circuit has an individual private IP address. PC can upload different phase delay parameter to the different module delay generator using the personal IP address. We measured a delay timing to evaluate the

synchronous drive for multiple phase delay control modules. Figure 3 shows the first prototype 88 channel phase delay control module. This module connected to array amplifier modules with thin cables. The module has 88ch driving circuit. This module size was 40mm height, 85mm width and 115mm length.

Fig.3 1st prototype phase delay generator.

3. Results

Figure 4 and figure 5 showed measurement results of synchronous control using two phase delay control modules. In this measurement, we input same phase wave parameter setting to each phase delay control module (module 1 and module 2). Figure 4 showed that a parameter setting was two pulse wave output. A top line was synchronous trigger pulse (2V/div). A middle line was an output pulse wave from module 1 (5V/div). A bottom line was an output pulse wave from module 2 (5V/div). Time axis was 500ns/div. Figure 5 showed that a parameter setting was continuous pulse wave output. These pictures showed that no signal delay was measured between each module. These results indicated that our delay control module design will be able to use phase delay control more than one thousand channels with easy operation.

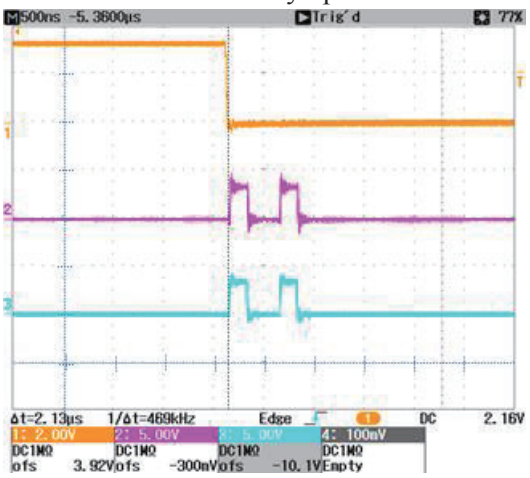

Fig. 4 Output pulse timing, 2 pulse waves

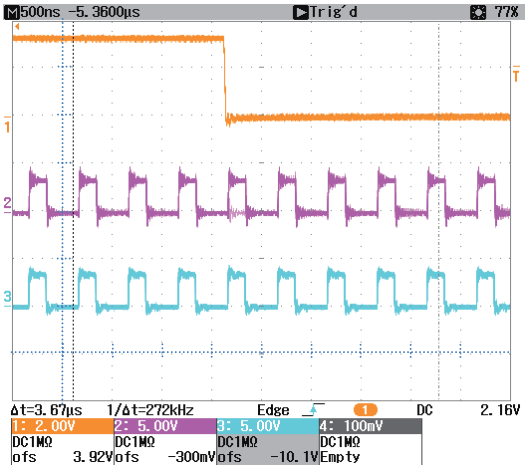

Fig. 5 Output pulse timing, Continuous pulse waves

4. Conclusion

In this study, we developed first prototype compact phase delay control module for HIFU therapy. This module can be used for many types of ultrasound therapy researches.

Acknowledgment

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