Pickering Interfaces Counts on LXI
for its High Performance Switching Matrix – The CERN Application

By David Owen, Pickering Interfaces

Pickering Interfaces has designed a new LXI switching matrix for the signal monitoring at CERN's high-energy collider. David Owen from Pickering Interfaces explains why LXI is the standard of choice for such highly complex switching systems with high performance requirements or a need for remote access, and why the new switching matrix is suitable for many other applications.

Near Geneva, CERN runs the Large Hadron Collider (LHC) a hundred meters below ground for experimental research in the field of high energy physics. The collider operates a pair of counter-rotating particle rings which have crossovers at four experiment sites. Their particles crash from opposite directions into each other and create the signatures that indicate the presence of short lived particles. To prove this, the generated data must be recorded reliably. Monitoring of the LHC for correct operation is accomplished through the Open Analogue Signal Information System, called OASIS. It picks up relevant monitoring signals from various places to make sure that the system is operating as intended.

The OASIS system uses a set of digitisers to acquire the signals and send them to users via Ethernet. The digitisers however are very expensive and there cannot be one distinct digitiser for every signal to be monitored. A switching system is used to allow OASIS to select, which signals to show from the variety of available signals. Historically this switching system has been based on VXI and more recently on cPCI systems.

A New Switching System for OASIS
Within the frame of a biennial system upgrade CERN has closed down the collider as of February 2013 to upgrade all systems – including OASIS. At each of the four experiment sites up to 16 signals, selected from 104 sensors, have to be made available for digitizing. "The analogue signals have frequency content to many MHz and there is potential for considerable differences in level from the various monitoring positions," said David Owen, Business Development Manager, Pickering Interfaces. "This puts challenging constraints on the required bandwidth and the allowable crosstalk between channels. If signals from high level sources and signals from low level sources are required at the same time on different channels, the high level signals could disturb the low level signals." Remote control is another essential requirement for the switching system.

So a switching matrix with a size of 104 x 16 was required, having excellent crosstalk and featuring a signal bandwidth of several ten megahertz. "The size of the matrix could not have been implemented using conventional standard products," Owen said. "Nevertheless, the cost of the new matrix had to be significantly lower than placing a digitiser on each analogue signal. It quickly turned out that the fixed modular structure of PCI did not lend itself to this sort of switching system. The same applied to cPCI and PXI."

LXI as a Platform
Pickering Interfaces designed a LXI based solution to fit the requirement. Owen describes the process as follows: "To implement a high performance matrix of this type we first had to determine the form factor of the final switching system. It quickly was shown that none of the existing products met the requirements at affordable cost and size. A modular approach was needed to make the matrix system size scalable as different locations required different sizes of matrix - one site required 64 x 16, another 104 x 16. Systems could also have their requirements changed with time if the number of sensors changed and more (or less) channels added. All the evidence suggested that a proprietary scalable modular approach was going to be required, to easily adapt the matrix size. So we opted for LXI as platform as LXI offers a large degree of freedom regarding size. LXI control also means that users could access the matrix state over their network without intervening controllers by the LXI

product's web server – in the same way as internet users access web sites. Knowing that we had implemented self-test in both LXI and PXI systems (called BIRST), CERN requested this kind of self-test for the new switching system. Ideally the test had to be capable of running with the inputs and outputs connected to a non-powered source/load. In addition, CERN wanted to be able to remotely start and run the self-test."

Highly flexible Wideband-Modular-Matrix

Pickering Interfaces came up with the Wideband Modular Matrix 65-110 as solution for CERN. The switching matrix is based on a chassis that has a dedicated analogue bus system. Into the chassis a set of plugins can be installed. The left hand pair of cards provides the 16 Y access connections required for the digitisers. The remaining X plugins then provide the analogue signal inputs, 8 signals per plugin module. The number of X plugins can be scaled from just one (8 off X connections) up to 13 (104 off X connections), allowing the user to create a matrix of any size within the chassis constraints. Not installing the second Y plugin allows Y=8 systems to be created. The design is fully user configurable, plugin modules can be arbitrarily installed and uninstalled. The LXI controller's firmware will recognize the configuration and amend the available matrix size to match the plugin modules installed. The web based soft front panel allows driverless control of the matrix by any authorized user with access the Ethernet backbone. The modular matrix can be scaled to fit the application and changed as needs changed. The 65-110 plugins and the analogue bus system also provide excellent RF performance and low crosstalk, significantly exceeding the requirements set by CERN. The RF BW in a typical configuration is above 300 MHz, driven largely by the need for low crosstalk.

LXI Advantage - Local Intelligence

The modules communicate internally to the LXI controller via a PCIe interface. The LXI controller "virtualizes" the set as a single matrix, so it facilitates the user's task of programming the matrix. The LXI controller hides the complexity of the switch system from the user; the matrix appears as just one entity to the user and not a set of separate modules. The design uses an analogue bus underneath the plugin modules rather than being at the back of the rack which is normally the case with modular systems. "In a matrix it makes sense to have the X and Y signals lines at right angles to each other to improve crosstalk and isolation," Owen explains. "This is one of LXI's great features – there are no particular restraints on the size of the modules or the placement of an analogue bus."

Integrated Self-Tests

The 65-110 Wideband Modular Matrix includes a self-test facility, which checks all the signal paths for failed relays (closed, open or high resistance). The design uses low level signals so that the connected devices do not need to be disconnected in order to run the test. The self-test can be initiated over the LXI compliant web interface without requiring an external controller program. The user can be several kilometres away from the switching matrix; they simply need to initiate the test via the web server. The embedded LXI controller runs the test and the results can be viewed over the web interface or reported to the user as a file.

For CERN the solution has been convincing, they will be making full use of the LXI features of 65-110 as part of the OASIS system during its next rounds of experiments running at ever-higher collider energies. Due to its highly flexible concept the new LXI switching matrix will be suitable for many other applications. It allows users to create wide bandwidth matrices that can be scaled to suit changing use requirements, minimizing the initial investment required an allowing easy upgrades as the task size increases.