

A REAL-TIME, DISTRIBUTED POWER MEASURING AND TRANSIENT RECORDING SYSTEM FOR ACCELERATORS' ELECTRICAL NETWORKS

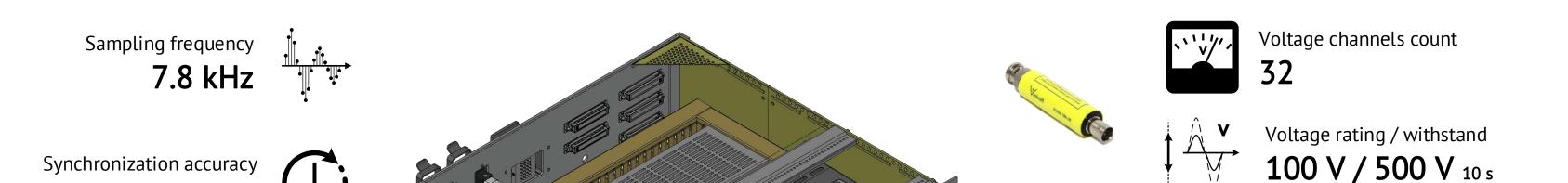
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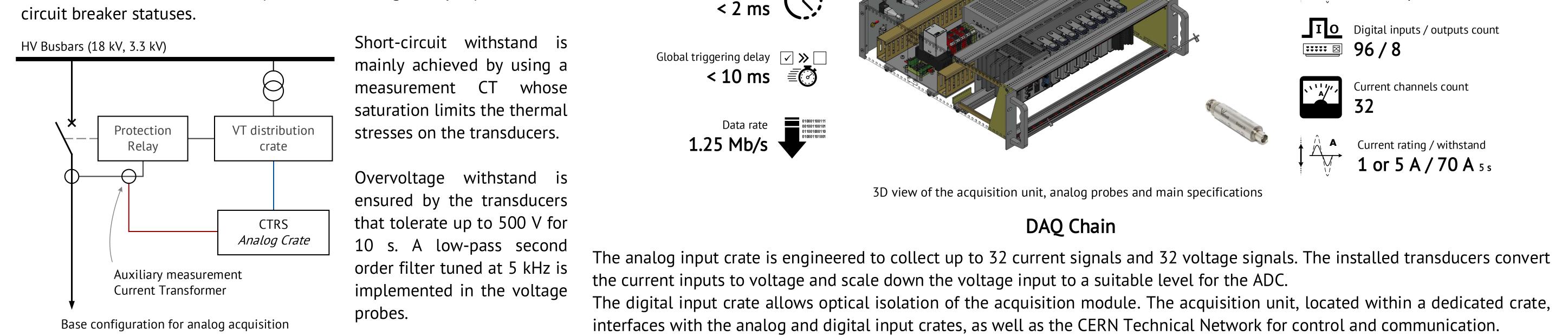
ABSTRACT

Particle accelerators are complex machines with fast and high power absorption peaks. Power quality is a critical aspect for correct operation. External and internal disturbances can have significant repercussions causing beam losses or severe perturbations. Mastering the load and understanding how network disturbances propagate across the network is a crucial step for developing the grid model and realizing the limits of the existing installations. Despite the fact that several off-the-shelf solutions for real time data acquisition are available, an in-house FPGA based solution was developed to create a distributed measurement system. The system can measure power and power quality on demand as well as acquire raw current and voltage data on a defined trigger, similar to a distributed oscilloscope. In addition, the system allows recording many digital signals from the high voltage switchgear enabling electrical perturbations to be easily correlated with the state of the network. The result is a scalable system with fully customizable software, written specifically for this purpose. The system prototype has been in service for two years and full-scale deployment is currently ongoing.

Connection to the Power System

In its base configuration, the CTRS acquires three phase voltages and currents directly from the voltage and current transformers already installed in the cubicles. It is capable of recording binary inputs such as circuit breaker statuses.





Software Features

Each DAQ station is equipped with an on board processor, allowing for continuous sampling, filtering and data processing, featuring:

- Sampling rate of 7.81 kHz, able to detect spikes and quick events
- Continuous acquisition cycle, with triggerdependant storage

System Architecture

The CTRS has a distributed architecture, connected on the Technical Network. To access the system from the General Purpose Network, a central controller interfaces with the DAQ.

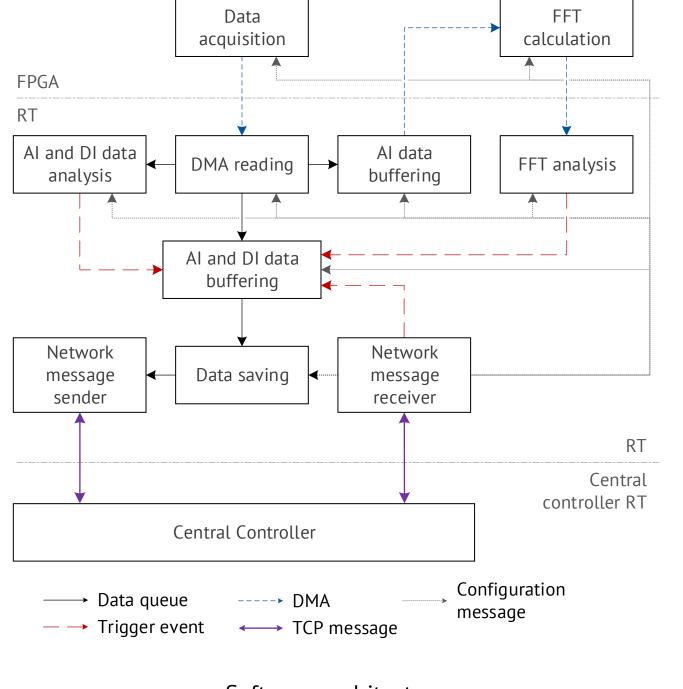


Configuration tool

The FPGA acquires raw data, buffer and transfer it to the RT application. It can control different relay outputs to give information of the cRIO status. The FPGA also performs FFT calculation, taking advantage of its high speed.

