

► Case Study

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| Application | Fusion Research |
| Product | M2i.4912-exp Digitizer 8 Channel 10 MS/s 16 Bit |

Digitizers from Spectrum used in race to create fusion reactor for limitless clean energy

Used to control complex fusion firing of 2.5 MJ that takes only two microseconds

Fusion has long been viewed as the ultimate goal for energy generation. Smashing together deuterium and tritium atoms releases energy as they combine and is the reaction at the heart of the sun. With no dangerous waste products and a virtually limitless supply of these atoms from seawater, billions have been spent on fusion research. However, recreating the extreme conditions of temperature and pressure on earth are not easy. A British company called First Light Fusion (FLF) is pioneering a very different approach to fusion and is on target to achieve fusion gain – more energy out than goes in – by 2024. In order to achieve the conditions needed for fusion, they launch a projectile to hypervelocities at a target which requires very high levels of precision to achieve and so they selected 32 digitizers from Spectrum Instrumentation to monitor the results.

Machine 3 fires 200 kJ of kinetic energy

Machine 3 has been constructed to electromagnetically launch the projectiles and consists of six banks of capacitors arranged radially around a central vacuum chamber where the experiment takes place. The capacitors are charged up to 200,000 Volts over the period of a minute and the stored electrical energy is discharged in less than two microseconds. This generates up to 14 million Amps which create intense magnetic fields that launch the projectile into the center at velocities approaching 20 km a second, delivering 200 KJ of kinetic energy. FLF tested the firing of three limbs last year and has now successfully commissioned the full, six limb machine and started science experiments. Each discharge is equivalent to 500 simultaneous lightning strikes. A total of 2.5 MJ are used for every discharge and the progress made so far gives the company confidence in achieving fusion gain by 2024 which, to date, has never been done in an experiment like this.



Machine 3: Vacuum chamber surrounded by 192 capacitors

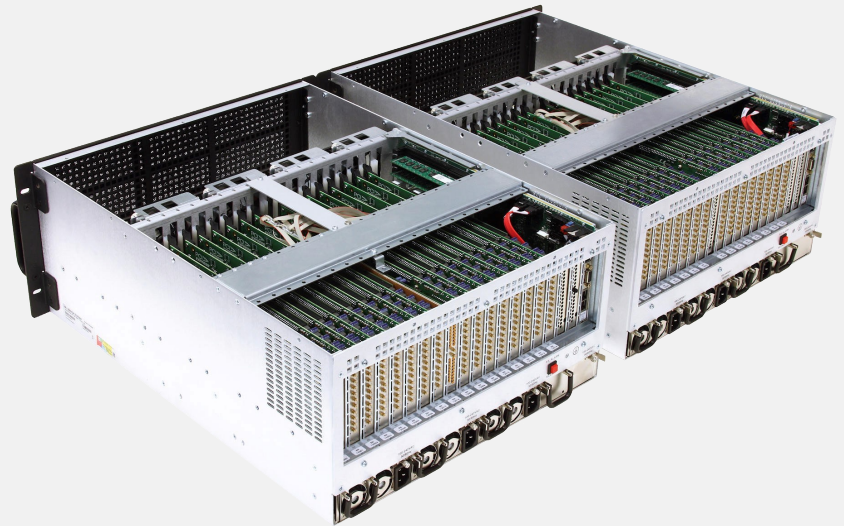
Paul Holligan, Head of Pulsed Power at FLF, explained: "We have a different approach to the other organizations trying to achieve fusion gain. We are not using lasers or intense magnetic fields which themselves can prove to be very complicated and costly to build. By choosing pulsed power as our driver technology, we have reduced the cost and complexity in this area and, in practice, the challenge is perfecting the design and shape of the target; that is where we are establishing unique IP and developing our simulation and modeling capability. This is the new science stage. Beyond that, we can clearly see a path to achieving

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clean energy that is simple and inexpensive within a realistic timeframe. We are driven by wanting to power a world worth inheriting by our children."

