COSYLAB



Compact controls for Kwan-tek's NV-Diamond Quantum Education set-up

Unleashing the power of quantum sensing through NV diamond technology — a joint project between Kwan-tek and Cosylab creates a user-friendly, mass-produceable single-box platform for quantum physics education.

Bridging the Quantum Workforce Gap with Hands-On NV-Diamond Sensing

The bottleneck to broader adoption of quantum sensing is not its physics but the development of workforce of engineers capable of understanding the complete end-to-end operation of NV sensors based upon diamond samples containing nitrogen-vacancy (NV) centres. Therefore, creating production-ready, affordable systems to educate younger engineers about NV sensors is essential.

Kwan-tek is a French deep-tech company that specializes in the development and commercialization of metrology solutions based on diamond NV technology. They adopted a two-stage approach. In stage one, Kwan-tek provides a hands-on experimental platform, KWANTEACH, to universities and research laboratories. Younger engineers and researchers can study quantum sensing through direct experimentation. In stage two, Kwan-tek will develop and scale up this technology for commercial NV-diamond sensing applications, Non-Destructive Testing and navigation.

To make phase one commercially viable and to establish a solid foundation for phase two, Kwan-tek needed a control system that was compact, precise, cost-effective, and ready for serial production. It turned to Cosylab to build it.

kwan-tek

CUSTOMER	SPECIALTY	COSYLAB INDUSTRY
KWAN–TEK founded in 2020 Ploemeur, France	Quantum Sensing Quantum Metrology Quantum Education	Industrial Hi-Tech Applications, Development Services and Custom Solutions

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Quantum Sensing Challenges at a glance

Challenges	Solutions	Results
Replace two off-the-shelf instrument boxes with one compact, teaching-friendly control box.	End-to-end hardware, firmware, and software delivered in a single custom enclosure.	Two prototype units delivered, specification met, and ready to deploy as a platform for KWANTEACH.
Deliver production-grade performance at an educational price point.	A solution based on Zynq Ultrascale+ in Zynq 7000 architecture.	Manufacturing and testing process defined for low-volume batches of identical units.
Prepare for CE compliance and industrial scale-up while safeguarding Kwan-tek's IP.	Fixed-price, fixed-scope engagement with full IP transfer to Kwan-tek.	Continuing collaboration on CE compliance and scale-up production for KWANTEACH.

The Challenge: Fitting Real Quantum Sensing Hardware into an Educational Budget

KWANTEACH is a comprehensive platform for studying quantum physics and advancing research into NV-diamond sensing. KWANTEACH's market success depends on two conditions being satisfied: the science must be genuine, which means real NV physics, real experiments. The whole system has also to be small enough, simple enough, and affordable enough for a university lab to buy, install, and run without a dedicated control-systems team.

Initially, KWANTEACH relied on two separate off-the-shelf instrument boxes to collect data and generate pulses. This functioned properly but required additional space, increased costs, added cable complexity, and created difficulties in managing student and instructor workflows.

Kwan-tek needed a single, compact custom control box that consolidated both functions, achieved tight technical requirements for NV-based sensing, and could be produced economically in smaller quantities. As the design had to work not only for phase one, the teaching platform, but also for phase two, the industrial scale-up into commercial NV sensors, Cosylab faced a challenging engineering assignment.

> “With more than 30 universities equipped worldwide across 13 countries, our ambition is to make KWANTEACH the benchmark platform for quantum physics education, from outreach activities and undergraduate teaching to master's level courses and research projects.”
>
> ***Aurore BARS***
> *Manager of Business Unit KWANTEACH, Kwan-tek*

Designing a Single-Box Control System Around the Zynq-7020 SoC

Cosylab established a fixed-price, fixed-scope contract with Kwan-tek under which it assumed full responsibility for all aspects of design, firmware development, integration, and delivery. Deliverables consisted of two prototype control boxes and the establishment of processes for manufacturing and testing low volumes of identical units.

Working closely with Kwan-tek's engineering team, Cosylab selected a solution that needed to be a System-on-Chip, support the control systems specifications and Kwan-tek's I/O interfaces, and be cost-effective. The solution that meets the specification is the Digilent Eclypse Z7 board, based on the Xilinx Zynq-7020 System-on-Chip, which serves as the platform core. The Zynq-7020 combines an ARM Cortex-A9 processor with FPGA fabric on a single chip, so the classical control logic and the real-time timing engine live in the same silicon and share a fast internal bus.

Next to the Eclypse Z7 card, Cosylab added a Zmod Scope 1410-125 module to acquire analog data. As such, the box includes a 14-bit ADC operating at 125 MSPS, which is fast enough for pulse generation experiments yet economical enough to remain within an educational budget.

To these building blocks, Cosylab added a custom PMOD breakout card for KWANTEACH's digital output sequences and a custom enclosure featuring KWANTEACH's branding. Together, these components replaced the two prior off-the-shelf instruments with a single, compact, purpose-built control box.

When Cosylab designed the custom control box for KWANTEACH, it drew on more than 25 years of firmware engineering for systems where nanosecond precision, deterministic behaviour, and absolute reliability are hard

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requirements. Cosylab usually bases its FPGA framework on the Zynq Ultrascale+ architecture for work on RFSoC-class quantum systems, but for the KWANTEACH project it had to move down to the lower-cost Zynq 7000 architecture.

