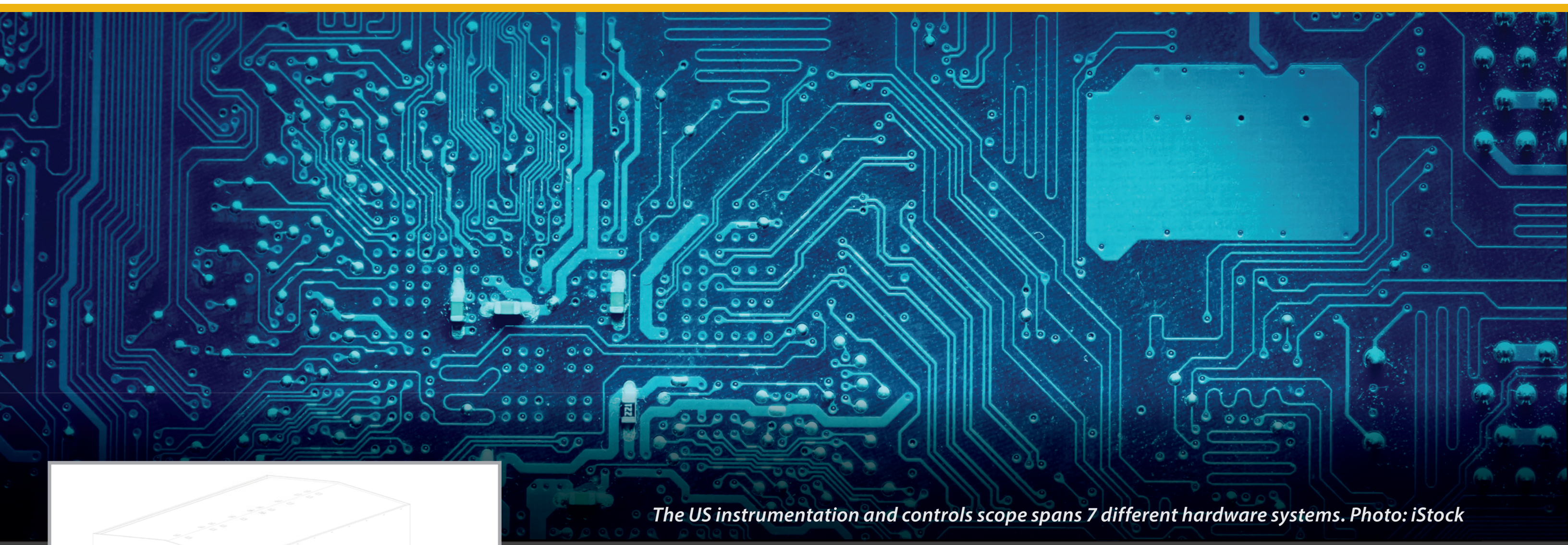
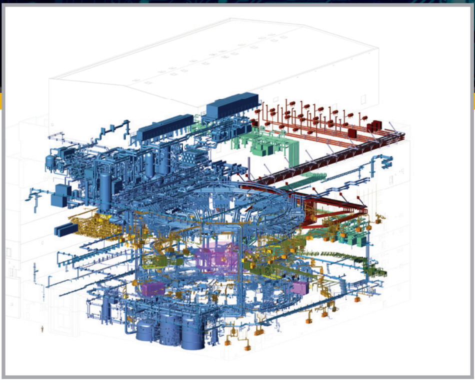
Instrumentation & Controls

www.usiter.org



The US instrumentation and controls scope spans 7 different hardware systems. Photo: iStock



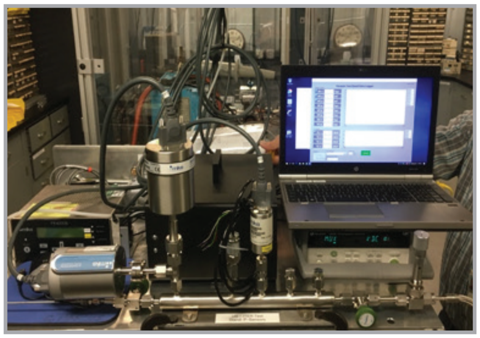
US ITER is responsible for providing instrumentation and controls for seven U.S. systems. Image: US ITER

US Contribution

US ITER is providing instrumentation and controls (I&C) for seven systems: the tokamak cooling water system, electron cyclotron transmission lines, ion cyclotron transmission lines, diagnostics, pellet injection, roughing pump systems, and vacuum auxiliary systems.

Overview

The work scope for instrumentation and controls includes conceptual, preliminary, and final design; software design; hardware and software procurement; equipment fabrication; and qualification and testing. Distributed real-time control of ITER plant systems is based on EPICS (Experimental Physics and Industrial Control System) for non-safety systems. Hierarchical control and exception handling is provided to the ITER Plasma Control System for control of plasma shape and kinetic parameters for electron cyclotron and ion cyclotron plasma heating systems, pellet injection, and disruption mitigation systems. Nuclear safety functions are based on the HIMA Planar4 logic solver contained within a cubicle assembly and qualified based on International Electrotechnical Commission (IEC) 61513 I&C safety lifecycle for nuclear power plants. All I&C equipment must be designed in compliance with the French Nuclear Safety Authority (ASN), including IEC and Institute of Electrical and Electronics Engineers requirements related to nuclear power plants as a nuclear licensed fusion reactor.

