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MPS COMMISSIONING PROCEDURE

MPS Commissioning Aspects of the Beam Presence Flag (BPF) System

ABSTRACT:

This document describes commissioning procedures for the **LHC Beam Presence Flag (BPF) system**.

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1. INTRODUCTION

Before injecting any high intensity bunches into the LHC a single circulating low intensity pilot bunch must be present to confirm the correct settings of the main machine parameters. The detection of such a pilot bunch is performed by the Beam Presence Flag (BPF) system providing logic signals to the Machine Protection System (MPS), which in turn enables high intensity injections. The PBF system features quadruple redundancy and is based upon beam signals from beam position monitors (BPM), whose position sensitivity is supressed by combining signals of the opposing electrodes. In order to maximise the reliability, the system architecture is very simple and its only inputs are the beam signals. Furthermore, the BPF front-ends do not have any remote control, programmable or adjustable elements. The front-ends have two redundant power supplies optimised for high reliability operation. The BPF system has been operational since 2011 run [1, 2] with no single hardware or operational fault to date.

2. SCOPE

This document covers the tests which will be performed to validate for operation all the components of the BPF system in relation with the MPS for both LHC beams. The tests cover all the components of the BPF system and its connections to the MPS.

3. PURPOSE

This document describes the procedures concerning the tests and their sequence, related to the participation of the BPF system in the MPS.

Each described test has in front at least one of the letters listed in Table 1. The letters specify at which interval, or at which occasion the described test needs to be repeated.

Table 1: Labelling of the tests repetition

Label	Repetition
S	To be repeated after every **s**hutdown
E	To be repeated after **e**nd-of-year stops
C	To be repeated after any significant **c**hange in the system
I	To be repeated after every **i**njection of the first pilot bunch
D	To be repeated after every beam **d**ump

This document is meant to be the reference document for the checklist, which will be used during the commissioning of the MPS.

All test results are reported by logged logic signals of the BPF system. The system does not provide any other signals neither for diagnostics nor operation.

4. THE LAYOUT

The whole BPF system consists of eight systems, four redundant systems per either of the LHC beams, as shown in Fig. 1 with the system block diagram. The systems are referred to as H1.B1, H2.B1, V1.B1 and V2.B1 for LHC Beam 1 and H1.B2, H2.B2, V1.B2 and V2.B2 for LHC Beam 2.

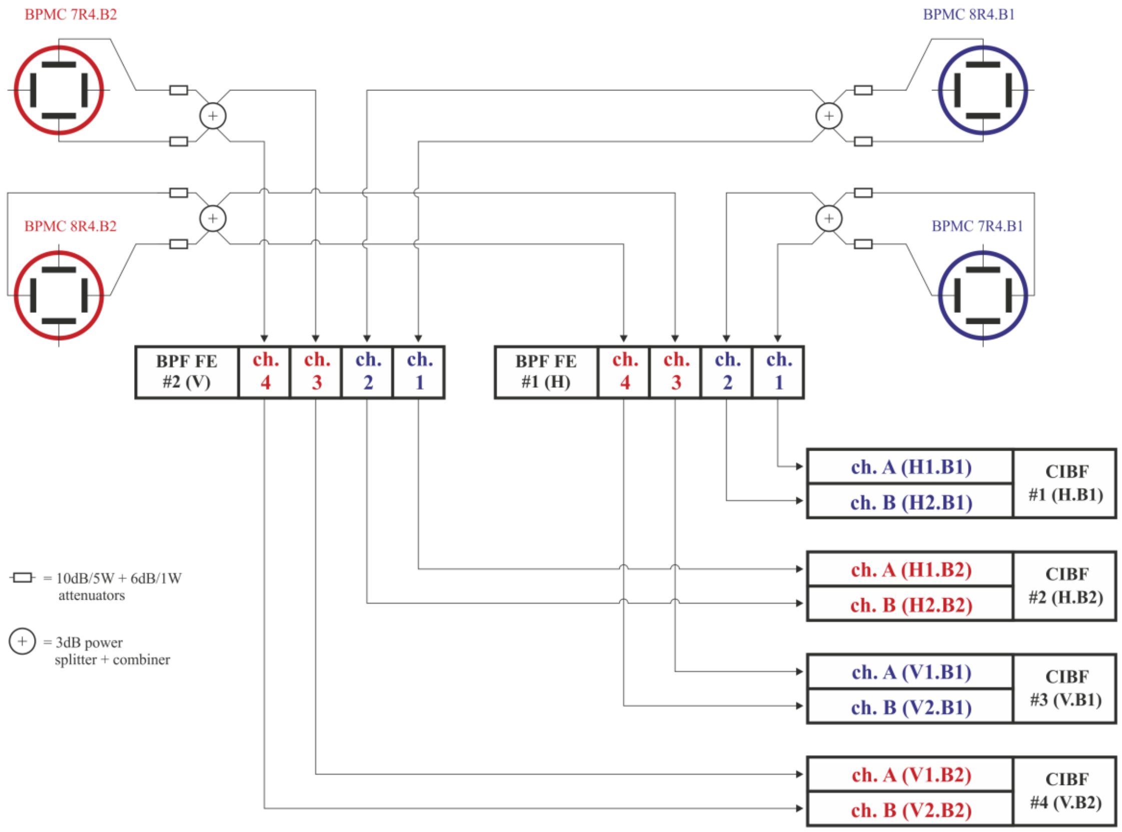

Fig. 1: A block diagram of the LHC BPF system with quadruple redundancy.

