INSTRUMENTATION ARCHITECTURE FOR ITER-DIAGNOSTIC NEUTRAL BEAM POWER SUPPLY SYSTEM

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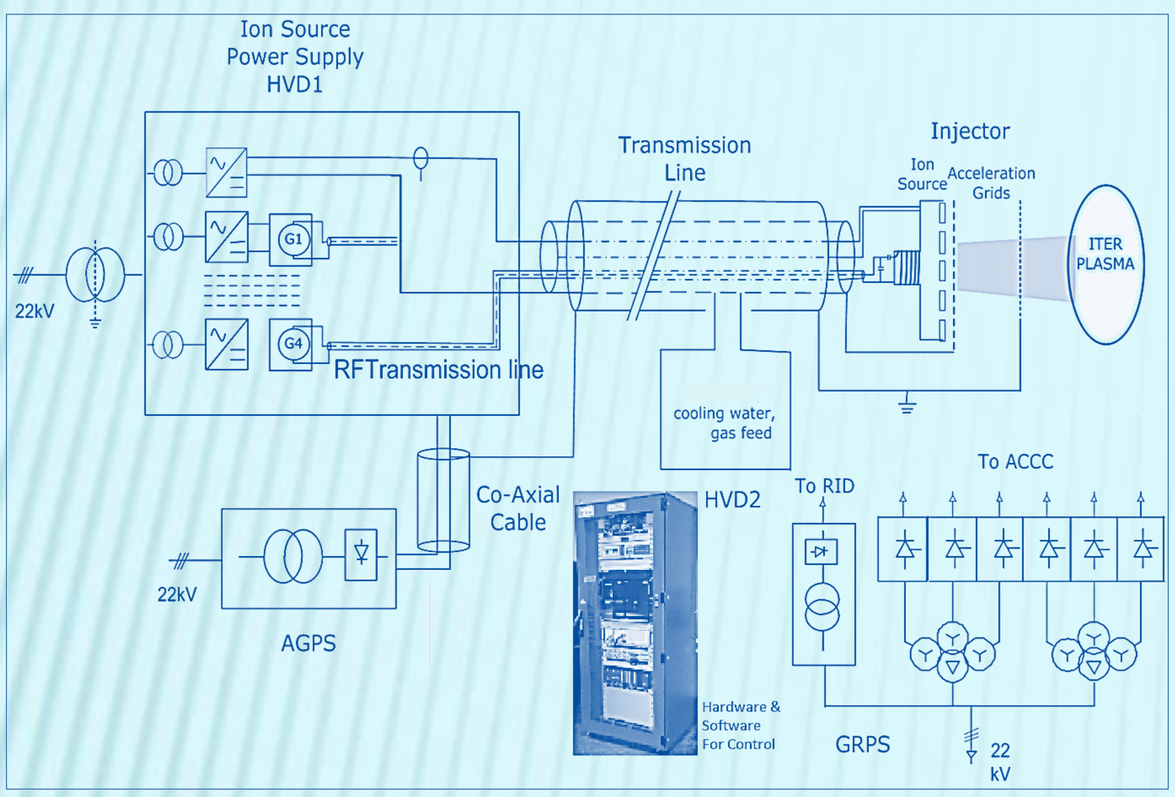
Introduction

Neutral Beam (NB) Injection system is used for heating or diagnostics of the plasma in a Tokamak. The Diagnostics Neutral Beam (DNB) system for ITER (International Thermonuclear Experimental Reactor) based on acceleration of negative ions; injects a neutral (H^o) beam at 100keV with specified modulation into the plasma for charge exchange recombination spectroscopy.

The DNB Power Supply system feeds the required controllable electrical power to the DNB beam source, the Residual Ion Dump and the Active Correction and Compensation coils. The system comprises of various high voltage, High Current power supplies and RF generators for plasma generation in the ion source, with integrated controllers.

