Acqiris Swept-Source OCT Solutions

Since 2014, Acqiris has developed swept-source OCT signal acquisition solutions for medical and industrial applications. Our solutions are based on high-speed DAQ modules, with on-board processing, supporting A-scan rates from 100 kHz up to 2 MHz. Thanks to on-board FPGA we provide a complete and flexible real-time OCT engine, allowing the acquisition of both OCT and K-clock signals and delivering high image quality and clarity.

Overview

Key features:

- A-scan rate: from 100 kHz to 2 MHz
- 1 or 2 OCT channel simultaneously
- Resolution from 8-bit to 14-bit ADC, enabling better contrast
- Deeper analysis thanks to high sampling rate up to 4GS/s
- Real-time processing in the FPGA
  - Digital K-clock resampling
  - Programmable analysis depth
  - Flexible real-time OCT Engine
  - Up and down sweep support
- Excellent image quality and clarity
  - Minimal artifacts and noise
  - Increased contrast and stability

Easy integration:

- Integrated XY Galvo control in real-time, allowing full synchronization with the A-scan and reducing the system footprint
- 2 additionnal analog inputs for feedback control
- 2 form factors available: PCIe or Thunderbolt 3 module
- Light source independent
- Dedicated OCT Graphical user interface & Software Development Kit (SDK)
- Custom options available

1. DAQ module hardware

Acqiris SS-OCT solutions are based on our 8-bit, 12-bit or 14- bit ADC technology with exclusive proprietary ICs and IPs enabling excellent signal performances, image details, depth, contrast, and acquisition speed.

Our front-end has been designed to minimize noise, signal distortion and enable stable signal performances over the full bandwidth.

With a high dynamic range, accurate triggering, and specific low jitter clock distribution, our DAQ module provides a better image clarity and pixel contrast, addressing the most demanding phase-sensitive OCT applications.

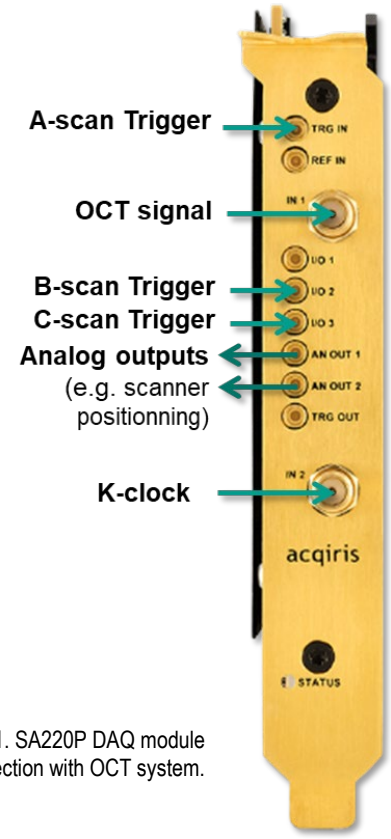

Fig 1. SA220P DAQ module connection with OCT system.

2. Real-time Processing

The OCT processing steps are implemented in real-time in the module's FPGA.