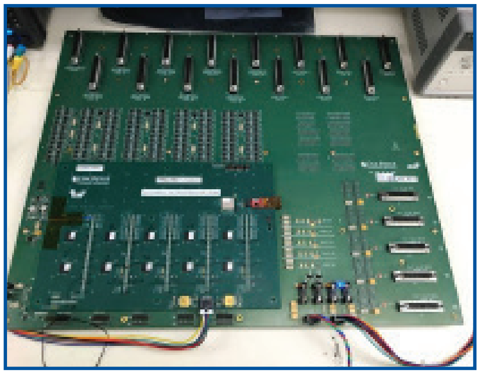


Pressure sensor electronics testing. Photo: US ITER

Status

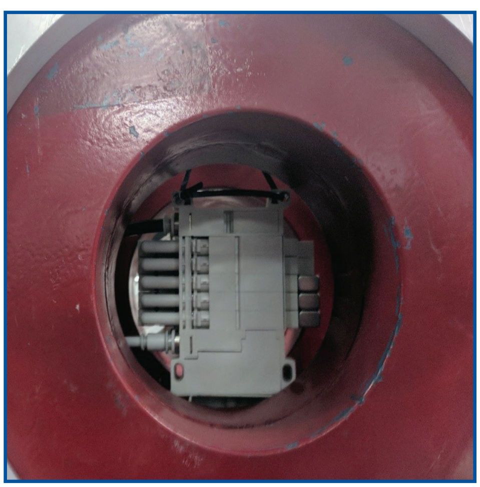
Instrumentation and controls for the cryo-guard vacuum system are in fabrication with the first delivery planned for 2024. For the service vacuum system, the final I&C design is complete and associated procurement activities have been initiated. The roughing pump I&C team has completed preliminary design of the cryogenic system and final design of the non-tritiated service vacuum system pumps and cryostat roughing and regeneration pumps. The preliminary I&C design for the vacuum auxiliary system supervisory control is in progress. The ion cyclotron heating transmission lines team has completed a final I&C design review for the radio frequency (RF) building.

US ITER Project Office • 1055 Commerce Park • Oak Ridge, Tennessee 37830-6483



Powered AFE-FEAC printed circuit board stack. Photo: US ITER

Control console and power supplies for Helmholtz coil arrangement. Photo: US ITER/ORNL



Solenoid valve manifold sandwiched between coil faces. Photo: US ITER/ORNL

Technical Description

Vacuum I&C: Scope includes the overall vacuum instrumentation and control system (VICS), and development of custom radiation-hardened electronics, as well as VICS-supervised I&C systems for the cryo-guard vacuum system, service vacuum system, electron cyclotron heating, ion cyclotron heating, and Type 2 diagnostics. These I&C systems span from conventional programmable logic controllers to custom electronics for high radiation/high magnetic field areas. The I&C systems monitor vacuum gauges and other instruments and actuate vacuum and gas-supply valves. For the roughing pumps system, more than 50 pumps of five different pumping technologies will be controlled and monitored.

Ion cyclotron heating I&C: Scope includes an interface to fast arc detection, real-time processing of a multi-variable state-space impedance control system to enable maximum radio frequency power transmission to the plasma, calorimetric measurements, and control of 124 water cooling loops and 14 gas cooling loops.

Electron cyclotron heating I&C: Scope includes fast arc detection, calorimetric power measurements, polarization control, data acquisition, and monitoring and control of 584 cooling loops for the 24 transmission lines for electron cyclotron heating.

Pellet injection I&C: Scope includes control of actuators and monitoring of gas and pressure sensors under real-time interaction with the ITER plasma control system.

Diagnostics I&C: Scope includes development of diagnostic of diagnostic residual gas analyzer readout system, development of custom impedance matching of quadrapole mass spectrometer radio-frequency controller to enable operation in high radiation environment, plus coordination of U.S. diagnostic infrastructure system architecture, common I&C solutions, and expert guidance on ITER standards and procedures.

Contributors include

Dynamic Structural & Materials (Franklin, TN): Design and fabrication of prototype custom radiation hardened piezo pilot valves

Hiden Analytical (Warrington, United Kingdom): Radiation hardened quadrupole mass spectrometer prototype development

Ohio State University (Columbus, OH): Neutron radiation test user facility

PMC Engineering (Danbury, CT): Radiation hardened piezo pressure transducer prototypes

VTI (Oak Ridge, TN): Fabrication and I&C procurement of the cryo-guard vacuum system

Claudell Harvey
US ITER Project Office
Manager, Instrumentation and Controls

Oak Ridge National Laboratory
harveycm@ornl.gov | 865-574-2138