Diagnostic Use Case Examples for ITER Plant Instrumentation and Control

14th International Conference on Accelerator & Large Experimental Physics Control Systems, 7-11 October 2013, San Francisco, USA

S. Simrock, P. Patil, V. Martin, L. Abadie, R. Barnsley, L. Bertalot, P. Makijarvi, D. Makowski, J.-Y. Journeaux, R. Reichle, D. Stepanov, G. Vayakis, I. Yonekawa, A. Wallander, M. Walsh
ITER Organization, Route de Vinon sur Verdon, 13115, St. Paul-lez-Durance, France..

Abstract

ITER requires extensive diagnostics to meet the requirements for machine operation, protection, plasma control and physics studies.
Most of the extremely complex ITER diagnostics systems are provided by the ITER Domestic Agencies (DAs) and their partners. On their demand the IO has created several diagnostics use case examples to enhance the understanding of diagnostics Plant System I&C and the associated deliverables.
The use cases come complete with documentation and implementation, further helping the DAs, their suppliers and diagnostic responsible officers to meet the ITER diagnostics requirements. In this paper, we present the current status and achievements implementation and documentation for the ITER diagnostics use case examples.

Background of Diagnostics I&C Use Case Examples

Why Diagnostic I&C Use Case Examples:
1. Produced on demand by DAs for examples
2. Provide incentives to follow PCDH by simplifying work from design to commissioning i.e. reduce cost).
3. Verify I&C can be be implemented in PCDH standards.

Note: Basic functionality represents only a fraction of each diagnostics I&C.

Benefits:
1. The diagnostics use case examples provide a framework in which domestic agencies can immediately start deploying their applications
2. Examples cover basic functions of many plant systems.
3. Demonstrate usage of components from fast controller catalog using supporting software.
4. Documentation templates provided. .

Products:

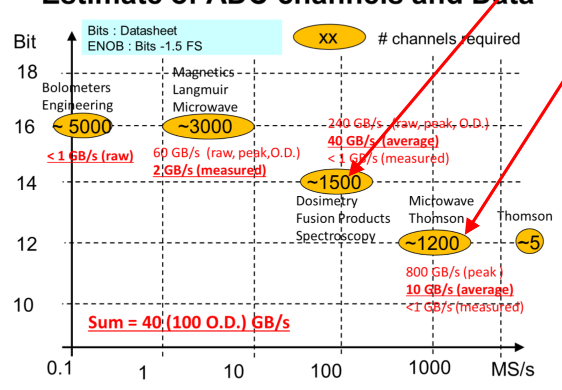
Documentation Products:
- System Requirement Specification (SRS)
- System Design Specification (SDS)
- System Manufacturing Specification (SMS)
- System Test Plan/Reports (STP)
- System Operation / Maintenance Manual (OMM)
- Diagrams in DB based repository

HW and SW Products:
- Complete working example system with basic functions.
- HW in fast controller catalog
- SW in SVN: Linux Driver and EPICS device support
- Automation (PSOS, COS)
- Network Interfaces (TCN, DAN, SDN…)