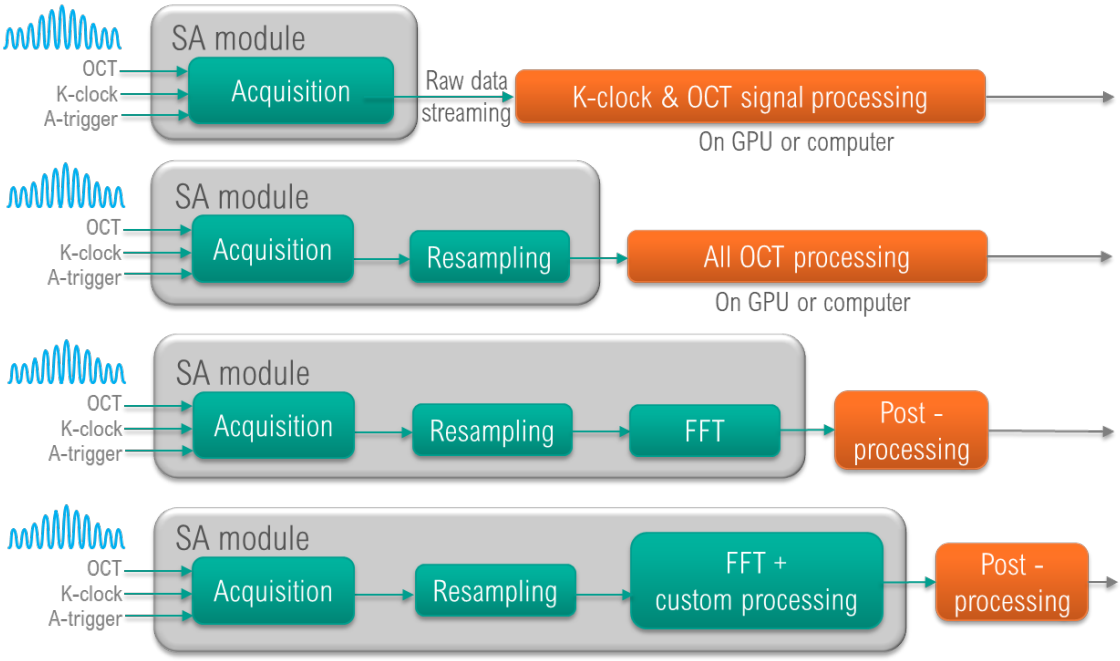

Fig 2. SS-OCT firmware and processing flexibility.

The following processing blocks are available and can be bypassed/switched on-off programmatically by the user:

1. Programmable FIR on both channels
2. Fractional re-sampler for K-space remapping
3. Background subtraction
4. Programmable Windowing/Dispersion compensation
5. FFT with complex/magnitude/phase output[1]
6. Adjacent A-scans averaging

