An environmental monitoring and control system for the ATLAS Outer Barrel QC and Integration

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1 – BACKGROUND

- ITk will be a major upgrade of the ATLAS detector[1]. It will consist of an inner pixel barrel, an outer pixel barrel with associated endcaps and a strip barrel with associated endcaps.
- The Outer barrel is composed of 4472 modules, distributed over 3 layers.
- The pixel modules are loaded on tiles (cells) which provide the modularity required for assembly and reworkability
- The loaded cells (cell + module) are mounted on two different flavors of "local supports" (LS), longerons and half rings
- QC tests will be performed on all the loaded local supports (LLS).
- Additional tests will take place at the integration stage.

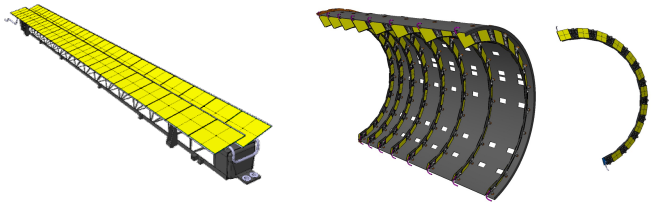

Figure 1: Local supports for the ITk pixel outer barrel. Model of longeron (left) and half shell / half ring (right).

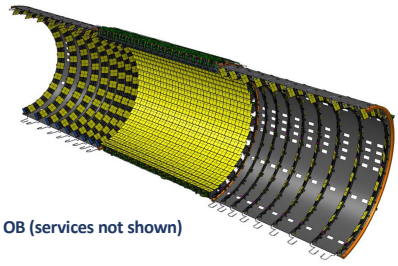

Figure 2: Half layer for OB (services not shown)

2 – DCS and Interlock requirements

To ensure the safe operation of the structures during testing, a dedicated DCS/Interlock system is required to implement the following features/characteristics:

- Monitoring and logging of environmental parameters of the test chamber
- Reliability
- Maintainability
- Scalability / Modularity

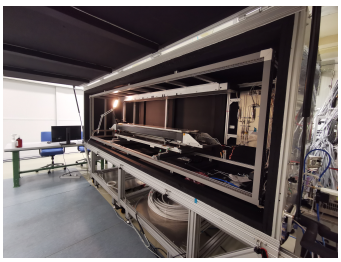

Figure 3: Test box for the OB demonstrator, operating under the same concept of the final test-boxes (currently being produced)

Sensor type	Q.ty	Signal	Range	Function
Door switch	4	DIGITAL INPUT	0-24V	Test box door status
Dewpoint sensor	2	ANALOG CURRENT	4-20mA	Test box environmental dew point
Flow meter	1	ANALOG CURRENT	4-20mA	Dry air flow in box
NTC RTD	18	ANALOG VOLTAGE	-50 - +100C	NTC on modules
PTC RTD	11	STD RTD	-100 - +100C	Inlet-Middle-Outlet of CO2 flow
LIGHT SENSOR	2	ANALOG CURRENT	0-60mA	Test box light tightness
PRESSURE SENSORS	2	ANALOG CURRENT	4-20mA	CO2 inlet/outlet pressure
Humidity sensor	2	ANALOG VOLTAGE	0-5V	Test box humidity
EMERGENCY BUTTON	2	DIGITAL INPUT	0-24V	Emergency shutdown
MODE SWITCH JUMPER	2	DIGITAL INPUT	0-24V	Switch panel mode longeron/half ring
CO2 PLANT STATUS	1	DIGITAL INPUT	0-5V	Check cooling plant general status
CO2 Plant FLOW MONITOR	1	ANALOG VOLTAGE		Monitor plant status

Table 1: list of inputs to the Interlock matrix / DCS

Signal name	Quantity	Signal	Range	Function
COOLING PLANT ENABLE	1	DIGITAL OUTPUT	0-24V	NOT(COOLING PLANT SHUTDOWN)
TRAFFIC LIGHT	1	DIGITAL OUTPUT	0-24V	Clear box open
PSU INTERLOCK	4	DIGITAL OUTPUT	0-5V	HV, LV, MOPS PSU, AUX PSU Interlock

Table 2: list of interlocked outputs

3 – Interlock Matrix

- Handling of operational criticalities:
  - CO2 – Cooling Dryout (loss of vapor quality)
  - Overtemperature (due to failing thermal interfaces of cooling issues)
  - Light penetration
  - Humidity / Dew point safe limits
  - Operator Error
  - Cooling plant anomalies

4 – A PLC based approach to interlocking and monitoring

- Development by CERN EP-DT-EO and DI
- Simatic S7 1500 PLC (Programmable Logic Controller)
- Multimodal configuration (LLS QC or integration mode)

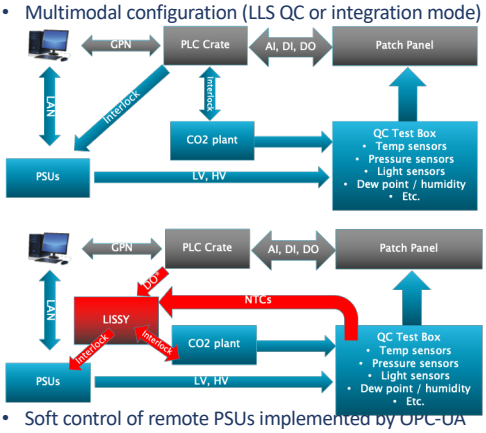

Figure 4: Block diagrams for LLS-QC mode (top) and integration mode (bottom). The Lissy is meant to provide interlocking over the NTCs embedded in the modules (thus bypassing the PLC). Analog Inputs (AI), Digital Inputs (DI) and Digital Outputs (DO) are interfaced to the PLC through a dedicated patch panel (see below).

- Soft control of remote PSUs implemented by OPC-UA
- Prototype produced. First production units expected in Q3/Q4 2022
- Lightweight version foreseen for OB loading and integration sites (cheaper CPU)

5 – Hardware implementation

- A PLC based implementation answers to requirements of reliability, scalability and maintainability
- Siemens S7 PLCs are the standard PLC in operation at CERN integrated in a standard 19" rack
- Custom patch panels and PCB interfaces for connection to the prototype

Figure 5: Left: PLC interlock unit. The back of the rack hosts signal conditioning cards and connectivity to patchpanels. Right: Excitation sources and interface PCBs for prototype connectivity

6 – Software interface implementation

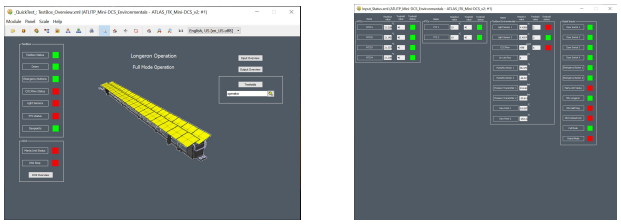

Figure 7: WinCC OA Scada interface for monitoring of environmental parameters and status of the unit under test.

References:
[1] ITk TDR (https://cds.cern.ch/record/2285585?ln=en

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