ICD between BLMs and the FBIS

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TABLE OF CONTENT **PAGE**

1. SCOPE

This Interface Control Document (ICD) encompasses the definition, documentation, and control of all interfaces between Beam Loss Monitors (BLMs) and the Fast Beam Interlock System (FBIS). This ICD contains a short description of the purpose of the interface and a functional, mechanical and electrical description of the interfaces.

2. ISSUING ORGANISATION

Integrated Control Systems - Protection Systems

3. CONTEXT

One of the proton beam instrumentation systems to be operated at the ESS linac is the Beam Loss Monitoring (BLM) system. Its primary goal is to detect abnormal beam behaviour and promptly inhibit beam production in case of beam failures in order to keep the machine safe from beam-induced damage. In addition to the protection functionality, the system is expected to provide the means to monitor the beam losses during normal operation with the aim to avoid excessive machine activation.

The ESS BLM system is divided in 3 sub-systems based on the detector technology:

- Ionisation Chamber based BLM (icBLM),
- Advanced BLM (cBLM),
- Neutron sensitive BLM (nBLM).

The first two BLM types mentioned above are based on charged particle detection and will be primarily located in the superconducting (SC) sections of the ESS linac. However, the expected particle fields outside the tanks in the normal conducting (NC) parts of the ESS linac are expected to be dominated by neutrons and photons. Thus, neutron sensitive detectors are needed in these sections [1].

The FBIS will interface the icBLMs and the nBLMs and stop the proton beam in case losses above acceptable levels are detected.

4. EXCHANGED SIGNALS

The exact specifications of the discrete signals and the datalink will be finalized and included in the coming revision.

4.1. Beam Permit – discrete signal

The Beam Permit is calculated by the “BLM protection block” which assesses whether the conditions to inhibit beam production have been met. In case they have, the block sets the BEAM_PERMIT signal to “not OK” on the line connected to the FBIS through the FBIS interface. The FBIS then further handles stopping of the beam production. Each AMC

provides one aggregated BEAM_PERMIT signal independent on the number of detector channels connected to it. The AMC BEAM_PERMIT calculation starts with evaluating the BEAM_PERMIT for each channel separately, BEAM_PERMITc (c runs over all channels on the AMC). This is performed by checking if the beam stop condition on each particular channel has been reached. The final BEAM_PERMIT is then determined by AND-ing the BEAM_PERMITc of all channels that are not masked out from the calculation.

Each AMC has to duplicate its BEAM_PERMT signal inside the FPGA to send it on the 2 redundant connections provided by the FBIS interface.

4.2. READY – discrete signal

This signal is set to “not OK” whenever the system is not ready to protect the machine. Currently the only potential usage for this signal is during the start up periods when system is collecting enough statistics for the user to check and/or set proper settings for the system. The gas status is not planned to be part of this signal due to the very slow evolution time (hours) of a gas failure. The READY signal is continuously transmitted to FBIS through "Ready to Protect" block.

Each AMC has to duplicate its READY signal inside the FPGA to send it on the 2 redundant connections provided by the FBIS interface.

4.3. Datalink

The Datalink transmits the discrete signals redundantly and some additional information.

- Redundant BEAM_PERMIT signal.
- Redundant READY signal.
- Current Beam Mode and Beam Destination configured into the processing card (or as received from EVR.
- Health status of the link, which is used by the FBIS to diagnose the problems in connection between the FBIS and the processing card. The health status is simply an 8 bits counter (from 0 to 255)
- AMC health status indicating the status of the data processing running on the AMC in question (see 6.2.10) [1].

5. BLM ELECTRONICS

The BLMs will have front-end electronics (FEE) in the tunnel connected to back-end electronics (BEE) in the Klystron gallery. The BEE are based on IOxOS IFC1410 AMC boards which has two FMC slots, see Figure 1