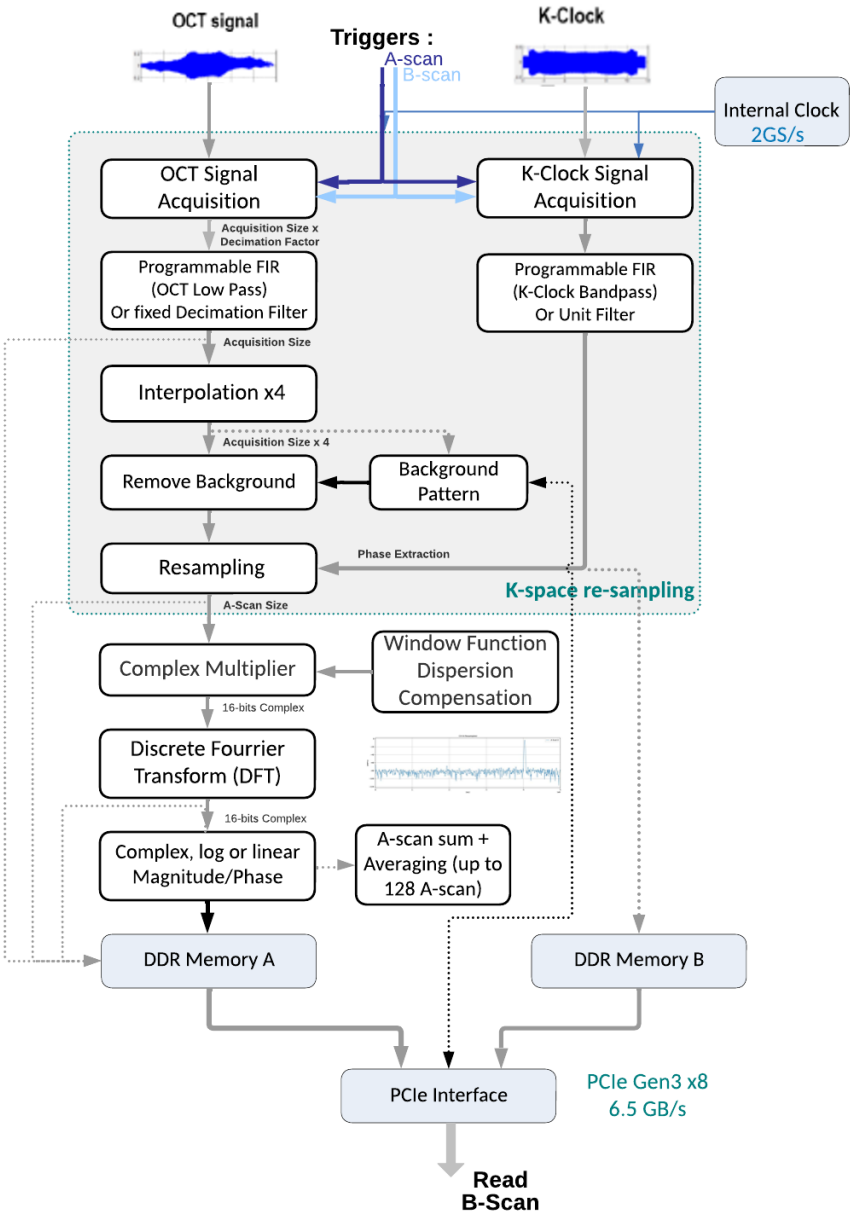

Fig 3. SS-OCT processing successive steps.

[1] Note: Depending on DAQ Module, some processing may not be supported in the FPGA.

The output data format can be selected programmatically:

- Raw data
- Re-mapped data
- FFT data

2.1. Programmable FIR

The programmable FIR on both channels contributes to reduce the in-band noise and improve the signa/noise ratio (SNR).
Two independent FIR filters are available on OCT (IN1) and K-clock (IN2) channels. They can be configured independently avoiding unwanted frequencies folding in the band of interest and smoothing a noisy or digital K-clock.

2.2. Digital K-space remapping

Both OCT-signal and K-clock waveforms are sampled by an independent low-jitter and stable fast clock synthesized on the ADC module. The digital K-space resampling allows to remap the digitized OCT signal in K-space, based on the K-clock phase.

Compared with the direct clock solution, there are multiple interests in this approach:

- Configurable analysis depth
- Minimize artifacts: No artifact coming from direct clocking
- No need for a dummy clock
- Support of higher sampling rates, so deeper analysis
- ADC sampling rate constant and independent from K-clock frequency
- Light Source flexibility
- Full flexibility and control: For example, compensation of the optical path difference between K-clock and OCT-signal.

2.3. Background subtraction

The background subtraction in the time domain effectively removes background artifacts. The background noise is first captured and then subtracted from all acquired A-scans. The background subtraction is performed after the resampling.
The background noise samples can also be saved/uploaded to/from the host.

2.4. Programmable windowing / Dispersion compensation

Using windowing and dispersion compensation improves image definition. A complex multiplier is available after the resampling and before the FFT block. The coefficients can be uploaded from the host. This processing can be used for the FFT windowing to reduce the leakage and dispersion compensation. Windowing and dispersion compensation can be combined for better results.

2.5. FFT with complex/magnitude/phase output

Acqiris solutions enable fine image resolution with real-time FFT on-board, up to 8k samples. Since the FPGA performs the heavy load processing in real-time, a less powerful host is required.
In addition, the B-scan output can be plotted directly to obtain the OCT image without additional software processing.

Complex samples or Magnitude and Phase can be read in real time. Both full or half FFT are available together with logarithmic or linear scale. An automatic zero padding is implemented in case of A-scan size not a power of 2.

2.6. Adjacent A-scans averaging

Successive A-scans can be accumulated in real-time (up to 128 A-scans) in order to reduce the asynchronous noise and improve the SNR.

3. Scanner control

Acqiris DAQ solution offers the possibility to control the scanner/galvo X,Y positioning without the need of external electronics.
The analog outputs allow for synchronization of the scanner, the OCT-source laser, and the OCT processing. A control signal can be configurated, enabling XY sweeps and galvo positioning (predefined or custom patterns can be generated).

4. Software and Development Environment

The Software Development Kit includes a dedicated API, code examples and a user-friendly Graphical User Interface.

The API dedicated to SS-OCT, allows to control all programmable features of the ADC module and the dedicated real-time OCT processing. It is provided with:

- Project and example
- Debug features, e.g., providing at output raw data + FFT

Supported OS	Windows 10/11 Linux (Debian, Ubuntu)
API	C++ API Labview API
FPGA Firmware	Real-time processing: • K-space re-mapping • FFT, log scaling • fast readout of B-scan to the host computer
Graphical user interface	• General purpose soft Front panel • SS-OCT GUI

Table 1: SS-OCT dedicated Software Development Kit.

