müller+krahmer

**compactRIO-based function generator with DIAdem interface for endurance testing of hydraulic accumulators**


## Summary

PC-based test systems quickly reach their limits when it comes to generating interference-free setpoint curves of analog quantities. Using real-time and FPGA hardware for frequently changing test tasks, on the other hand, overtaxes occasional users. The solution lies in combining configurable standard PC software with tailor-made applications on programmable automation controllers (PAC) that communicate via standard interfaces. In the endurance testing of hydraulic accumulators, the robustness of the compactRIO real-time controller family from National Instruments is an additional benefit.


## Endurance testing under high pressure

The hydraulic accumulator systems of Roth Hydraulics GmbH in Biedenkopf-Eckelshausen are used wherever large amounts of energy have to be stored – for example to dampen pulsations and absorb mechanical shocks, to provide energy reserves at short notice in emergencies, as on offshore drilling rigs and wind turbines, or to release energy for extreme accelerations within a very short time, as in crash test facilities and roller coasters. The hydraulic accumulators operate at extremely high pressures of up to 2000 bar. Their development and testing are correspondingly demanding.

To prove their fatigue strength, the hydraulic accumulators are subjected to mostly sinusoidal pressure curves over long periods in so-called pulse tests. A typical test comprises more than two million load cycles, during which the expansion of the accumulators is monitored. Highly dynamic, electrically controlled hydraulic control valves set the pressures, which can reach several hundred bar during the tests. The sensitivity of the valves to the smallest setpoint changes requires interference-free setpoint generation, which PC-based systems in a Windows environment cannot ensure. For a long time, tests were carried out with combinations of PCs, external measuring instruments and analog function generators that were cumbersome to operate and whose settings could only be documented manually. To make the work of the test engineers easier, employees of müller+krahmer GmbH developed a universal software-controlled function generator with simultaneous acquisition of analog signals on behalf of Roth Hydraulics.

Numerous aspects had to be considered when selecting the hardware. The decisive criterion was the system's ability to generate smooth setpoint curves with as many interpolation points as possible, i.e. at the highest possible clock rate, in order to minimize the shock load on the downstream hydraulics. Given a required maximum signal frequency of 100 Hz, setpoint generation was to take place at a clock frequency of 100 kHz to ensure 1000 interpolation points per period even in this case. Another selection criterion was a rugged and compact design that allows the device to be operated in a workshop environment and installed in an existing control cabinet with little space required. PC-compatible interfaces were to ensure simple data exchange between the function generator and the test computer. In addition, according to the specifications, the device had to be able not only to output setpoints but also to acquire measured values.

Because of its industrial design, the standard availability of Ethernet and RS-232 interfaces and, above all, the powerful real-time controller and FPGA hardware platforms, National Instruments compactRIO was chosen as the basis for the device. Even the "entry-level model" cRIO-9073 with integrated controller and an FPGA with two million gates meets the computing power requirements and contributes to a cost-effective solution.




| mueller+krahmer GmbH | Koenitzer Str. 14, 07338 Kaulsdorf, Germany | Phone: +49 36733 / 23286 | E-Mail: email@mueller-krahmer.de | Web: www.mueller-krahmer.de |
| Headquarters: Kaulsdorf | Commercial Register: Jena Local Court, HRB 514035 | VAT ID: DE315104478 | Managing Directors: Dipl.-Ing. Holger Müller, Dipl.-Ing. (FH) Marco Krahmer |

