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Improvement of the power efficiency by direct driving for HIFU transducer

HIFU 用振動子の直接駆動による電力効率の改善

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1. Background

In recent years, HIFU (High Intensity Focused Ultrasound) technology has been increasingly used in treating begin tumor. Unlike in normal surgical operations, tumors can be heated and ablated with pinpoint accuracy without incision. The side-effects are limited and localized treatment effects can be obtained without impairing the appearance of the body, therefore the QOL (Quality of Life) is greatly improved.

However, as HIFU technology is the energy application of ultrasound, it is therefore necessary to supply a large amount of electrical power to a transducer of a large diameter.

At that time, there are losses in the transmission cable between the transducer and the drive circuit, reducing the power transmission efficiency. There is also a problem with the cable generating heat, so a thicker cable is required.
Furthermore, the driving circuit must drive a load from both the cable and the transducer.

Thus the circuit itself needs to supply a large amount of electrical power. As a consequence of heat generated by the circuit, a large heat radiation area is required to dissipate it, increasing the shape of the circuit.

Furthermore, when the multi-element transducer is advanced for focus control purpose, even though it does not change the total area of the sound radiating surface, the number of cables used is increased, and the power consumption ratio of the cables has greatly increased too.

When moving the focal point of the ultrasound, the robot arm requires a large force to move the heavy thicker cables too, consequently some of the benefits of the ultrasound technology have been diminished.

2. Objective

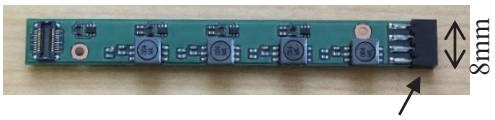
2.1. Designing a miniaturized driver circuit.

2.2. Eliminating the transmission cable, improving the power efficiency by driving the transducer directly.

3. Method

3.1. A pulse transformer was manufactured with magnetic material suitable for the high-frequency applications. The magnetic material is a small Ni-Zn system and a large Mn-Zn system of relative magnetic permeability, adopting good Ni-Zn based high frequency characteristics according to the limit law of Snoek.

3.2. A small size driving circuit is selected and a high speed switch FET. The circuit was specifically designed using the DMN5L06VK (Diodes Inc. package size 1.7mm x 1.7mm). Figure 1 shows designed circuit board. There are four channels at the front and back



8 elements of the transducer to this connector is directly attached.

<Fig.1>Driving circuit board

of the circuit board, a total of eight channels are mounted.

3.3. The load of the driving circuit is substantially proportional to the size of the transducer.
So to confirm the validity of the proposed theory, we compare the power efficiency for equivalent areas of the transducer with two methods, the direct drive one (without cables) and through cables.
Specifically, we assess the efficiency using the circuit shown in Figure 2, the denominator is the input power from the power supply (HV) of the driving circuit.

4. Result

Figure 3 shows the power efficiency. The x-axis of the graph indicates the number of parallel elements of the transducer, the y-axis means actual measurement value of efficiency. The elements are arranged on a square pitch of 2mm × 2mm. Here the power means active power, that is actually consumed power. 2m of widely available thin coaxial cable AWG40 (outer diameter of about 0.35 mm) is used. On the graph, the broken line corresponds to the power transmission efficiency via the cable, and the solid line, driven through transducer directly. From the graph, we can see the efficiency of the direct drive system is about 70%, a significant improvement if we compare it with the transmission via cable, where the efficiency is only 27%.

5. Conclusion

By not driving the transducers via a cable, the power transmission efficiency from the driving circuit showed significant improvement.

Designing and manufacturing a driving circuit using small parts.

6. Acknowledgments

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7. Reference

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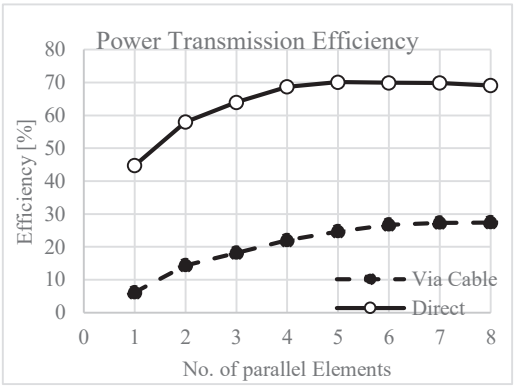
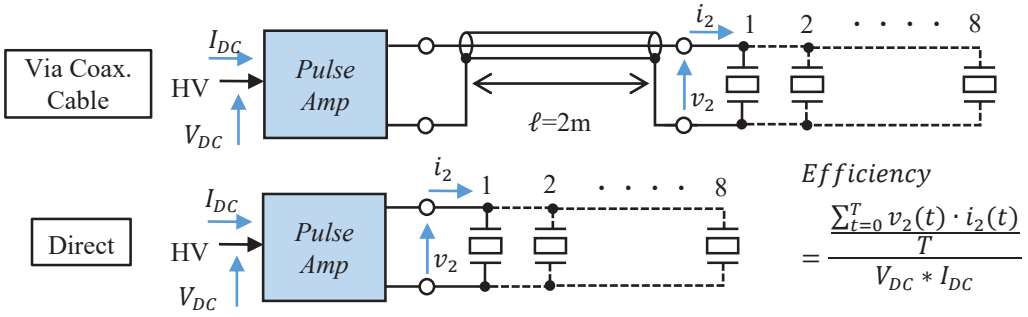


<Fig.3>Power efficiency of the driving



<Fig.2> Block diagram for measuring