Fast Fourier transform algorithm for wide bandwidth and high resolution signal

We are looking for partners for a joint development of this invention and its potential applications

Real time FFT process available for wide bandwidth and high-resolution spectrum Implemented on a broadband spectrometer for the search of dark matter

◆Background

The FFT is an algorithm that speeds up the Discrete Fourier Transform (DFT). It is used in the spectral analysis of input signals in various fields, and various methods have been proposed to increase its speed and efficiency and reduce memory usage.

In the search for dark matter, a significant challenge in astrophysics, there is a need for spectrometers capable of high-resolution and highly efficient spectroscopy of radio waves and light, as well as improving the performance of FFT computations, which is crucial to these spectrometers. Specifically, FFT technology is required to handle a large amount of input data, with the ability to scan a wide spectrum of several GHz in one shot at a high frequency resolution of tens of kHz, i.e. to process simultaneously a sample of the scale of [1 x 10^5] FFT points. Although FFT implementations on GPUs and FPGAs have been previously developed, none have met all the performance requirements for instantaneous bandwidth, frequency resolution, and continuous data processing.

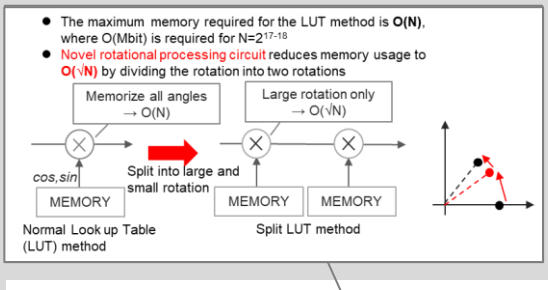
◆Summary and advantages of the invention

Focusing on the exponential law of twiddle factors, the inventors designed a specific operation rotation circuit that can be implemented with minimal memory and few computational components. Furthermore, they developed a FFT algorithm by combining an innovative method for splitting the rotation factor matrix and implemented the FFT circuit on a FPGA. This enabled a significant reduction in memory usage compared to conventional methods, and also achieved faster data processing.

➢ **Can be implemented in smaller circuits than conventional methods**
- Memory usage for rotation operations can be reduced to 1/8 and up to 1/16
- The overall FFT circuit requires about 20-40% less memory than the conventional methods while the number of multiplications increases by about only 10%

➢ **Enables continuous FFT for a wide-bandwidth, high-resolution spectral analysis**
- The implementation of a spectrometer “dSpec” using this FFT algorithm has demonstrated the capability of performing spectroscopy on **12-bit** input signal with a bandwidth of **4 GHz** and a resolution of **31.25 kHz**, **without dead time**.
- Effective for wide-bandwidth, high-resolution spectral analysis with a large number of FFT points [N].

➢ **Can be implemented on versatile hardware FPGAs**



◀Fig 1.
Memory reduction method in FFT circuit design

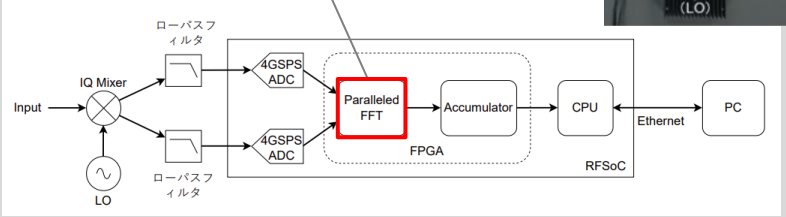


Fig2. Implementation example of the invented FFT: a broadband spectrometer “dSpec”

◆Development Phase
- TRL 4-5
- Algorithm design
- Developed a wideband spectrometer equipped with the FFT technology

◆Application Fields
- Spectrum-analyzer, spectrometer, wireless technology (FPGA implementation available)

◆Publications
- The 14th Excellent Master Thesis Award for Development of Measuring Instruments, The Physical Society of Japan Japanese
- 30th ICEPP Symposium (2024) Japanese

◆Intellectual Properties
- Patent application filed
- Current Assignee: Kyoto University

◆Collaboration form
- License agreement (non-exclusive)
- Option agreement

◆Inquiries to

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