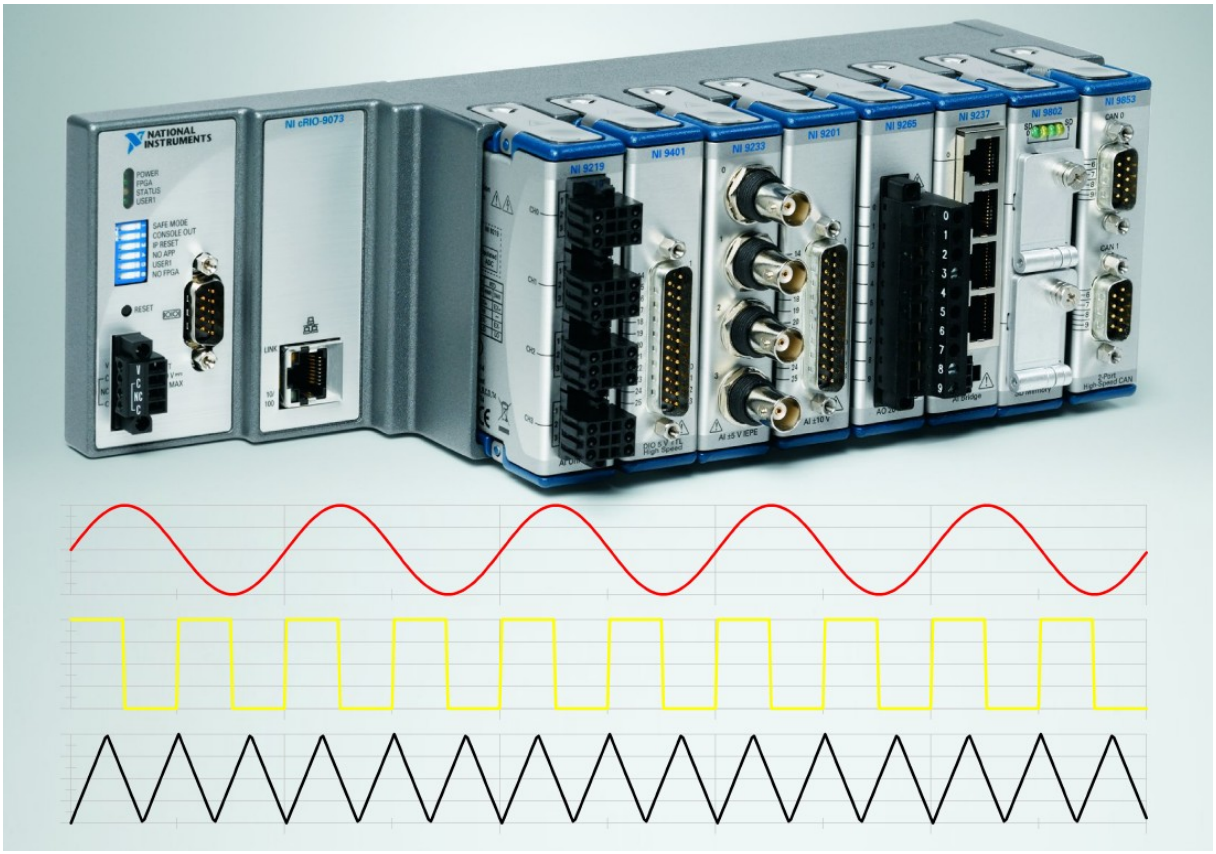



Figure 1: The cRIO-9073 PAC forms the basis of the software-controlled function generator (National Instruments)

Analog output and acquisition modules form the interfaces to the test setup. An NI 9263 module outputs voltage signals in the range of ±10 volts. Temperatures are currently acquired via resistance thermometers and the NI 9217 acquisition module. Further signals can be added at any time with little effort.

According to the specifications, the device provides two-channel setpoint output with separately configurable parameters. The FPGA module generates the setpoint curves at the required high clock rate. Trapezoidal, sine, square and triangle signals can be output, with the parameters frequency, amplitude, offset, phase, duty cycle and slope adjustable as relevant. Signal frequencies between 0.001 and – as already mentioned – 100 Hz can be generated. Based on these parameters, the connected hydraulic control valve sets variable test pressures.

**Powerful technology, easy to operate**

Apart from the technical parameters, easy operation by personnel without special programming skills is the most important requirement for the system. For this reason, and because of the users' existing application experience, DIAdem was chosen as the user interface. Both the parameters of signal generation are specified and the acquired measured values are processed here. Since DIAdem has no standard interfaces to compactRIO, a connection between the DIAdem DAC module and the PAC had to be created that fits organically into the concept of DIAdem DAC diagrams. On the hardware side, interfaces available on both the PAC and the PC were to be used. In the configuration described, this applies to both Ethernet and RS-232. Each interface has its specific advantages and disadvantages. While Ethernet has above all the speed advantage on its side, connecting it to a PC integrated into the company network requires a second network card for reasons of security and stability. RS-232, on the other hand, allows a peer-to-peer connection to be set up without additional hardware, but is considerably slower, especially when transferring measurement data. To use the advantages of both interfaces, they were implemented in parallel. The PAC automatically detects which type of communication is currently being used. These functions, as well as the interpretation of



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the received parameters and the sending of the analog measured values, are handled by a LabVIEW Real-Time application on the real-time controller, which is by no means fully utilized by these tasks and thus offers potential for future applications.

