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Timing Synchronisation and Controls Integration for ESS Detector Readout

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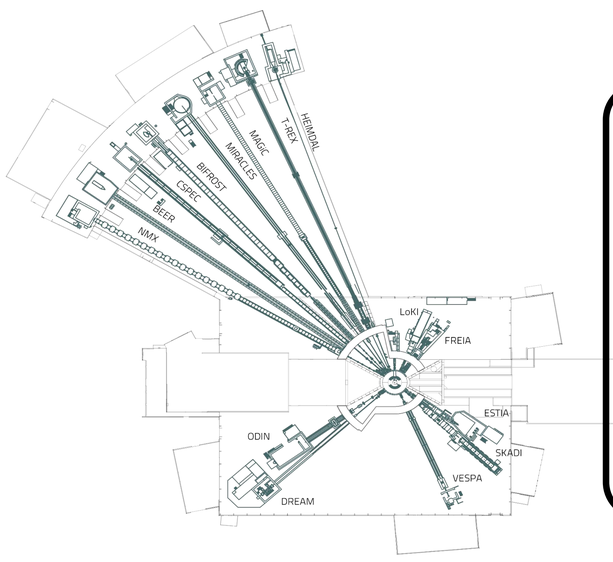
ESS

The European Spallation Source (ESS) is a new facility being built in Lund, Sweden which when finished will be the world's most powerful neutron source. Neutrons are produced at the facility through the process of spallation when protons collide with a tungsten target. These neutrons are guided along beamlines to 15 different scientific instruments.

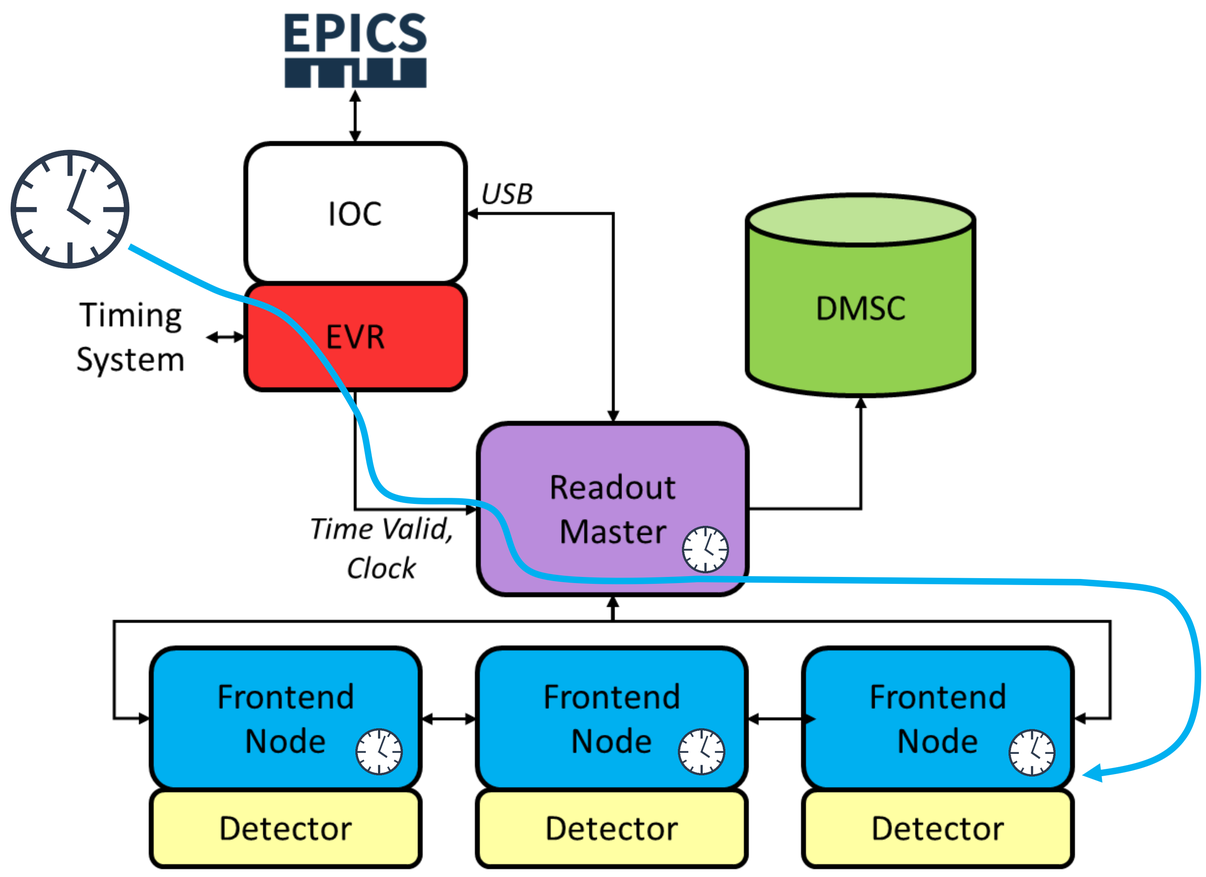


Instrument Data

The detectors that form part of each instrument generate neutron events which are then timestamped. Data produced by detectors is acquired by detector readout front end nodes. These are connected in a ring or star topology to a detector readout master. The readout master runs firmware on an FPGA that controls the front ends, ingesting the data they produce and sending it to the DMSC (Data Management and Software Centre).