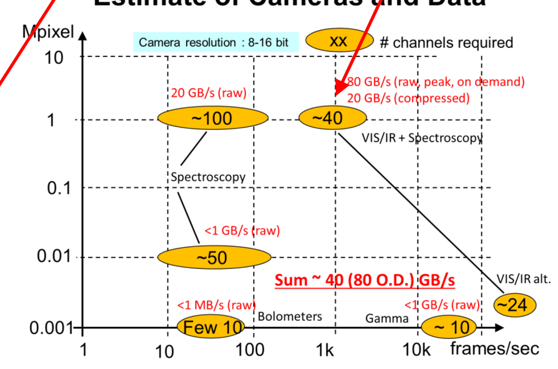
Selection of Use Cases

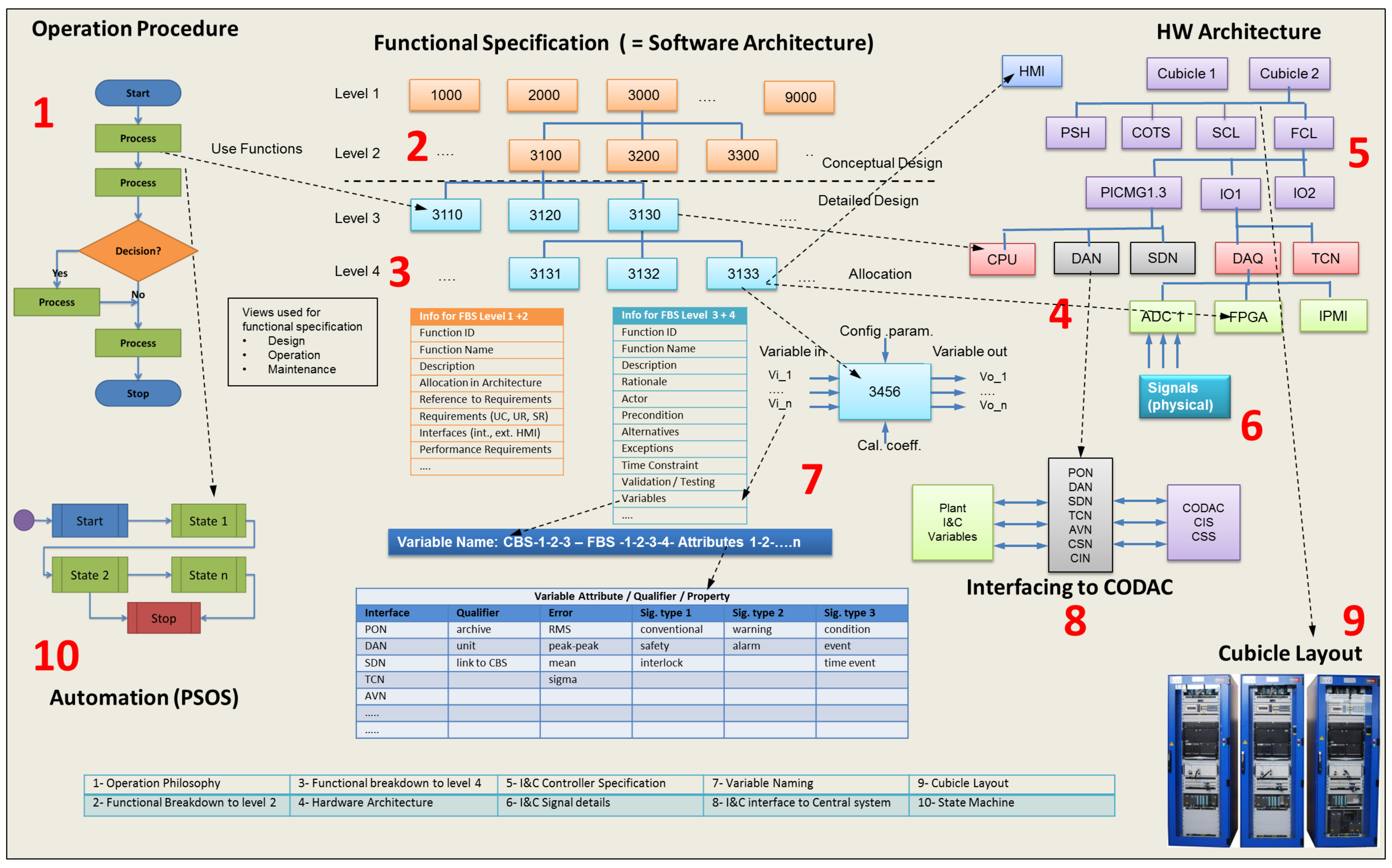
- Neutronics Diagnostics (MFC) — 100 MHz ADC
- Image acquisition (VIS/IR) — Mpixel / kHz framerate
- Microwave Reflectometry — 1-2 GS/s ADC
- Magnetics Integrator — Signal Conditioning

Estimate of ADC channels and Data



Estimate of Cameras and Data





USE CASE DOCUMENTATION

The designer starts with the description of the operational procedure of the relevant diagnostics. This is followed by a functional breakdown to level 2 for conceptual design and to level 4 (or more if needed) for the detailed design. The functions have to support all operational needs with process variables and their attributes being defined for individual functions as part of the detailed design. Then the hardware architecture is developed in which all of the functions can be implemented. The allocation of functions to hardware will be also documented. Finally a state machine for automation has to be defined, the cubicle layout with all cabling documentation developed, and the interface sheets are produced. All of these deliverables are documented in the design documents.

