Analysis of tone-burst signals received by driving single and multiple cycles in measuring acoustic nonlinearity parameters

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In the nonlinear ultrasonic technique, the acoustic nonlinearity parameter is measured to evaluate microstructural changes in a material. This parameter is determined by the amplitude of the second harmonic wave, the amplitude of the fundamental propagating wave, and the propagation distance. To measure the acoustic nonlinearity parameter, a narrowband signal, such as a tone-burst signal, is employed to clearly obtain the amplitude of the second harmonic wave in frequency analysis. While increasing the number of cycles is advantageous for reducing sidelobes in frequency analysis, it becomes limited when measuring thin specimens. Therefore, when driving a limited number of tone-burst signals, an obvious signal analysis is necessary to accurately obtain the acoustic nonlinearity parameter. In this study, we analyzed the structure of the tone-burst signal with several cycles, derived from the received signal by a single-cycle excitation, and assessed whether signal processing was possible with a small number of cycles. The received signal from a single-cycle excitation is calculated by the difference between the received signal from driving a specific several-cycle signal and the received signal from driving a signal with one more cycle than the previous one. During the analysis, it was confirmed that the tone-burst signal is composed of a combination of one-excitation signals, and the analysis of a single excitation signal was also found to be consistent with the results of multiple cycles of signal excitation. Based on this study, it is expected that a method for accurately measuring nonlinear parameters with a small number of cycles will be developed in further research.