The counterpart to the communication functions on the real-time platform are special function blocks in DIAdem based on the Script DAC driver. It supports both TCP/IP via Ethernet and RS-232 and allows communication via either of these interfaces depending on parameters to be set. One DAC block is used to parameterize the signal generation, with a signal to be connected for each of the parameters mentioned above. All parameters can be changed at any time. At the same time, signals are acquired – both via the PAC and via other measuring devices that can easily be integrated into DIAdem – visualized, stored and then evaluated using DIAdem's wide range of reporting functions. The parameters of the signal generation can be included in the data recording in order to document the test conditions comprehensively.

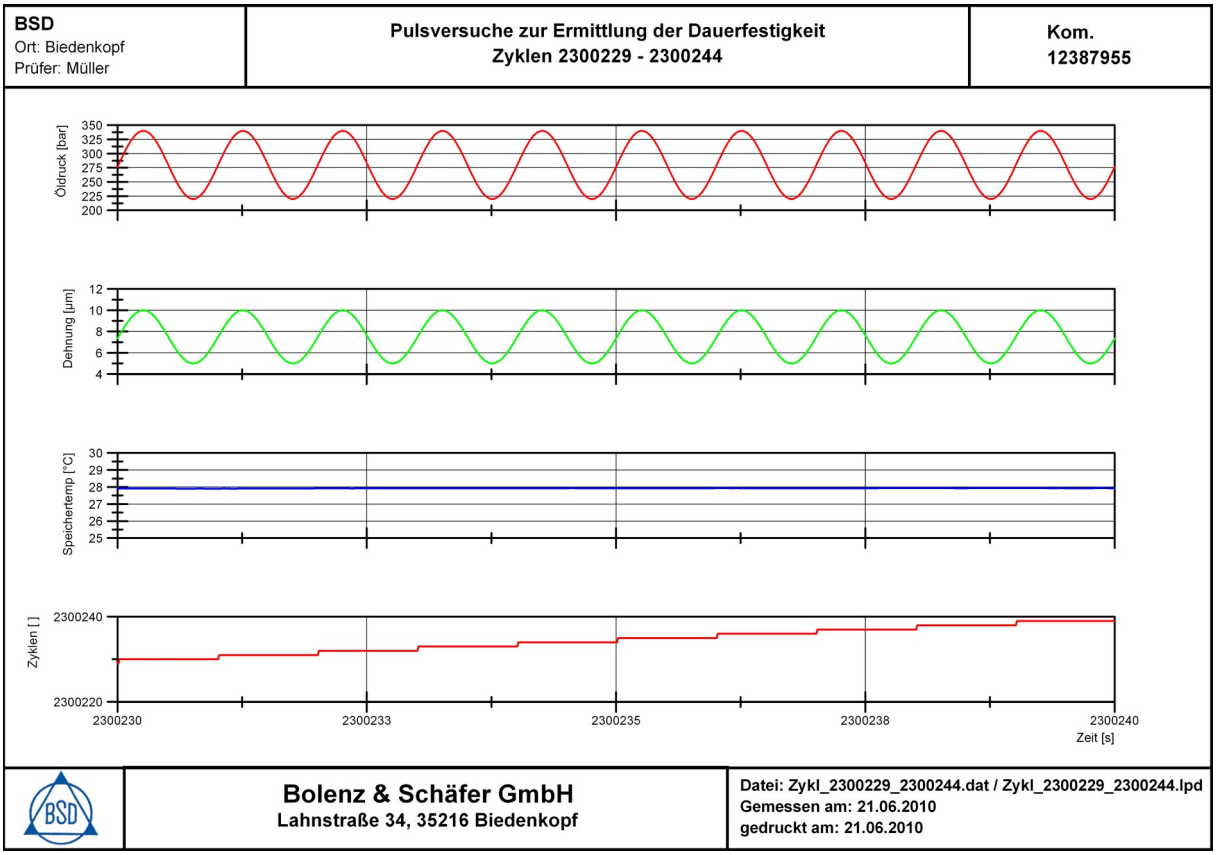



Figure 2: All test parameters come together in the report

The availability of the software-controlled function generator has decisively simplified the test engineer's work. Instead of operating different devices and laboriously combining their measurement data and parameters into a test result, all data now comes together in DIAdem and is available for evaluation immediately after the end of the test. Thanks to the device, users without programming skills can solve variable test tasks purely by configuration in DIAdem while using the performance of a programmable automation controller.



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