256 digitizer channels acquire machine diagnostics

One of the challenges in this design is ensuring synchronicity in the firing of all six limbs that has to have nanosecond level accuracy. The electrical energy is stored in 192 capacitors that are arranged in pairs and each of the 96 pairs is controlled by a bespoke switch which is capable of holding off the voltage and transferring the huge currents involved. After the firing, Spectrum M2i.4912-exp digitizer cards are used to acquire hundreds of machine diagnostics from each capacitor and switch along with numerous probes in the limbs covering current and voltage readings with a sampling rate of 10 MS/s (100 ns time interval). 32 cards are linked together in two banks of 16 using Spectrum's Star-Hub feature to ensure synchronicity across all 256 input channels. This configuration provides the flexibility of adding additional channels if required in the future.



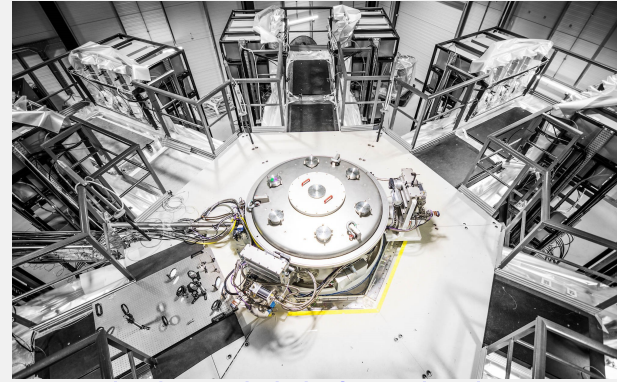
Spectrum's 256 channel system with 32 digitizer cards in two 19" PC systems

"This synchronization feature was a key reason why we chose Spectrum," added Paul Holligan. "Everything happens in nanoseconds so accuracy of firing and data gathering is paramount. We could not have any possibility of errors coming in from this equipment as every firing provides us with invaluable data and we have to be confident in the quality of that data. We looked at proposals from other suppliers and they were either hugely over specified for what we needed with a huge price to match or could not deliver the requirements we needed. I was very impressed by the attention to detail in the proposal for the Spectrum solution that made sure that the equipment was a perfect fit to our specifications. And the price was competitive so it was the obvious choice."

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Inertial Confinement Fusion

One of the founders of FLF was inspired by the pistol shrimp that clicks one of its claws in such a way as to create cavities in the water that heat as they implode forming plasma, resulting in a shockwave that stuns its prey. The precise mechanism of the collapsing is inertial confinement and is the only naturally occurring example of this phenomenon. FLF is using this to remove the complexity of needing huge containment mechanisms and focuses on managing the complexities of the implosion phenomenon to create the temperatures and pressure that match those at the heart of stars for fusion to occur. Inertial confinement means that the plasma is held together by its own inertia rather than by magnetic fields or lasers, both of which require large amounts of energy to maintain, making fusion gain much harder to achieve than FLF's system that uses a fraction of the energy to operate. Effectively, FLF has dramatically lowered the energy produced threshold that needs to be reached for fusion gain.



Vacuum chamber in which the firing takes place

About First Light Fusion

First Light Fusion was founded by Professor Yiannis Ventikos, who is currently the Head of the Mechanical Engineering Department at University College, London, and Dr. Nicholas Hawker, formerly an Engineering lecturer at Lady Margaret Hall, Oxford. The company was spun out from the University of Oxford in July 2011, with seed capital from IP Group plc, Parkwalk Advisors Ltd and private investors. Invesco and OSI provided follow-on capital. The business has developed from a research-focused university project to a fully-fledged company that has developed not only a strategy for how to make fusion energy work, but also a sustainable business model based on the technology. The team comprises experts in relevant scientific and engineering fields plus the management experience necessary to address the challenges which lie ahead. The company has been able to attract a world class advisory board, meaning it can benefit from decades of relevant experience to help it streamline the path towards realizing its vision.

About Spectrum Instrumentation

Spectrum Instrumentation, founded in 1989, uses modular design to create over 500 digitizer and generator products as PC-cards (PCIe and PXIe) and stand-alone-Ethernet-units (LXI). In 30 years, they have gained customers all around the world, including many A-brand industry-leaders and practically all elite universities. The company is headquartered near Hamburg, Germany, and known for their outstanding support that comes directly from the design engineers. More information about Spectrum can be found at www.spectrum-instrumentation.com