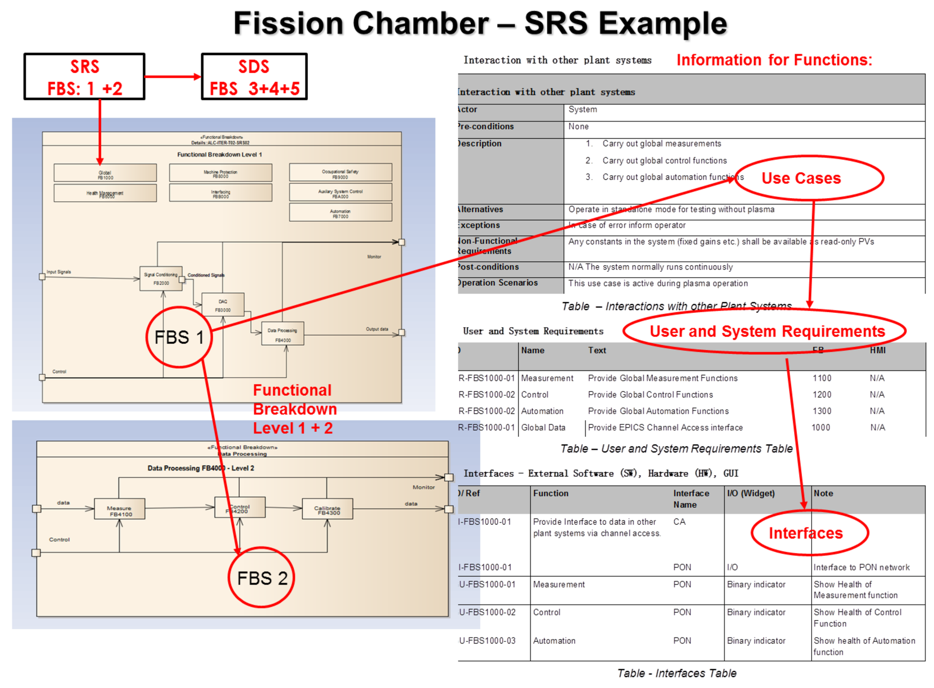
Systems Requirements Specification (SRS)

Almost all of the ITER diagnostics are procured according to functional specifications. Usually the requirements for plant I&C are not specified in sufficient details for the plant I&C designer. Therefore, the plant I&C system requirements needs to be elaborated in more detail, in the plant system I&C SRS.
The functional breakdown to level 2 represents the conceptual design. It decomposes the complex diagnostic function into smaller functions. Each function has to be described by its use cases, user requirements, and interfaces with internal and external functions including user interfaces. All functions and their requirements have a unique and structured ID which supports its use in the plant profile database.

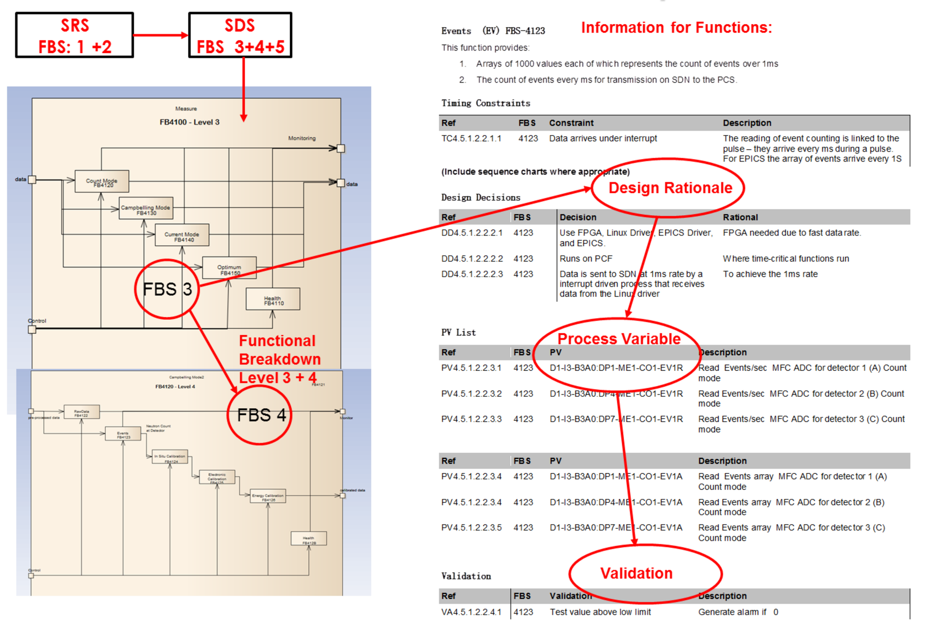
System Design Specification (SDS)

