3P5-5

Proceedings of Symposium on Ultrasonic Electronics, Vol. 35 (2014) pp. 517-518
3-5 December, 2014

Degradation Analysis of Ultrasound Imaging using Split and Merge Chirp

時分割チャープ信号を用いたパルス圧縮による超音波画像の劣化評価

Hodaka Tamura[1‡], Masayuki Tanabe[1], and Masahiko Nishimoto[1]
([1]Grad. School Science and Tech., Kumamoto Univ.)
田村穂高 [1‡], 田邉将之 [1], 西本昌彦 [1] ([1]熊大院 自然科学研究科)

1. Introduction

For improvement of the signal-to-noise ratio (SNR) of ultrasound imaging, coded excitation has been used. For example, Barker, Golay and chirp are commonly used for ultrasound imaging [1].

In chirp code, the SNR improvement is propotional to a time-bandwidth product (TBP), which is a product of the coded duration time and frequency bandwidth, of the coded signal. The TBP of non-coded pulse is approximately an unit. The longer the code length is, the more SNR improves.

If obtained echo signals are decoded before beamforming, each channel requires a decoder separately. If received signals are decoded after beam forming to suppress cost, image degradation occurs when coded excitation and dynamic focusing are used with a phased array transducer.

Split-and-merge technique of chirp was proposed [2] for the purpose of avoiding overlap between transmitted and received echo signals, because it is difficult to separate echo signals from the overlapped signal. In this method, a long chirp signal is split into plurl chirp signals in time domain. The split chirp signals are transmitted separately, received, and decoded simultaneously.

In this study, we conducted computer simulations and evaluated the degradation of ultrasound image with split-and-merge chirp to improve SNR of echo signals.

2. Method

In this study, the degradation of ultrasound image using a split-and-merge chirp technique and dynamic focusing was investigated. A linear up chirp *s(t)* and trapezoidal window *w(t)* was expressed below:

$$s(t) = \sin(2\pi(f_0 + \frac{f_1 - f_0}{2T}t)t) \cdot w(t), \quad (1)$$

$$w(t) = \begin{cases} t/\tau & (t \le \tau) \\ 1 & (\tau \le t \le T-\tau) \\ (T-t)/\tau & (T-\tau \le t \le T), \end{cases} \quad (2)$$

where f_0 is the starting frequency, f_1 is the final frequency, t is time, τ is window size, and T is time duration. **Figure 1** shows the pre-split chirp signal with trapezoidal window. This signal was a pre-split chirp, f_0 was 7 MHz, f_1 was 13 MHz, τ was 0.5 μs and T was 32 μs. The TBP of the pre-split chirp signal was 192. Its frequency spectrum and autocorrelation function are described in **Fig. 2**. The mainlobe to sidelobe ratio was approximately −13 dB. A linear array transducer including 64 channels excited the chirp separately. The number of split was set as 7. Time duration of each split chirp was 5 μs. Split chirp signals and their frequency spectra are shown in **Figs. 3 and 4**. Sampling time was set as λ/256, where λ is wavelength of center frequency.

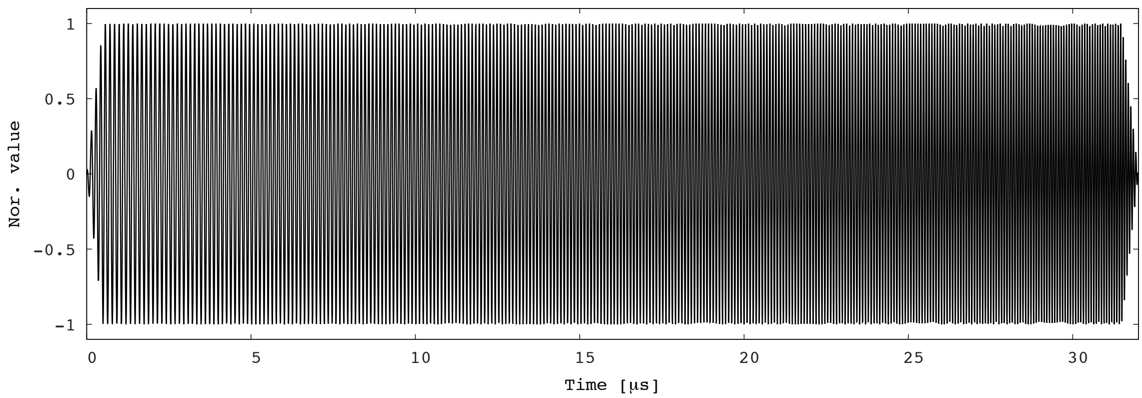

Fig.1 Pre-split chirp in time domain.