DNBPS System Diagram



Instrumentation

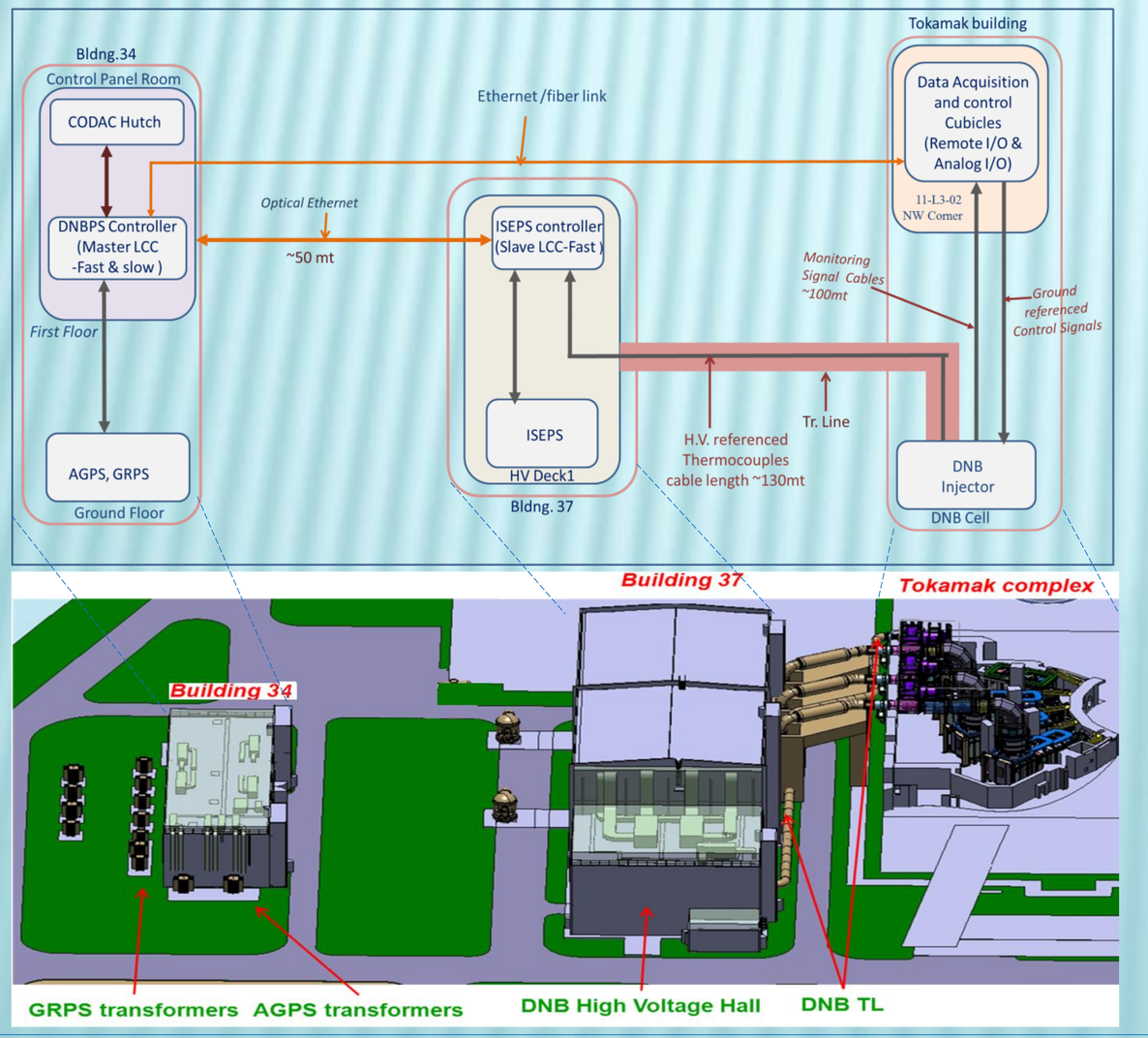
Instrumentation is to be provided to operate the DNBPS system remotely with required control and protection in synchronisation with ITER operation as directed by CODAC, central interlock system and central safety system . Instrumentation functionality includes ,

1. **Operation and control of DNBPS subsystems and associated auxiliaries**
2. **Protection of DNB components and power supplies using interlock system**
3. **To ensure safe operation of high voltage hazardous systems**
4. **Acquisition of injector performance parameters**
5. **To facilitate test and maintenance of individual subsystem**

Issues

1. **ISEPS controller to work on HV reference in presence of RF radiations from generators.**
2. **High Voltage Transients due to fast switch off of AGPS and EGPS during breakdowns.**
3. **Stray magnetic Field from Tokamak.**
4. **Instrumentation Design shall follow Applicable IEC standard 61000, 61158, 61508, 61511, 61069, 60709 and IEEE 802.3.**
5. **Power supplies and injector located at different and distant locations.**
6. **Tokamak Building with Nuclear Radiation demands transmission of sensor signals to remote safe location for acquisition.**

