Powering Ultra High-End Data Acquisition at Swabian Instruments

Opal Kelly

Swabian Instruments GmbH, headquartered in Stuttgart, Germany, was founded in 2016 by Helmut Fedder, Michael Schlagmüller, and Markus Wick as a spin-off from the Physics Department at the University of Stuttgart.

The "Time Tagger Series" from Swabian Instruments is emerging as one of the most powerful data acquisition tools used by the physics research community—from quantum optics to biophysics.

Building a cutting-edge piece of measurement and test equipment is not easy. By leveraging an off-the-shelf FPGA module from Opal Kelly and building their application on top of the FrontPanel SDK, Swabian Instruments has been able to focus on delivering a vital tool to the research community without sacrificing their high-value resources on building the foundations.

The Opportunity

Helmut Fedder, co-founder and CEO of Swabian Instruments, began studying the challenge of time tagging for quantum optics nearly a decade ago. During his years studying physics in Germany, Sweden, and the Netherlands, Helmut became a research group leader in quantum optics, FPGA development, and experiment design. As he studied, Helmut developed ideas for commercial products, built on top of leading-edge Opal Kelly FPGA modules, that would substantially aid other scientists and researchers in their studies of quantum optics. Swabian Instruments GmbH emerged from the Physics Department at the University of Stuttgart in 2016, when Helmut Fedder and co-Founders Michael Schlagmüller and Markus Wick took the leap into the commercial world.

To make an apple pie from scratch, you first must create the universe.

— Carl Sagan

The Solution

Today, significant innovations are often made possible through a chain of value-added tools. Sometimes proprietary, sometimes open source, these tool chains incrementally add value and provide efficiencies for the developers at the next level. Opal Kelly and Swabian Instruments both hold important positions in these tool chains.

Products built by Swabian Instruments and Opal Kelly combine to provide two seamless layers of technology that deliver instrumentation for easy and intuitive data acquisition and signal generation in the quantum optics space. The two firms share similar design philosophies, as both companies strive to encourage accelerated design and development.

Opal Kelly's philosophy is to make the 'reusable stuff' — using FPGA boards for PC to device interconnection — frictionless. Its customers, and customers' customers, are developing staggering advances in medicine and technology. Rather than wasting time building their own FPGA modules, interfaces, and APIs, their time is focused on the really hard work of their core competencies — inventing world-changing approaches and products.

If it wasn't for Opal Kelly, our company would not exist. It would have been too complicated to create our solutions.

Opal Kelly gave us an easy way to get started, saving us a lot of time and work and enabling us to focus our expertise on our unique products."

— Helmut Fedder
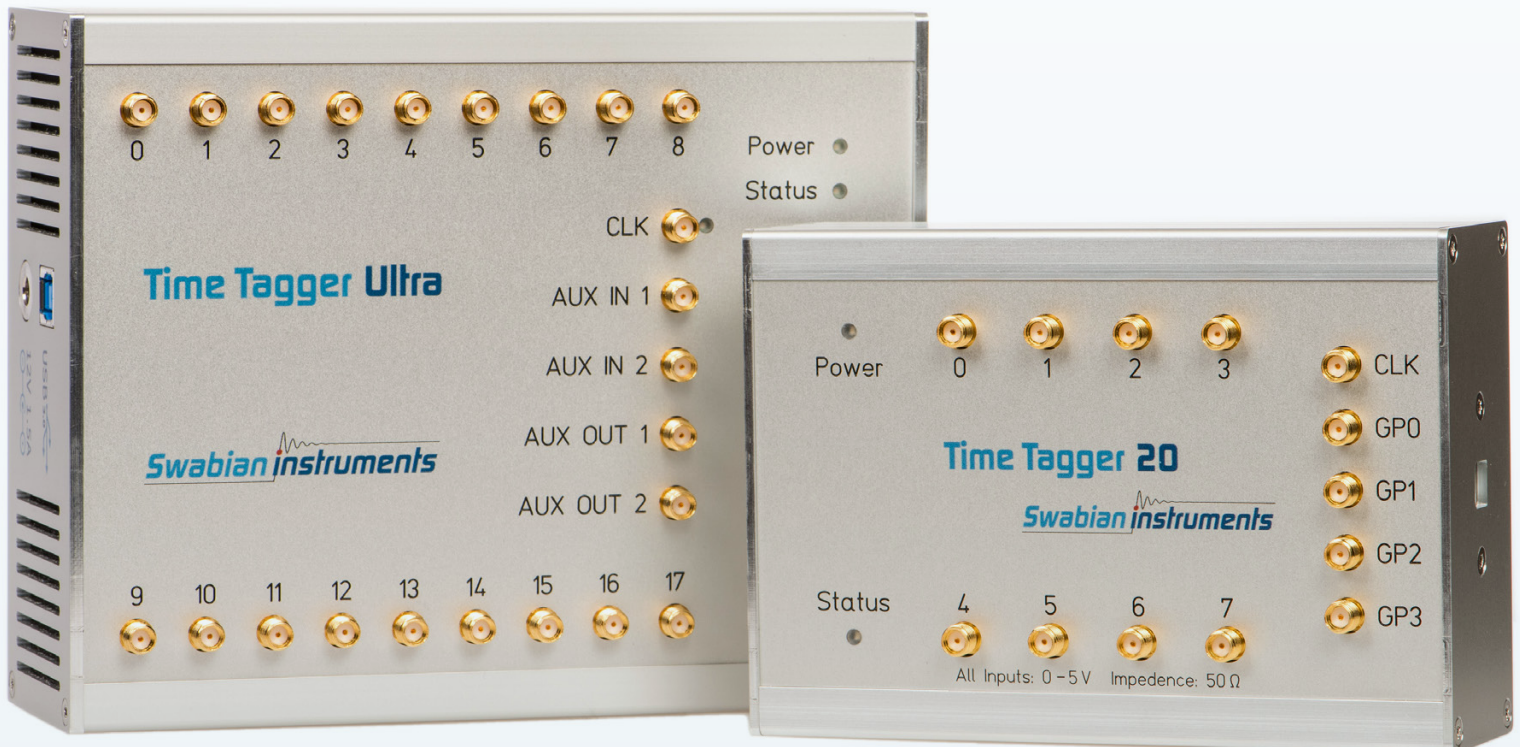
"Like Opal Kelly, our goal is to give scientists powerful tools so they have more time for leading-edge research. Our combined enabling technologies deliver data acquisition tools that are super easy to use and accelerate experiments," says Helmut Fedder, co-founder and CEO of Swabian Instruments.