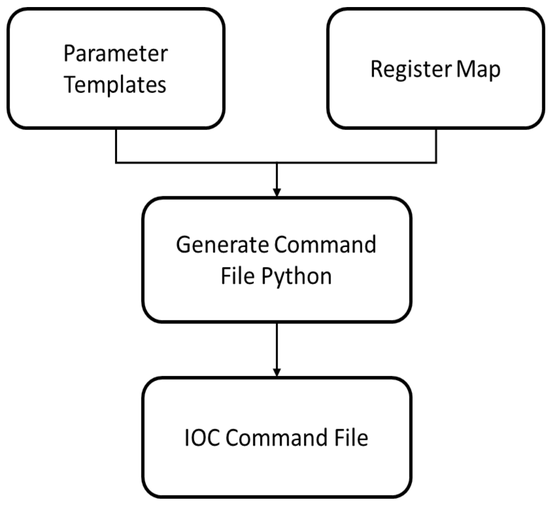
Control of Readout System

An EPICS IOC runs on an industrial PC with a serial connection to the readout master. The IOC communicates with the readout master over a serial protocol and can read and write individual registers or blocks of them. Parameters that monitor or control the readout system are exposed as EPICS process variables (PV's). These can then be accessed over the control system network. An EPICS Archiver Appliance records PV's which give information about the status and performance of the readout master, and where relevant the



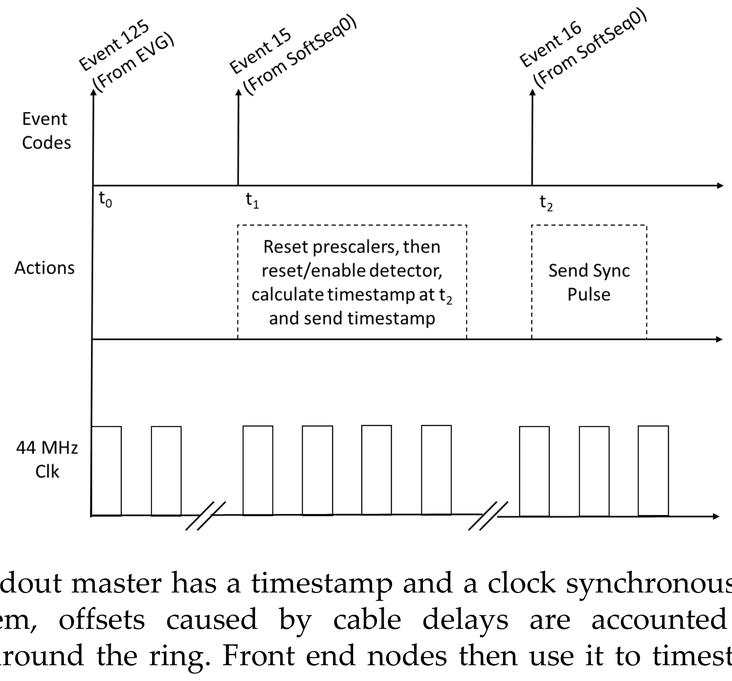
From Register Map to IOC

The readout system does not specify anything about the front ends. Instead the readout master exposes a register space to the control system and forms packets of data to be sent to the DMSC. The EPICS support module defines the communications between the control system and the detector. EPICS database template files are defined for different types of parameters that contain all the records needed to perform processing and communication. A Python script is used to parse a register map file and create an EPICS command script that loads the appropriate templates. Adding a new register just involves changing the register map, no knowledge of EPICS is required. A similar script is used to generate the register map in the readout firmware.



Timestamping Neutron Events

ESS uses the MRF event timing system to distribute an 88.0525 MHz clock and send events to event receivers (EVRs). Embedding an EVR in the readout master would mean loosing one of the transceivers and reducing the data acquisition bandwidth. A solution using one of the available mezzanine slots would take too much effort to design and produce. Instead a clock is supplied to the readout master from an EVR, a timestamp is then sent using the serial connection and this is then validated by a "time valid" signal from the EVR to the readout master. This is achieved using an event sequencer on the EVR as shown in the diagram below.



Once the readout master has a timestamp and a clock synchronous with the ESS timing system, offsets caused by cable delays are accounted for and it's distributed around the ring. Front end nodes then use it to timestamp Neutron events.

Deployment and Future Work

A test system has been deployed at a laboratory in Lund, Sweden. This comprises of a readout master with an ADC. It's been shown that data acquired by the system can be timestamped and sent to the DMSC. It's also been used for beam monitors at the ESS test beamline at V20, HZB, Berlin.

A development system including front end nodes and parts of the LOKI detector is planned in early 2020.

EUROPEAN SPALLATION SOURCE

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