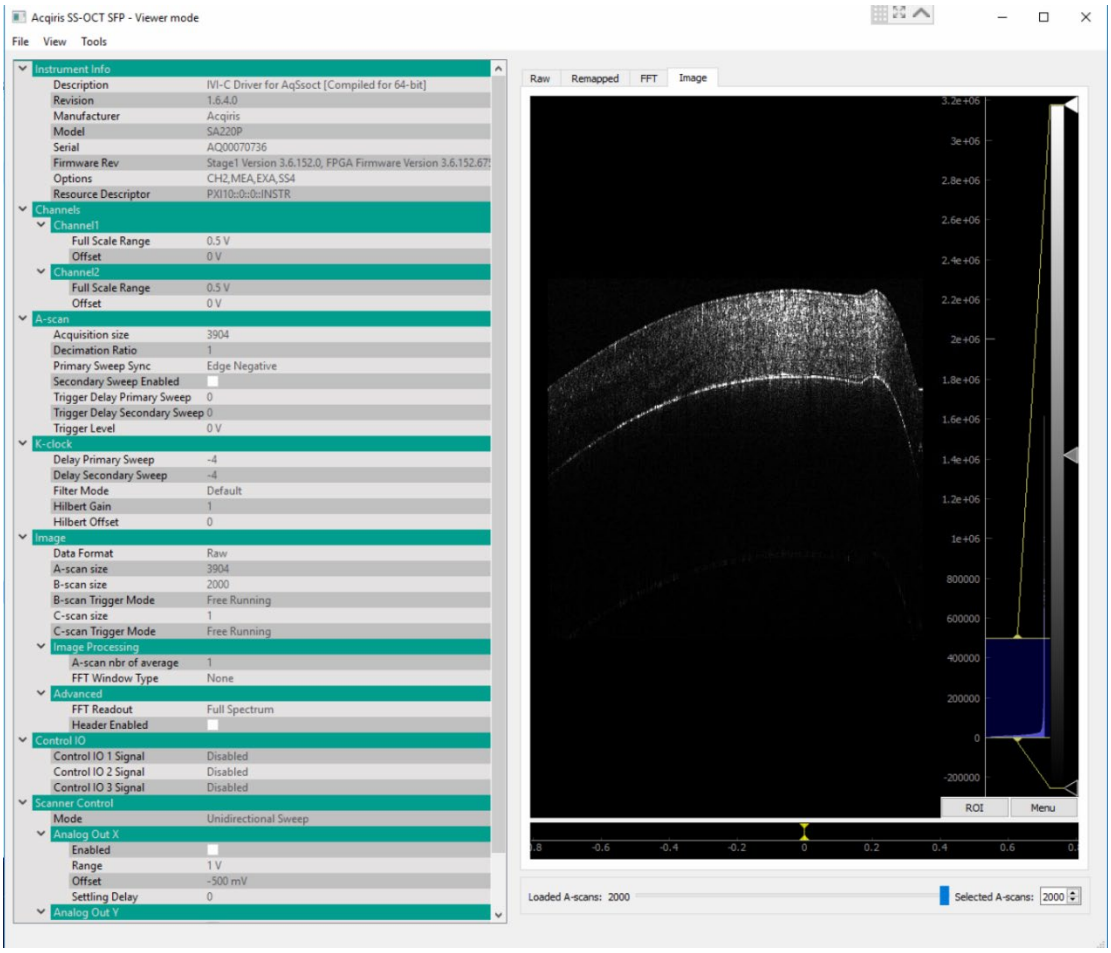

Fig 4. Dedicated SS-OCT Graphical user interface.

The SS-OCT dedicated Graphical User Interface allows quick get started with the DAQ module and get OCT images live. It supports 3 modes:

- **Viewer mode**
  - Data visualization with SW OCT Processing
  - Import saved data directly from CPP example
  - Save processed data for analysis
- **Live mode**
  - Directly control the DAQ OCT firmware
  - Easy tuning of the parameters
  - Save and export the data
  - Save and export the configuration
- **Simulation mode**
  - Makes easy the SW application development
  - Uses emulated K-clock and OCT signals

For more information, please contact solutions@acqiris.com .

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