Test automation for control systems at the European Spallation Sources

Karl Vestin, Fabio dos Santos Alves, Lars Johansson, Stefano Pavinato, Kaj Rosengren, Marino Vojneski

Introduction

The control system of extensive research facilities, like the European Spallation Source (ESS), encompasses thousands of diverse subsystems. Managing the development and maintenance of such a complex system-of-systems poses significant verification challenges.

At ESS, diverse test automation approaches are tailored to the specific type and application of each control system.

PLC based systems

Test automation for Programmable Logic Controllers (PLC) is facilitated using a standardized Python virtual environment that bundles essential tools for PLC project connectivity and testing.

The tests utilize the Open Platform Communication Unified Architecture (OPCUA) to emulate input and output signals for the PLC. This approach enables automation engineers at ESS to easily and consistently verify the behavior of the PLC software.

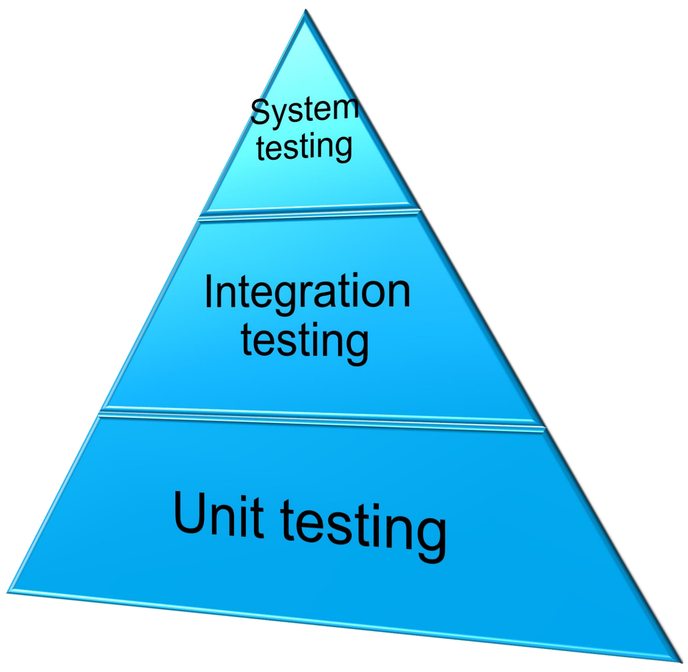
PLC system in test rig

EPICS modules

Unit tests for EPICS modules are developed in Python and seamlessly integrated into the ESS continuous integration process.

Hardware emulation eliminates the need for hardware dependency, ensuring that tests can run with every merge request.

Test results are stored for all historical builds, facilitating rapid identification of root causes for regressions and production environment issues.



Firmware

Firmware for field programmable gate arrays undergoes testing at the unit, integration, and system levels using various techniques.

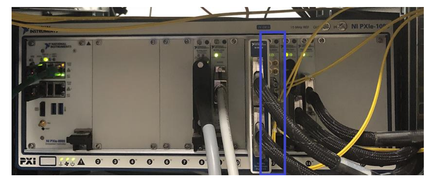
- Unit testing employs test benches with constraint-randomized test vectors for efficient function-level testing.
- Integration testing relies on hand-written test cases using register transfer languages like Verilog.
- System-level verification uses Python and pytest with emulated input data.

Test results are stored on a shared file server to ensure traceability.

Fast beam interlock system

The ESS Fast Beam Interlock System undergoes comprehensive testing using a hardware-in-the-loop test setup. This automated testing comprises thousands of test cases, ensuring extensive test coverage.

All test results are systematically stored to facilitate traceability and baselining.



Conclusions

Test automation is employed across various disciplines at ESS to mitigate the risk of regression.

The current direction is to expand test coverage while concurrently standardizing on Python-based test automation for most disciplines.

Acknowledgements

Zurich University of Applied Sciences for their contributions to the development of the Fast Beam Interlock system.

International Thermonuclear Experimental Reactor (ITER) for developing the EPICS OPCUA module.

Science and Technology Facilities Council for their contribution to the ESS readout master module for neutron detectors.