Swabian starts with the Opal Kelly XEM7360-K410T, a high-performance, high-gate-count FPGA module and the powerful FrontPanel interface that eases the way for Swabian's value-add.

The XEM7360 is a USB 3.0 integration module based on the Xilinx Kintex-7 FPGA. The XEM7360 is ideal for the high-performance timing measurement and I/O integration needs of Swabian.

Opal Kelly's FPGA modules include the FrontPanel SDK, an easy-to-use, robust API for communication, configuration, and interfacing to PCs, Macs, or Linux hardware. FrontPanel handles all the interaction between the software and the FPGA internals, dramatically reducing the time and effort required to interface to a design.

Swabian Instruments products, built on top of the Opal Kelly XEM7360, are easy-to-use, high-performance, and packed with useful features. "Opal Kelly modules are really carefully designed and the ease of use that the libraries provide is the key distinguisher for our work," Fedder says.

Swabian implements streaming time-to-digital converters that covers a frequency range from DC to about 400 GSa/s directly in the FPGA fabric. Processing of time stamps is performed at the software level. This provides the flexibility and extensibility of a software solution, while maintaining the best possible timing resolution and performance of a dedicated hardware.

"We strive to make data acquisition and signal generation as easy and intuitive as possible. Our goal is to help scientists maximize the time they spend on actual research. We achieve this by empowering researchers with software and hardware tools that require minimal programming efforts and are packed with useful features. We push the boundaries of what is possible with modern data acquisition and signal generation," Fedder says.
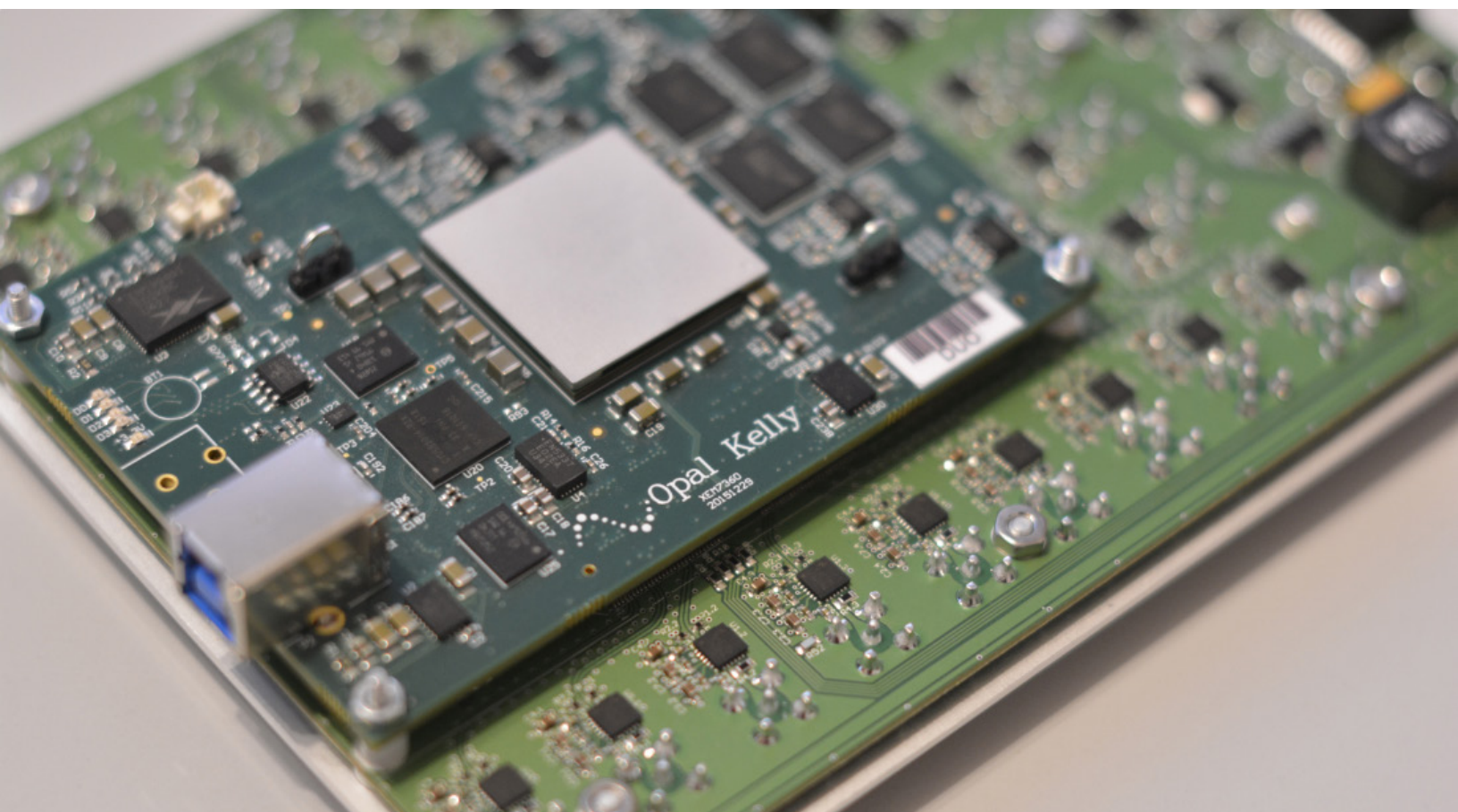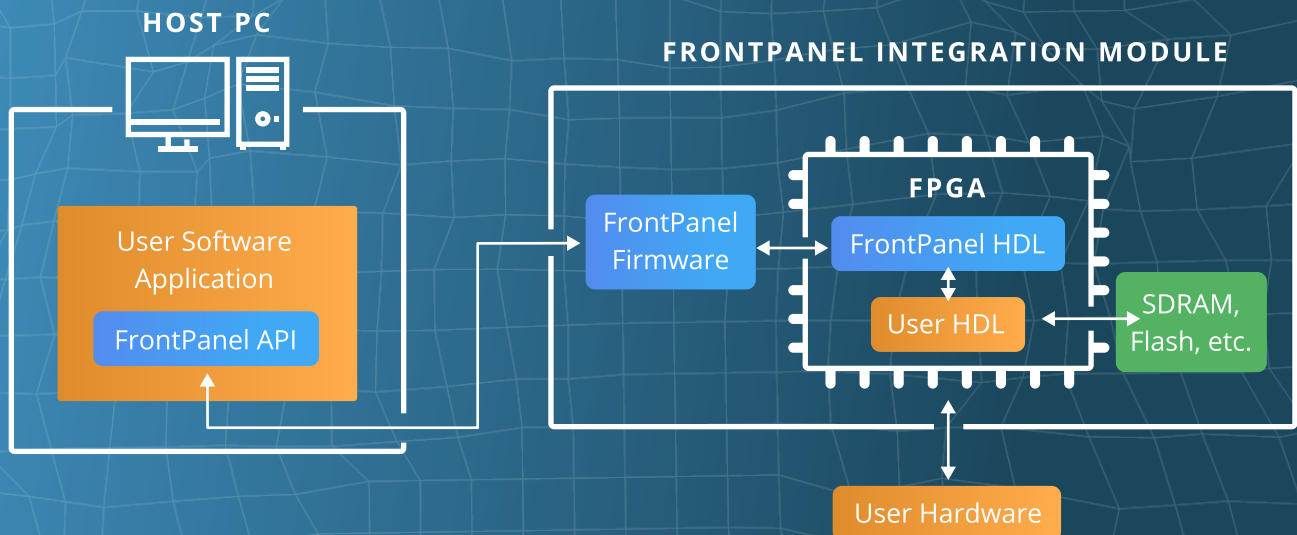
What is FrontPanel?