While the SRS provides a functional breakdown to level 2, the SDS elaborates on the details of the functions to at least level 4 (or more if necessary).
The functional breakdown to level 4 represents the detailed design. It decomposes the conceptual function blocks into smaller units. Each function has to be described by its design rationale, reference to requirements, timing constraints, validation reference, signal interface, and variables with all of their attributes

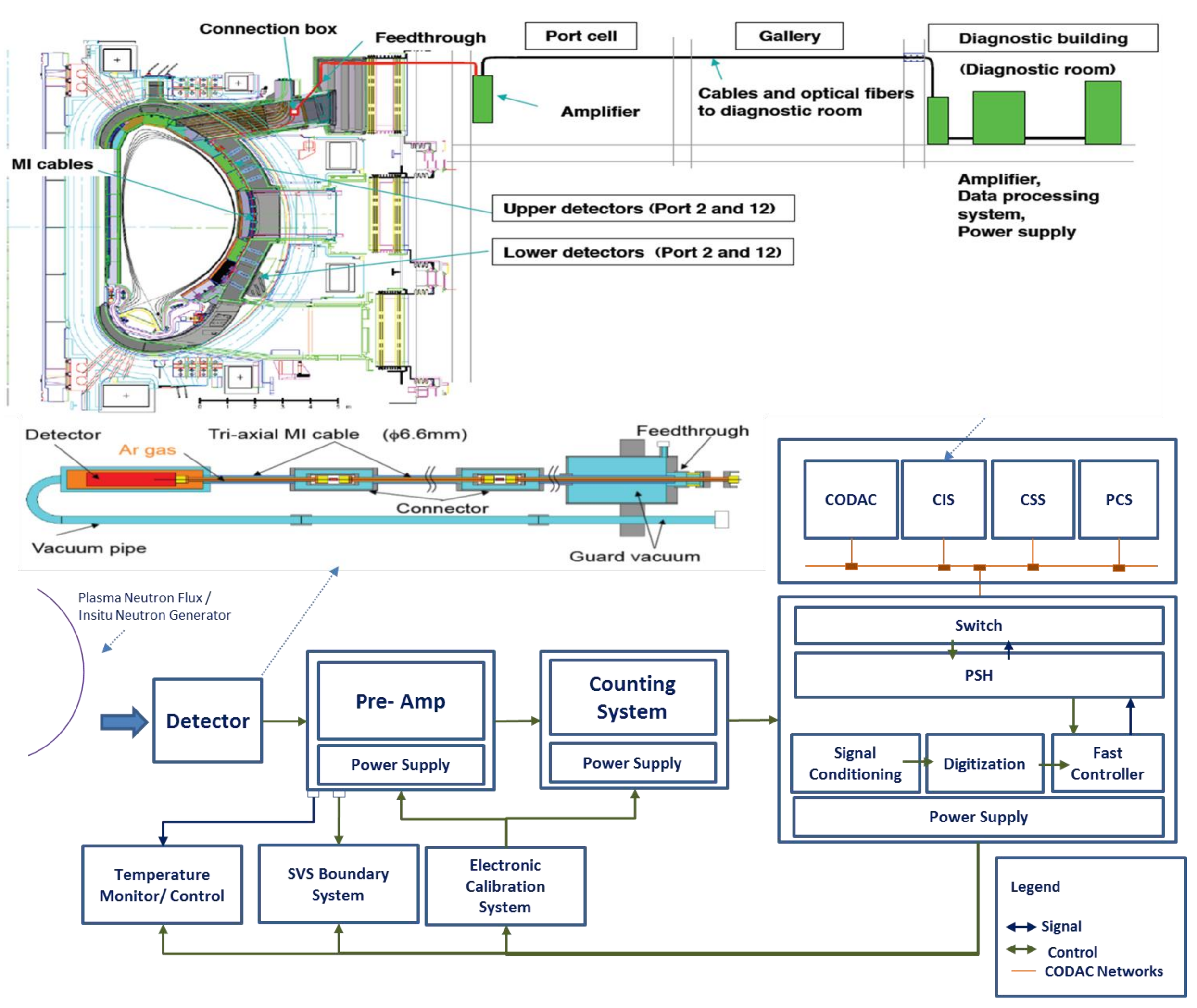
Fission Chamber – SRS Example



Fission Chamber – SDS Example



Neutronic Diagnostics Use Case



CONCLUSIONS

For the development of the diagnostics use case implementations we have followed the engineering methodology described in the PCDH. The work covers all required plant I&C deliverables through all lifecycle phases from requirement capture to operation. The documentation templates and examples have shown to be particularly useful for design review preparation and are now widely accepted as a standard for diagnostic plant system I&C. The use case implementations are demonstrating fully integrated diagnostics plant system I&C. They can be rapidly deployed by the domestic agencies who can focus on creating plant specific functions