e-mail: tmrh@st.cs.kumamoto-u.ac.jp

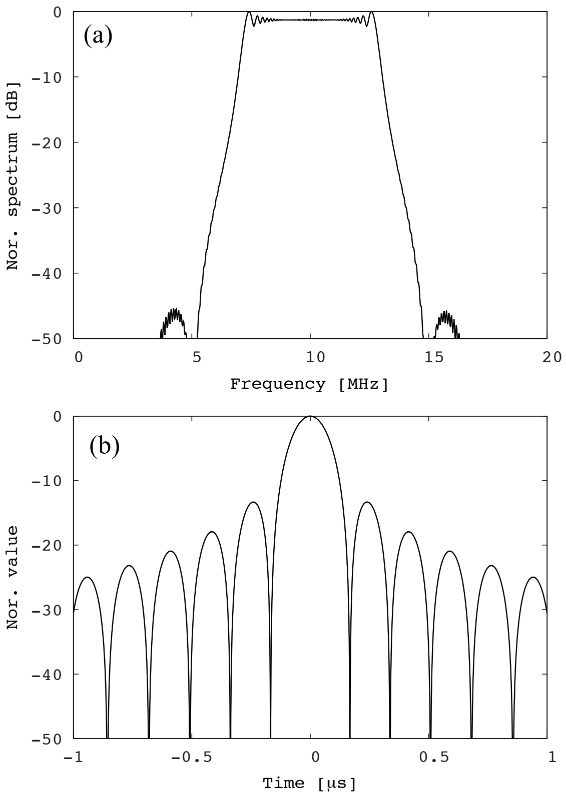

Fig.2 (a) Frequency spectrum and (b) autocorrelation function of pre-split chirp signal.

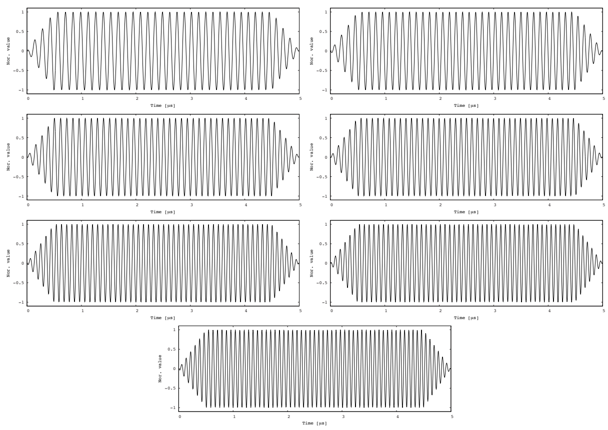
Fig.3 Split chirp signals.

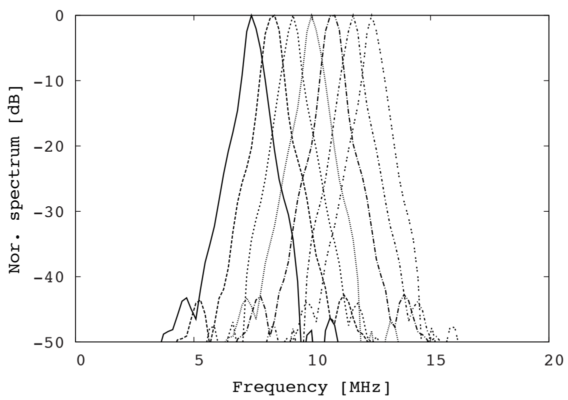

Fig. 4 Frequency spectra of split chirp signals.

The receiving aperture had an f-number of the receiving aperture had an f-number of 0.8 and no apodization.

3. Results

Figure 5 illustrates the decoded waveforms. From 50 to 53 μs, the SNR of proposed method was improved. However, reparative noise occurred.

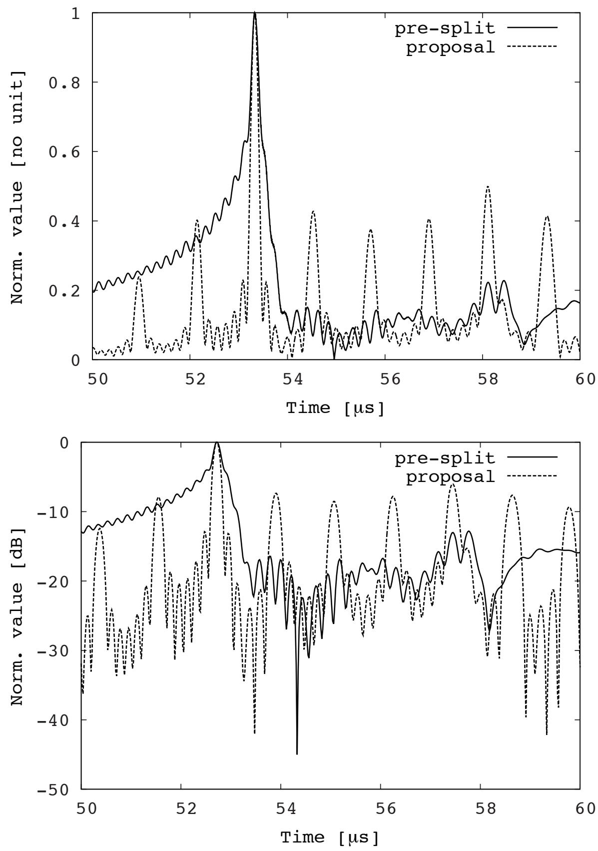

Fig.5 (a) Decoded waveforms of pre-split chirp (solid line) and split-and-merge chirp (broken line) and (b) their decibel representation.

4. Conclusion

We applied split and merge chirp technique to a phased array transducer and dynamic focusing. Although reparative noise occurred, this technique has a potential to improve ultrasound image quality. Further investigation will be conducted.

Acknowledgment
This work was supported by JSPS KAKENHI Grant Number 24760318.

References

1. T. Misaridis and J.A. Jensen: IEEE Trans. UFFC **52** (2005) 177.
2. M. Tanabe, T. Yamamura, K. Okubo and N. Tagawa: Jpn. J. Appl. Phys. **49** (2010) 07HF15.