I&C Layout



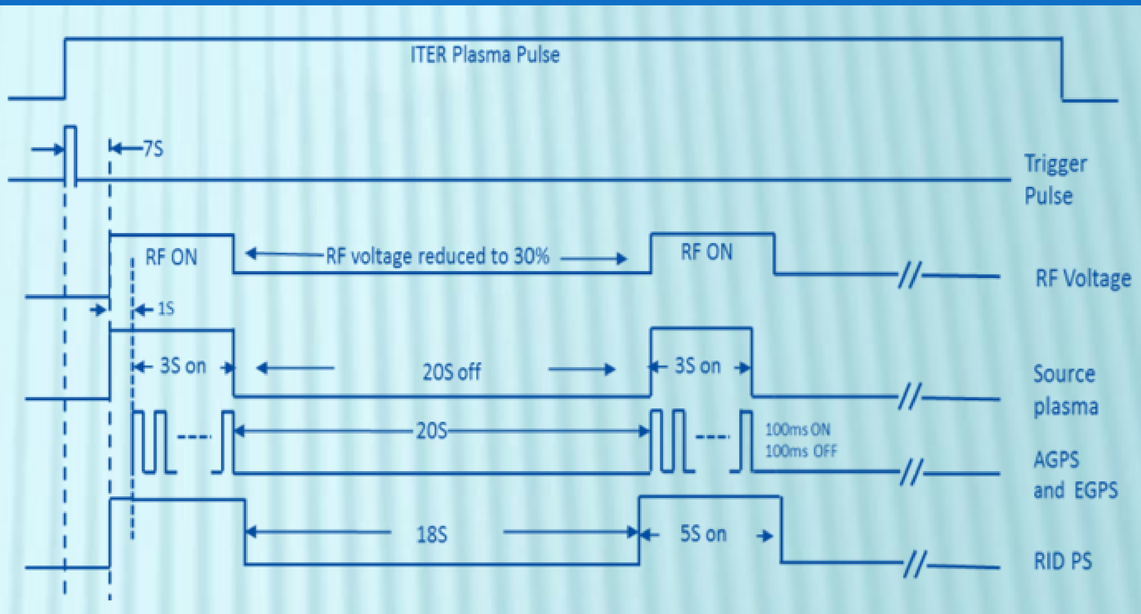
DNBPS Main Subsystems : Control, Measurement and Protection parameters

Sub Systems	Controlling parameter	Measurements	Protection events
Acceleration Grid PS (AGPS) 96kV, 75A	Voltage, Modulation	Voltage, Current, Cooling water parameters	Breakdown, Beam off, Failure in RID voltage, Short circuit at power supply end
Extractor Grid Power Supply (EGPS) 12kV, 140A	Voltage, Modulation	Voltage, Current , Cooling water parameters	Breakdown, Beam off, Short circuit at power supply end
Residual Ion Dump Power supply (RIDPS) 8kV, 60A	Voltage, Operation time	Voltage, Current, Cooling water parameters	Short circuit
RF Generators 4 X 200kW	Frequency, RF power, Modulation	Frequency, Phase, Power, Cooling water parameters	Break down, Beam off (Reduce RF power to notch level)
Active Correction Coil Power Supply (ACCPS) 1.4kV, 440A	Current	Current, Magnetic field around DNB cell, Cooling water parameters	Short circuit protection
Plasma Grid Bias Power Supply ; 30V, 600A	Current, Voltage	Current, Voltage, Cooling water parameters	Short circuit protection
Plasma Grid Filter Power Supply ; 15V, 4kA	Current, Voltage	Current, Voltage, Cooling water parameters	Short circuit protection
Cs oven	Shutter control, Temperature	Temperature	-

DNB Operations Sequence

1. **Preoperational preparation of different sub systems and auxiliaries.**
2. **To start beam operation, start different sub systems in a predefined sequence.**
3. **Modulate the beam using AGPS and EGPS, control beam energy and monitor performance.**
4. **Stop/Restart the beam.**