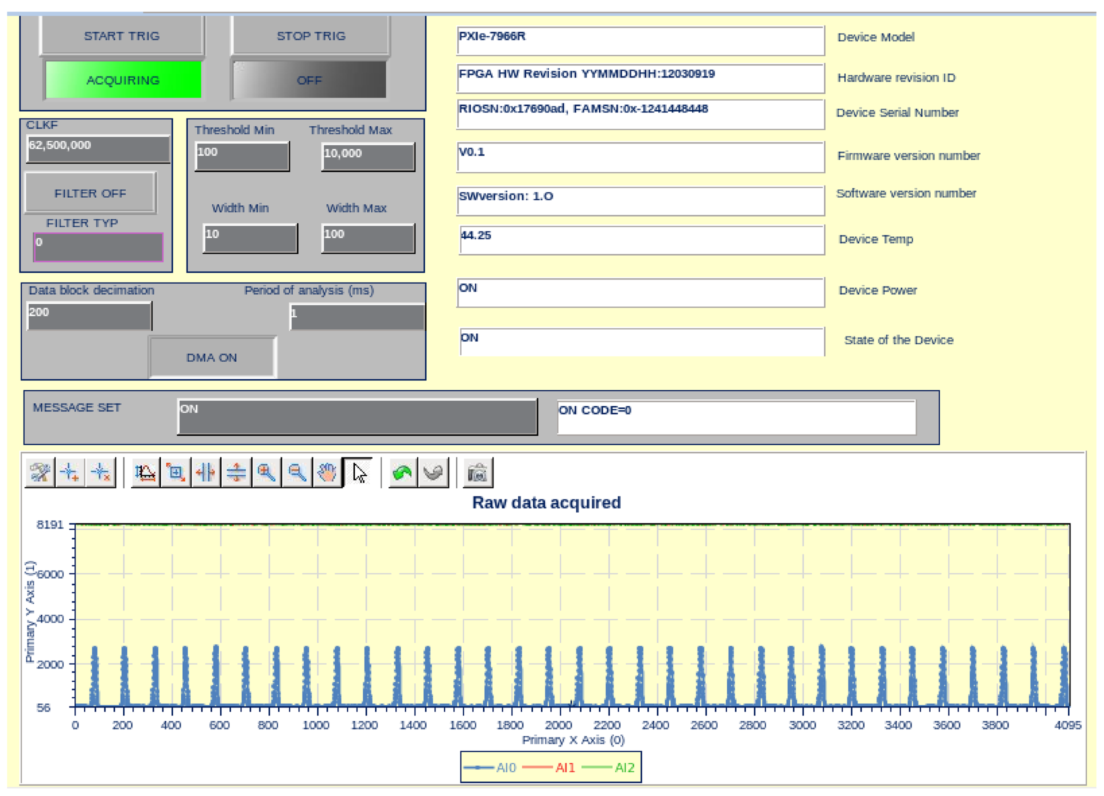
USE CASE IMPLEMENTATION

Image Acquisition Use Case

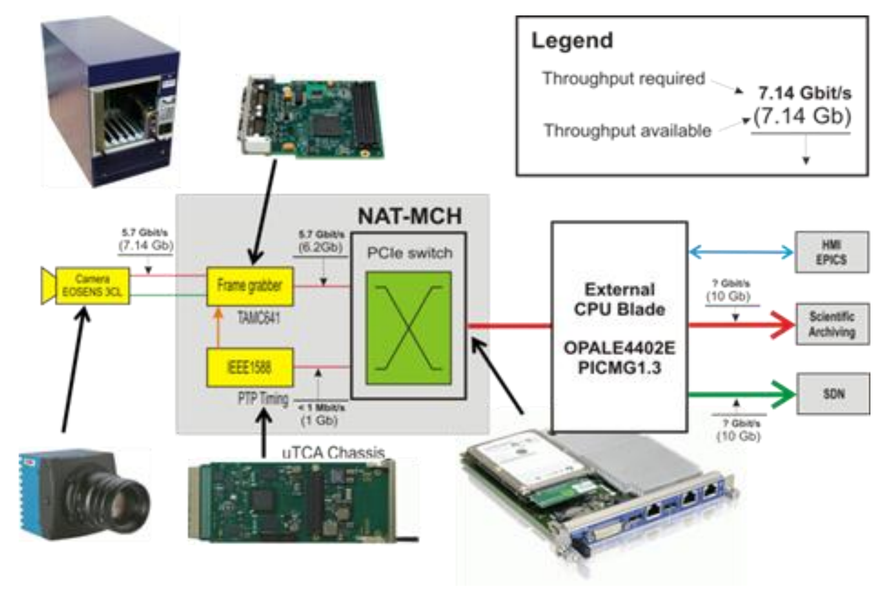
The goal of the image acquisition use case is to develop a CODAC relevant prototype that can be used to assess the feasibility of I&C functions regarding to:
diagnostics requirements (e.g. algorithmic performance)
Plasma Control System requirements (e.g. computational performance)
Moreover, the developed parts (hardware and software) are reusable for many diagnostic systems (e.g. visible and infrared, spectroscopy, x-ray cameras, etc.).
The prototype is composed of a fast HD visible camera connected via a Camera Link interface to a frame grabber. As for the neutronics use case, fast controllers in PXIe and MTCA.4 form factor are used