Software Architecture

The Real Time application analyses the raw signals received from the FPGA, maintains a data buffer in order to save the data in case of trigger and communicates with the central controller. To reduce FPGA memory overhead, the RT application



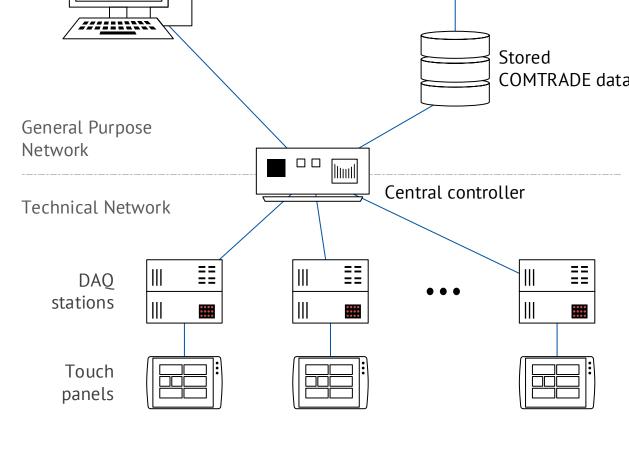
 $\widehat{\bigcap}_{\mathbb{Z}_2}$ Inter-trigger between units over Ethernet

Configurable recording window of up to 10 s, with settable pre and post triggers

Real-time FFT analysis

Remote configuration and programming capabilities

Export data in COMTRADE format



System architecture

buffers some data before sending it back ADE data to the FPGA for FFT calculation.

All the DAQ stations can be configured remotely. The system features channelspecific triggering: maximum or minimum instantaneous value, maximum or minimum RMS value in a cycle (50 Hz), over- and under-frequency, harmonics content. Triggering can be propagated over the different DAQ stations.

Software architecture

Configuration tool

The configuration tool allows setting up each channel of every DAQ station. Setup includes offset, trigger qain, thresholds and trigger types. The configuration communicates tool directly with the central controller, and it can be used to send a general trigger to all the DAQ stations at once.

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	AICh020	False	01:00:00.00	False	1.000	0.000	1.000	0.000	AICh017		
/in Data Value Max Data Value	AICh021	False	01:00:00.00	False	1.000	0.000	1.000	0.000	AICh017		
0 0	AICh022	False	01:00:00.00	False	1.000	0.000	1.000	0.000	AICh017		
ransformer Ratio Primary Factor	AICh023	False	01:00:00.00	False	1.000	0.000	1.000	0.000	AICh017		
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rimary/Secondary Data Scaling Identifier	AICh025	False	01:00:00.00	False	1.000	0.000	1.000	0.000	AICh017		
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Transient viewer

data viewer is a The COMTRADE file reader with searching and filtering capabilities for files on the storage server. Despite the fact that the files recorded by the CTRS can be read by any COMTRADE compatible software, the data viewer is embedded in the electrical SCADA system and it is particularly suited for filtering the many recordings available after an event.

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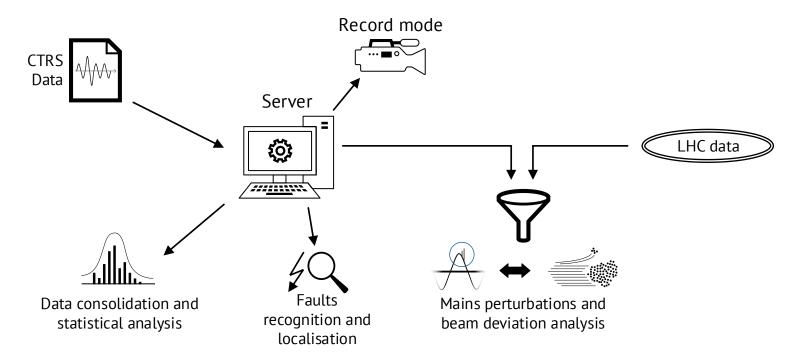
Transient viewer interface – perturbation on the main 400 kV incoming line

Improving of the automatic disturbance type recognition for statistical analysis and data consolidation;

Configuration tool interface

 Automatically linking the electrical perturbation on the network to the accelerators' behaviour (RF and magnets) during the run in order to discover and potentially prevent incipient failure modes;

- Improving the data viewer capabilities to allow advanced COMTRADE file analysis, automatic selection of the most relevant recordings after a
 network fault or disturbance to help the operation teams to better identify the type and the cause of the problem;
- Implementing a continuous acquisition and storage mode with scalable base time, e.g. hourly, daily or weekly.



Future developments and functions

Engineering Department

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