Technology from Kyoto University

Low-Memory, Wideband, High-Resolution Real-Time FFT Circuit Technology

We are looking to out-license the technology for its commercialization.

Low-memory FFT circuit enabling Wideband, High-resolution Real-time FFT processing Demonstrated in Spectrometer for Radio Astronomy, Suitable for FPGA/ASIC

◆Background

This technology was developed for radio observation spectrometers in the field of astrophysics, enabling wideband, high-resolution real-time FFT processing with lower memory usage than conventional methods.

In radio astronomy, spectrometers capable of high-resolution and highly efficient spectral analysis of radio signals are required. Specifically, FFT technology capable of simultaneously processing several GHz of bandwidth with frequency resolutions on the order of several tens of kHz is demanded. This requires processing extremely large-scale input data corresponding to FFT sizes on the order of [1 x 10^5]-points. In conventional FFT implementations on GPUs and FPGAs, twiddle-factor memory requirements increase rapidly as bandwidth and frequency resolution increase, leading to challenges such as insufficient FPGA resources and increased power consumption..

◆Description

The inventors focused on the exponential properties of twiddle factors and devised a rotation-processing circuit that can be implemented with minimal memory and arithmetic resources. Furthermore, they developed a novel FFT architecture combining this circuit with a proprietary structure for efficient utilization of twiddle-factor tables, and implemented it on an FPGA. Compared with conventional approaches, the proposed technology significantly reduces memory usage while minimizing the increase in multiplication operations, thereby enabling low-memory, wideband, high-resolution real-time FFT processing.

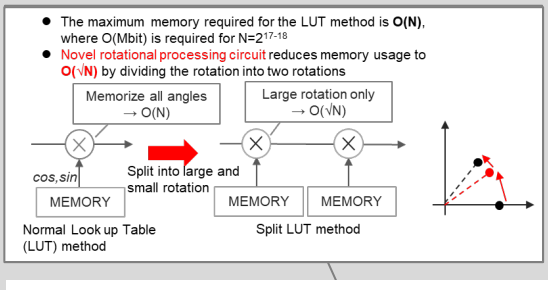
➢ **Reduced Memory Usage Contributing to Lower Power Consumption and Smaller Circuit Scale**

- Twiddle-factor memory reduced to approximately **1/8–1/16** of conventional implementations
- Overall FFT circuit memory reduced by approximately **20–40%** while limiting the increase in multiplication operations to approximately 10% compared with conventional methods

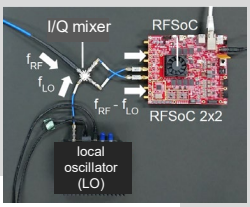
➢ **Real-Time Processing of Wideband and High-Resolution FFT**

Demonstrated specifications of the “dSpec” spectrometer incorporating the proposed FFT algorithm:

- FFT size: **N = $2^{17\sim18}$**
- 12-bit input width
- **4 GHz** bandwidth with **31.25 kHz** frequency resolution
- Continuous spectroscopic processing with **no dead time**



◀Fig 1.
Memory reduction method in FFT circuit design



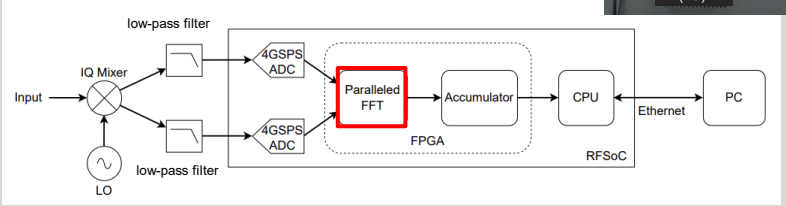


Fig2. Implementation example of the invented FFT: a broadband spectrometer “dSpec”

◆Development Status

- Implemented and currently operated in the wideband spectrometer “dSpec”
- Next-ver under devlopment
- TRL 5–6

◆Applications

- Spectrometers and radio astronomy observation
- EMC
- Wideband signal processing for OpenRAN / 5G base stations
- FPGA / ASIC implement

◆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

◆Offer

- License agreement (non-exclusive)
- Option agreement

◆Contact

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