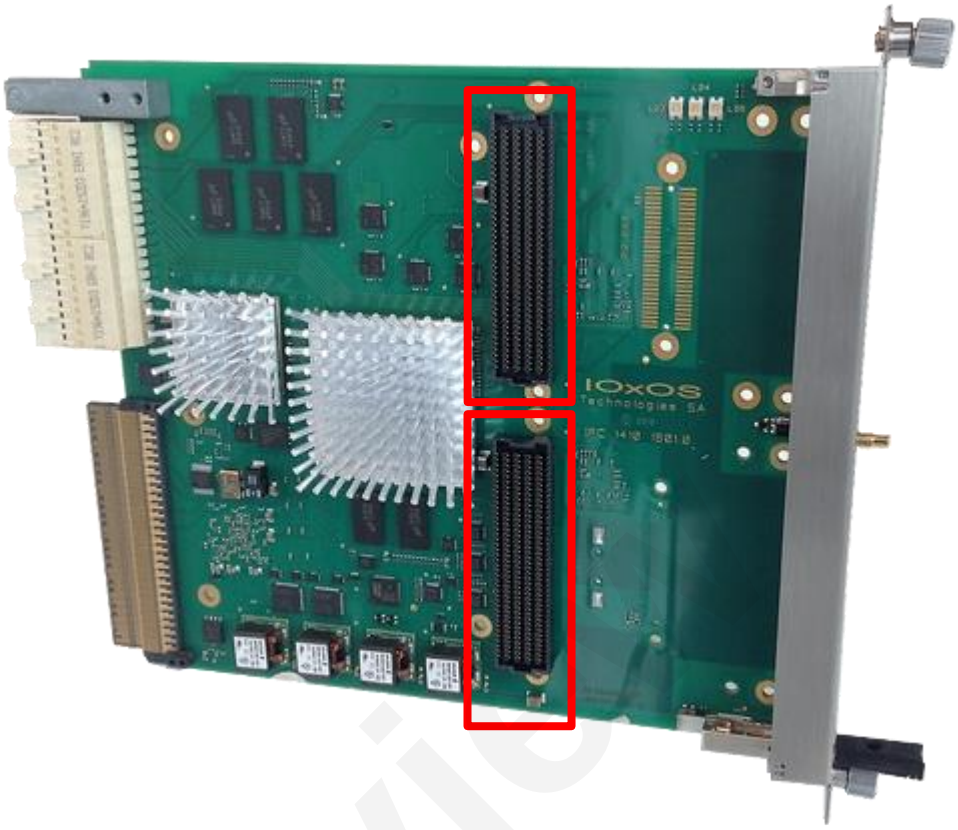

Figure 1: IFC_1410, the two FMC slots are marked with red rectangles [2].

5.1. nBLMs

For nBLMs one of the FMC slots will be occupied by a DC coupled 8 channel ADC (IOxOS ADC3111 FMC board) which will be used to digitize the signal from the FEE. The other one will be unoccupied [1].

5.2. icBLMs

For icBLM, a pico4 card (4 channels) is selected as the acquisition unit, i.e. both FMC slots will be occupied [3].

6. FINAL INTERFACE

All BLM subsystems are required to use the same FBIS hardware interface options and be able to process up to 8 detector channels [3]. Since the RTM is the only option for the icBLMs, the RTM solution has been selected.

An RTM is being developed by PSI for the IFC 1410. The FBIS interface will be implemented by a piggyback board on the RTM. The FBIS piggyback is foreseen to have one RJ50 (for the discrete Beam Permit and Ready signals) and one RJ45 (for the datalink) connector [4].

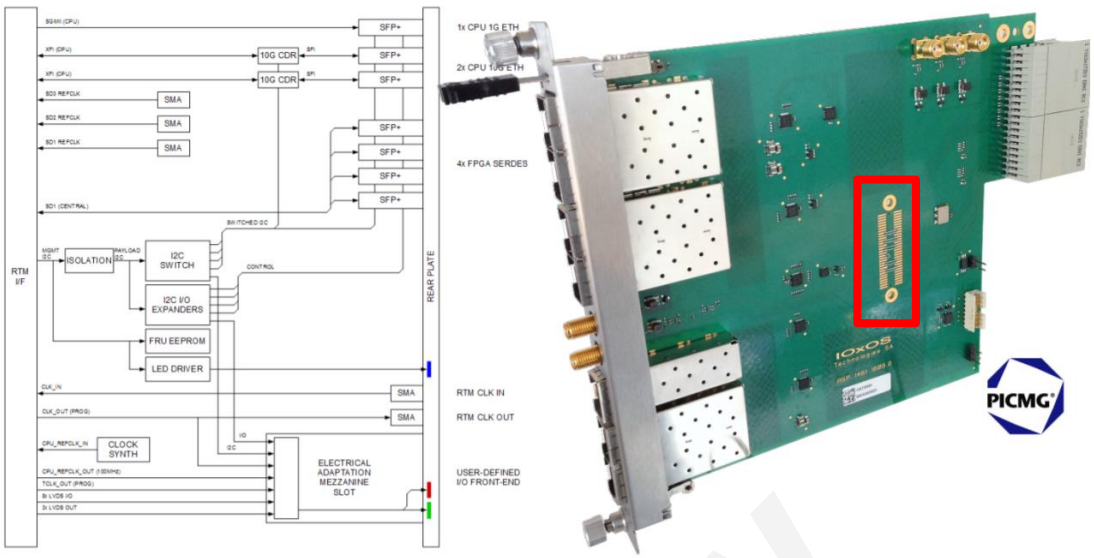

Figure 2: A RTM (RSP_1461) similar to the one being developed showing the same type of interface that will be used for the piggyback, the interface is marked in red [5].

7. INTERMEDIATE INTERFACE

However the RTM card is currently still under development and is anticipated to be available only in September 2019. Therefore a solution based on the IOxOS DIO3118 FMC has been foreseen as an intermediate solution for test purposes, though this option does not fulfil the FBIS interface requirements [3].