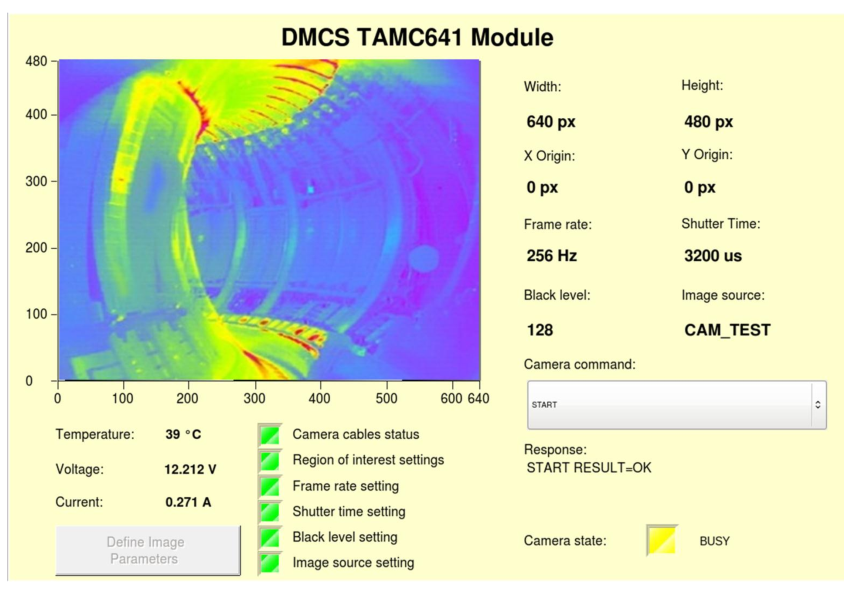
Neutronics Diagnostics Use Case

The neutronics diagnostic use case example is based on fast controllers with multichannel ADCs in the 100-250 MS/s range. Both PXIe and MTCA.4 form factors are used. The use case can serve as a basis for the design of fission chambers, neutron flux monitor, and neutron activation system.



Imaging Diagnostics Use Case





NEXT STEPS

The currently implemented diagnostic use case examples are still under development and testing. In the near term, the IO will add the high performance networks (DAN, SDN, TCN) to neutronics and imaging diagnostic use cases (both in PXIe and MTCA.4 form factor). In the following phase use cases for Thomson scattering / microwave reflectometry and magnetics integrators will be added.