Opal Kelly's FrontPanel SDK provides end-to-end communication between your software application and FPGA-connected hardware over a high-performance USB 3.0 connection. Included in the SDK are: a robust software API, device firmware, and lightweight HDL for your gateware.

The multi-platform system is available for Windows, Linux, macOS, and Android hosts with an API available in C/C++, C#, Java, Python, Ruby, and third-party integration via shared library.

Opal Kelly modules and the FrontPanel SDK dramatically accelerate the development of prototypes and proof-of-concept builds. Production deployments benefit from simpllified supply chain manamagement and Opal Kelly's commitment to lifecycle management for long-lifetime products.

HOST PC

FRONTPANEL INTEGRATION MODULE

User Software Application

FrontPanel API

FrontPanel Firmware

FPGA

FrontPanel HDL

User HDL

SDRAM, Flash, etc.

User Hardware

Multi-Platform

Multi-Interface

2.0   3.0   FPOIP

Empowering Results

"We empower developers with software and hardware tools that require minimal programming efforts and are packed with useful features. The power of our combined system architecture and interface pushes the boundary of what is possible with modern data acquisition and signal generation."

Pushing the boundaries of modern data acquisition and signal generation, Swabian's Time Tagger products are emerging as some of the most powerful data acquisition tools used by the physics research community from quantum optics to biophysics. "With the development of the Time Tagger, the scientists have revolutionized measurement technology and enabled scientists all over the world to perform their measurements in a flexible, scalable, and cost-efficient way.

Internationally renowned research institutions, such as the Massachusetts Institute of Technology (MIT), Max Planck Institutes and the Tsinghua University, are among their customers," said Dr. Christine Neuy, congratulating Swabian Instruments for winning a Baden-Württemberg Innovation Prize in 2018.

"Enabled by Opal Kelly FPGA modules and the FrontPanel SDK, we are able to go beyond the borders of what has been achieved in the past with digital data acquisition. Together, we and Opal Kelly are enabling scientific research to go where no one has ever gone before!" — Michael Schlagmueller.

The Bottom Line

"If it wasn't for Opal Kelly, our company would not exist," Fedder says, "It would have been too complicated to create our solutions. Opal Kelly gave us an easy way to get started, saving us a lot of time and work and enabling us to focus our expertise on our unique products."

"It gives us a tremendous sense of pride to hear stories like Swabian's," says Jake Janovetz, President of Opal Kelly. "That we can contribute in some way to the innovations and accomplishments of entrepreneurs like Helmut, Michael, and Markus is what drives us."

Real World Applications

Leveraging Opal Kelly and Swabian Instruments, Netherlands-based Single Quantum, experts in SNSPD (superconducting nanowire single photon detector) have demonstrated a commercially available TCSPC setup with a record-breaking low timing jitter. This measured correlation of a full two photon coincidence with two detectors results in a total jitter of 7.6 ps RMS (18 ps FWHM) using a Single Quantum Eos SNSPD system and a Swabian Instruments Time Tagger Ultra HiRes.

And more...

LINEAR OPTICS APPROACH TO QUANTUM COMPUTATION (LOQC)
Qubits encoded in quantum states of entangled photons while algorithmic transformations are performed with linear optical elements.

FLUORESCENCE LIFETIME IMAGING
The brightness of each pixel represents a fluorescence lifetime

SINGLE PHOTON MICROSCOPY
Solid state defects, quantum dots, single molecules.

About Swabian Instruments

Swabian Instruments is a rapidly growing high-tech start-up from Stuttgart, Germany that is developing world leading FPGA based time-to-digital converters (TDCs) with a timing jitter down to 2.7 ps. Among its customers are top research institutions worldwide, such as MIT, NASA, Harvard University, University of Cambridge, University of Oxford, and Max-Planck Institutes. Swabian Instruments' technology serves applications ranging from quantum technology and photonics to life sciences. In 2019 the team was one of the top-3 finalists of Germany's most important entrepreneur award, the Deutscher Gründerpreis.

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We do the most nerdy things you can do with an FPGA. Our FPGAs are 95% full. We work at the gate level and attach to digital converters to measure time — pushing to 2.7 picoseconds, far in the microwave domain — directly on the FPGA. We push the Opal Kelly modules to their extreme limits.

— Helmut Fedder

Opal Kelly

ISO 9001:2015 Certified

Opal Kelly Incorporated, located in Portland Oregon, provides a range of powerful USB-based FPGA modules that deliver the critical interconnection between a PC and many electronic devices. Since 2004, the use of Opal Kelly modules has spread throughout the world–from University research labs and classrooms to some of the largest global commercial firms (and some of the very smallest).

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