Reasons for intermediate interface:

- The icBLM don't need to use the 2 FMC slots of the AMC this year, so one of the 2 FMC slots is free for the FBIS connection.
- The FMC is used because the RTM is not ready. When the RTM will be available (before the end of the year), the second FMC slot will be free for BI use.
- The IOxOS DIO3118 DIO FMC is used since the piggy back is not ready. When the Piggy back will be designed, it is possible to use it instead of this FMC on the AMC.

Figure 3: IOxOS DIO3118 DIO FMC board [6].

8. LIST OF INTERFACES

This chapter lists all the PBI racks and FBIS racks which will be used for the interfaces between BLMs and the FBIS. Information marked in red is not fixed yet.

8.1. nBLMs

Table 1: List of interfaces for nBLMs

Section	Detector count	AMC count	Crate count	PBI Rack	MPS rack
MEBT/ DTL/SPK	24	**4**	2	FEB-050Row: CnPw-U-012	ISrc-010Row: CnPw-U-005
MEBT/ DTL/SPK	22	**4**	2	SPK-010ROW: CnPw-U-018	SPK-010ROW: CnPw-U-007
MEBT/ DTL/SPK	14	**3**	1	SPK-030ROW: CnPw-U-018	SPK-020ROW: CnPw-U-005
MEBT/ DTL/SPK	12	**2**	1	SPK-050ROW: CnPw-U-018	SPK-040ROW: CnPw-U-005
MB	2	**1**	1	MBL-050ROW: CnPw-U-018	MBL-050ROW: CnPw-U-004
HB	2	**1**	1	HBL-090ROW: CnPw-U-018	HBL-080ROW: CnPw-U-004
A2T	2	**1**	1	HEBT-030ROW: CnPw-U-003	HEBT-030ROW: CnPw-U-007
A2T	4	**1**	1	A2T-010ROW: CnPw-U-005	A2T-010ROW: CnPw-U-008

8.2. icBLMs

Table 2: List of interfaces for icBLMs

Section	Detector count	AMC count	Crate count	PBI Rack	MPS rack
	7	**1**		SPK-010ROW: CnPw-U-018	SPK-010ROW: CnPw-U-007
	20	**3**		SPK-030ROW: CnPw-U-018	SPK-020ROW: CnPw-U-005
	26	**4**		SPK-050ROW: CnPw-U-018	SPK-040ROW: CnPw-U-005
	20	**3**		MBL-020ROW: CnPw-U-018	MBL-020ROW: CnPw-U-004
	16	**3**		MBL-050ROW: CnPw-U-018	MBL-050ROW: CnPw-U-004
	16	**3**		MBL-090ROW: CnPw-U-018	MBL-090ROW: CnPw-U-004

	16	**3**		HBL-050ROW: CnPw-U-016	HBL-040ROW: CnPw-U-003
	16	**3**		HBL-090ROW: CnPw-U-018	HBL-080ROW: CnPw-U-004
	16	**3**		HBL-120ROW: CnPw-U-018	HBL-120ROW: CnPw-U-004
	19	**3**		HBL-160ROW: CnPw-U-018	HBL-160ROW: CnPw-U-004
	15	**3**		HBL-200ROW: CnPw-U-018	HBL-200ROW: CnPw-U-003
	14	**2**		HEBT-010ROW: CnPw-U-001	HEBT-030ROW: CnPw-U-007
	33	**5**		HEBT-030ROW: CnPw-U-003	HEBT-030ROW: CnPw-U-007
	32	**6**		A2T-010ROW: CnPw-U-005	A2T-010ROW: CnPw-U-008

9. GLOSSARY

Term	Definition
ADC	Advanced Data Connector
AMC	Advanced Mezzanine Card
BEE	back-end electronics
BLM	Beam Loss Monitoring
cBLM	Advanced BLM
EVR	Event Receiver (part of the Timing System)
FBIS	Fast Beam Interlock System
FEE	front-end electronics
FMC	FPGA Mezzanine Card
icBLM	Ionisation Chamber based BLM
ICD	Interface Control Document
nBLM	Neutron sensitive BLM
PSI	Paul Scherrer Institut
RTM	Rear Transition Module

10. REFERENCES

[1] nBLM specification (BIG-1245)

[2] https://www.ioxos.ch/produit/ifc_1410/ 2019-02-04 10:32
[3] Requirements and Technical Specifications - ESS icBLM System (BIG-1247)
[4] Specification document for a RTM compatible with AMCs supporting D1.4 class – ESS-0459017
[5] https://www.ioxos.ch/produit/rsp_1461/ 2019-02-04 10:32
[6] https://www.ioxos.ch/produit/dio_3118/ 2019-02-04 10:32

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue <<Keep only full number revisions when approving document>>	Szandra Kövecses	2019-02-05