Operational Timing Diagram



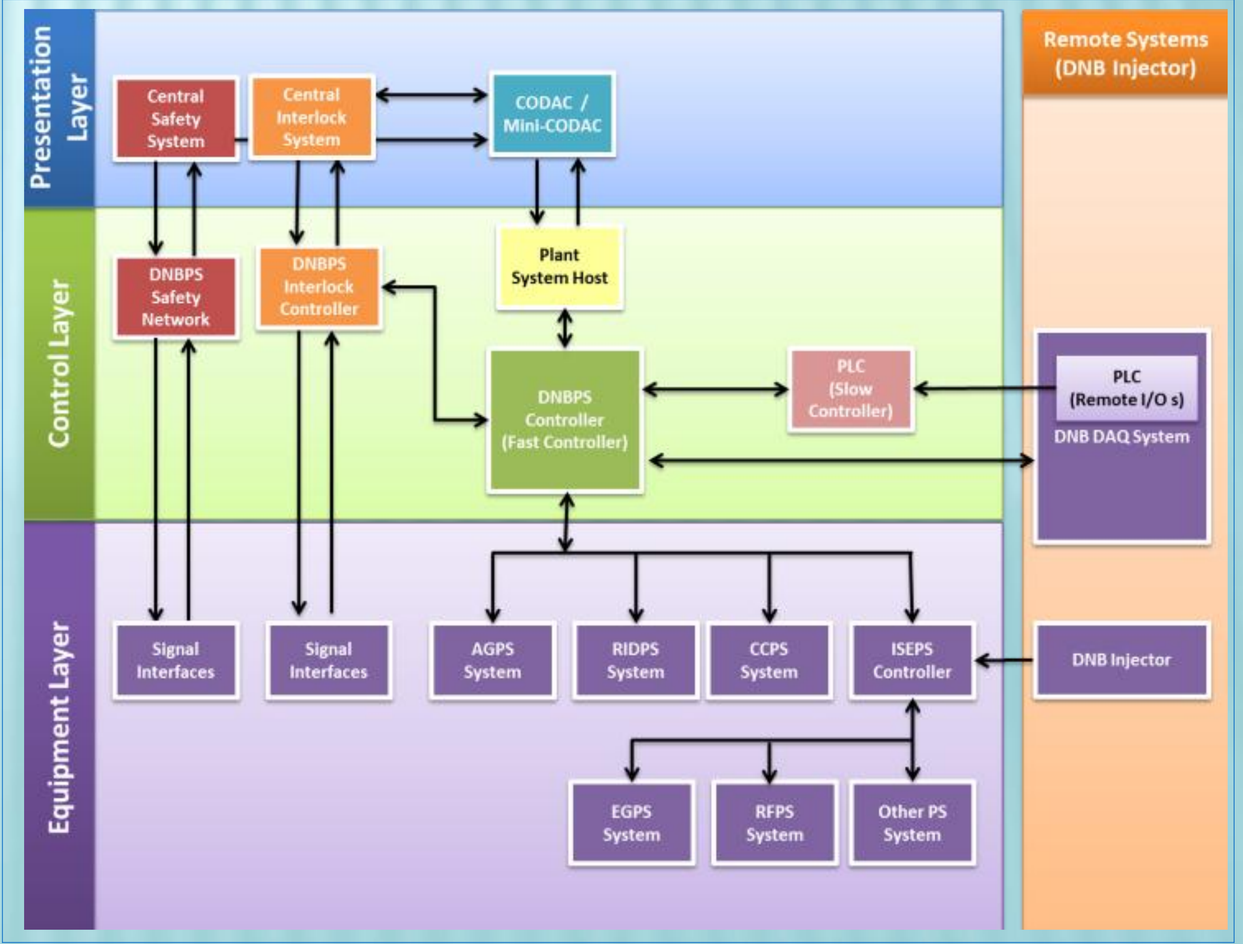
DNBPS Controller

The instrumentation design consists of,
1. Fast controller for control and data acquisition, runs with EPICS on Linux Platform.
2. Slow controller for control and data acquisition with SIEMENS S7 PLCs
3. Sensors, actuators and signal conditioning modules

Facilitates DNB operation in two different modes,
1. **Local operation: for testing of individual system (commissioning mode) and maintenance.**
2. **Remote operation: operation by central control system or CODAC in two different modes.**
   - **Beam interception on calorimeter (conditioning mode)**
   - **Beam injection into the Tokamak (injection mode)**

Status of DNB subsystems shall be monitored by CODAC through single point contact; i.e. DNBPS controller.

Interface with CODAC



REFERENCES
[1] R. Hemsworth et. al, Status of the ITER heating neutral beam system, Nucl. Fusion 49 (2009)
[2] Lennart Svensson et.al, Instrumentation and diagnostics for the ITER Neutral Beam System, Fusion Engineering and Design 86 (2011)

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