This transition was the most difficult single piece of engineering of the project. The Zynq 7000 uses a different ARM architecture and memory space than the Ultrascale+ and depends on a different build of PetaLinux. Therefore, Cosylab had to rewrite the kernel modules and block designs to ensure that all communication is reliable – from the ARM processor running the high-level control loop, down through the FPGA fabric handling millisecond time scales, and out to the analogue and digital I/O. KWANTEACH can thus deliver the solution without exposing the complexities behind the scenes and feels like a completed educational product rather than a laboratory setup.

Full IP Transfer, No Vendor Lock-In: How Kwan-tek Retained Ownership

Cosylab transferred the intellectual property rights, together with the delivered system, to Kwan-tek, without vendor lock-in.

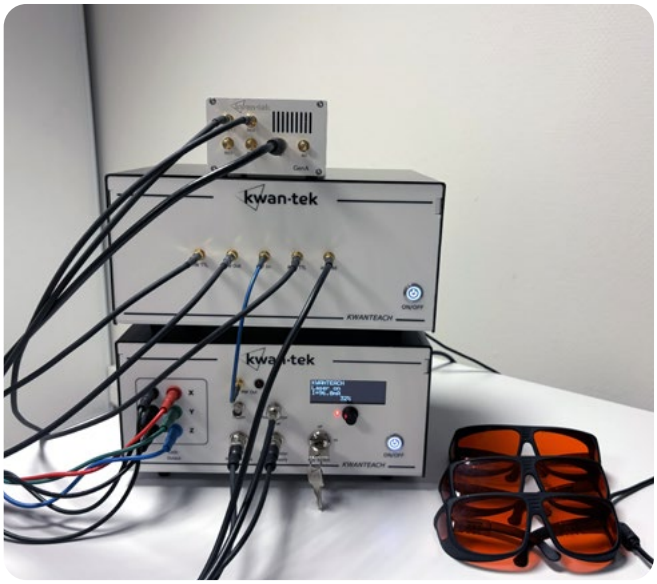
Ownership models, where customers retain full ownership of the core algorithms and application layer and where the control-system partner has responsibility for providing the engineering base, are crucial in developing industries, such as quantum sensing. This model also helps both partners clearly establish where the separation lies between each other's responsibilities.

Results

With Phase One complete, Cosylab delivered two custom control boxes that meet Kwan-tek's specifications for compactness, timing precision, and NV-sensing performance. It also provided the documentation required for low-volume production and testing. Cosylab is currently providing support to Kwan-tek regarding integrating the control box into the larger KWANTEACH product line, obtaining CE certification, and beginning scale-up activities, during which KWANTEACH units will continue moving to university and lab environments.

Kwan-tek now has a working product ready for the education marketplace, with a cost-effective, repeatable production process and technological foundations that will support the transition to Phase Two—developing industrial NV sensors.

This impact is deeper than at first glance. Each KWANTEACH unit shipped puts a functional quantum sensor in the hands of students and researchers who will contribute to the future of the quantum industry. Kwan-tek's goal of making quantum physics concepts tangible in the classroom and growing the commercial quantum workforce is therefore quite a few steps closer.



What's Next: CE Compliance and Scaling KWANTEACH for Production

The main objective of Kwan-tek is to produce and distribute as many KWANTEACH units as possible to provide students with direct experience using experimental methods to learn quantum mechanics. These students then become prime candidates for the future quantum workforce. At the centre of this pipeline is the control box, which began as a fixed-price project between two groups of engineers whose design principles will carry over into the industrial NV-sensing systems Kwan-tek will build next.

Quantum startups can shorten their path from working experiment to a production unit by partnering with a control-system company that has already solved the FPGA, RF, timing, and data acquisition problems and lets them retain the underlying IP.

For universities and labs that wish to conduct authentic NV-diamond-based research and teaching, the takeaway is that such activity no longer requires the footprint or cost of an instrumentation rack.

> "We were excited to work on the Kwan-tek project because of the challenging specifications."
>
> ***Jernej Kokalj,***
> *Quantum Tech Lead, Cosylab*

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> Overall, our collaboration with Cosylab has been very positive. Communication was fluid, the team was highly attentive, and the specifications were rigorously met. The custom hardware solution met our requirements for compactness and performance precisely, while simplifying our measurement processes. So, the final result is there: a Kwan-tek high-performance, ready-to-deploy platform, and the transfer of intellectual property ensures our complete autonomy for the future.

Emile Figuerola,
Electronics Engineer, Kwan-tek

Learn More

Every quantum breakthrough ultimately demands a control system that a student can use to perform experiments, a startup can scale, and a manufacturer can produce in quantity. The growing quantum industry needs a well-educated workforce of young researchers and engineers to propel itself into the future, so solutions such as KWANTEACH are essential. The partnership between Cosylab and Kwan-tek demonstrates what that looks like in practice: real-world NV-diamond physics available today on any laboratory bench; repeatable industrial platforms for NV-sensing available tomorrow; and customer-owned IP at each stage of development.

For universities and research labs:

explore the KWANTEACH NV-diamond teaching and research platform at ***kwan-tek.com/KWANTEACH.***

For quantum startups and labs:

if you are moving from a working experiment to a production-ready quantum system, talk to Cosylab about full-stack control-systems engineering for quantum applications at ***cosylab.com/solutions/quantum.***

Ready to start a conversation:

reach the Cosylab quantum team at ***cosylab.com/get-in-touch.***