Fiber-based Clock Synchronization Method for Biomedical Ultrasound System

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Background, Motivation and Objective

Ultrasound has played an important role in medical diagnosis and therapy applications. Array transducer is usually used for electronic scan of ultrasound beam. In recent years, large scale ultrasound arrays with thousands of elements have been proposed for real time 4D brain imaging and brain therapy. The ultrasound beam can be controlled precisely using large amout of array elements. However, the major problem faced by the large amount array elements is the control system. Four 256-channel Verasonics systems have to be used to drive a 1024 elements array transducer. The synchronization between the systems is a crucial issue to be controlled. This work presents a fiber-based clock synchronization method for large scale ultrasound array system.

Statement of Contribution/Methods

The clock synchronization between subsystems is performed through optical fibers, and the data upload and command delivery are also completed through it. Optical fiber is distributed to the subsystems through fiber distribution board and the uppermost fiber is controlled by a computer through an USB interface. The transmitter encodes the data, and then the serializer combines the clock with the encoded data to convert it into a high speed serial data stream. It is then converted into an optical signal by a fiber optical transceiver and transmitted to the receiver through the fiber. The receiving deserializer coverts the high speed serial data stream into parallel data and latches it after recovering the transmit clock from the serial data stream with the local reference clock and phase locked loop (PLL). The receiver obtains the data by decoding the parallel data. Since the link is full duplex, the receiver can also send clocks and data to the transmitter at the same time.

Results/Discussion

The subsystems can drive multiple ultrasonic array transducers under the same clock source. The accuracy of the clock synchronization can be less than 300 ps. The method has been applied to a MRI-guided ultrasound array system, and the acoustic radiation force can be achieved at predetermined locations under MRI guidance. The acoustic field power can be high than four MPa. The phase difference errors for all channels are less than 10 ns when the center frequency of transducer is 1 MHz. It means that the phase error of the proposed ultrasound subsystems is less than 4 degree, which can support a good beamforming performance.

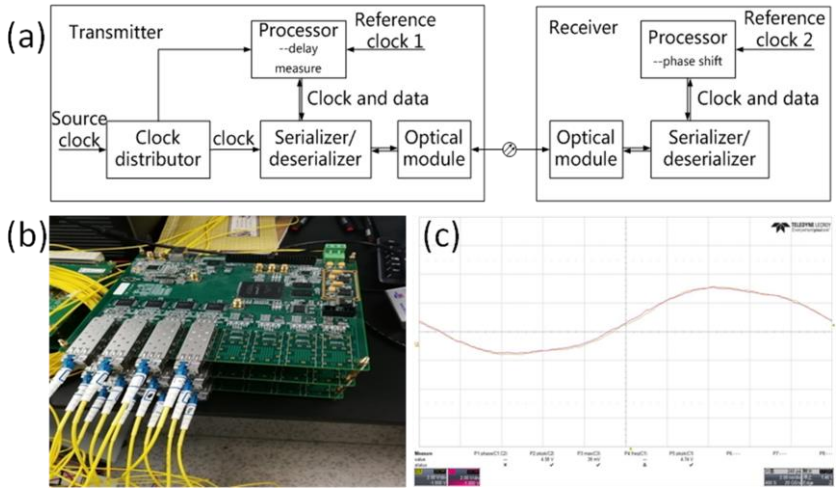

Fig. 1. (a) Schematic of the proposed fiber clock synchronization method; (b) The fabricated clock distribution board; (c) The derived synchronous clocks.