The eight systems use signals from the following BPMs:

- BPF systems H1.B1 and H2.B1: the horizontal plane of BPMC 7R4.B1
- BPF systems V1.B1 and V2.B1: the vertical plane of BPMC 8R4.B1
- BPF systems H1.B2 and H2.B2: the horizontal plane of BPMC 8R4.B1
- BPF systems V1.B2 and V2.B2: the vertical plane of BPMC 7R4.B1

The BPMs used by the BPF system are shared with the transverse damper system. The damper system uses the remaining BPM planes with favourable beta functions, which are of no relevance for the BPF system.

BPM electrode signals are first attenuated to limit the power dissipated in the following RF processing chain, in order to increase the system reliability. Next the signals from the opposing electrodes are combined to supress their dependence upon the beam position and then split to feed two inputs of either BPF front-end. In the front-ends the beam signals undergo entirely analogue processing [3], whose results are two complementary beam presence logic signals for each front-end channel, transmitted as currents to a CIBF module providing the interface to the MPS.

Amplitudes of the BPM signals are adjusted with the input attenuators in such a way that the BPF system generates transition from the logic TRUE to FALSE for one pilot bunch of intensity about $2{\times}10^9$ charges, referred in this document as the nominal threshold level. The front-ends feature a hysteresis to prevent their logic signals from flickering.

Details of the design and operation of the BPF front-ends can be found in [3], along with measurements assessing their performance.

5. TESTS PERFORMED DURING THE HARDWARE COMMISSIONING

The BPF system is bult upon two four-channel BPF front-ends and four two-channel CIBF interfaces. Each module is tested for its full functionality in the laboratory prior to its installation in rack BY08 located in LHC alcove UA47. The system is designed to be very simple and reliable to the extent that its full functionality can be checked only with beam signals. During hardware commissioning it is only verified that both redundant power supplies of each of the six modules of the system are powered. This is done by visual inspection of the system rack and checking that all power indicators are lit.

6. LINK TO OTHER EQUIPEMENT

This chapter considers only aspects of the BPF system related to MPS.

6.1 INTERFACES WITH THE BEAM INTERLOCK SYSTEM

The interface with the BIS is described in more detail in the corresponding test specification [4] and shall be tested within the scope of the BIS tests.

6.1.1 SIGNALS BETWEEN THE BPF SYSTEM AND BEAM INTERLOCK SYSTEM

Each of the eight BPF systems is linked to the MPS via a CIBF channel and is connected to a maskable input. The BPF front-ends do not use Beam_Info signal from the CIBF module.

6.2 CONDITIONS AND SEQUENCE FOR CHANGING THE SYSTEM STATE

The BPF USER_PERMIT (see Fig. 2) of any of the eight systems is set to TRUE if:

- The system detects at least one circulating bunch of intensity above the system threshold level, which is about 2×10^9 charges.

The BPF USER_PERMIT of any of the eight systems is set to FALSE if:

- The system does not detect any circulating bunches with intensity above the system threshold level of about 2×10^9 charges.

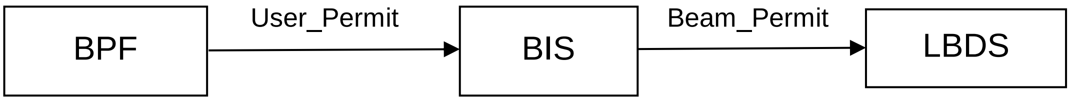

Figure 2: Schematic view of the signal flow for the User_Permit and Beam_Permit.

Please note that the system state transitions from FALSE to TRUE and TRUE to FALSE feature a small hysteresis to prevent the system state from flickering. Furthermore, to increase the system operational reliability, the system response for detecting a circulating bunch is almost three orders of magnitude longer (≈ 200 ms) than detecting the contrary situation (≈ 300 μs), with no circulating bunches with the intensities above the nominal threshold level [3].

7. SYSTEM TESTS DURING THE MACHINE CHECKOUT

As the BPF front-ends do not have any remote control, no tests are performed on the system during the machine checkout.

8. TESTS WITH BEAM

Proper operation of the BPF system can be monitored at every injection of the first pilot bunch and every dump. Only when the system undergoes significant changes it is required to test the intensity levels at which the systems change their state from TRUE to FALSE.

8.1 CONDITIONS REQUIRED TO PERFORM TESTS

- All system modules operational.
- MPS operational.

8.2 DESCRIPTION OF THE TESTS

Each test shall be done in parallel for all four BPF systems of either beam.

8.2.1 TESTS WITH ONE PILOT BUNCH

The tests described in this section should be done with a single pilot bunch with the intensity at least 3×10^9 charges, that is 50 % above the nominal system threshold level of 2×10^9 charges.

#	Rep.	Action
1	SEC	Check that the beam presence flag changes the state from FALSE to TRUE once the pilot bunch is injected.
2	SEC	Dump the beam and check that the beam presence flag changes the state from TRUE to FALSE.
3	C	Inject one pilot and scrape the intensity down so that all PBF systems change the state from TRUE to FALSE at the intensities about 2×10^9 charges. All the changes should have just one transition, with no flickering.

8.2.2 TESTS WITH BEAM AT EVERY PILOT INJECTION

Proper operation of the BPF system is monitored every beam injection.

#	Rep.	Action
1	I	Check that at the injection of the first pilot bunch with the intensity above the nominal system threshold level all the BPF systems change their state from FALSE to TRUE.

8.2.3 TESTS WITH BEAM AT EVERY BEAM DUMP

Proper operation of the BPF system is monitored at every beam dump.

#	Rep.	Action
1	D	Check that after the beam dump all the BPF systems change their state from TRUE to FALSE if before the dump there was at least one circulating bunch with the intensity above the nominal threshold level.

8.3 STATUS OF THE SYSTEM AFTER THE TESTS

After these tests with beam, the BPF system can be used as an LHC machine protection system.

REFERENCES

[1] B. Todd, M. Gasior, "Safe Machine Parameters System - Beam Presence Flag", LHC-OP-MPS-0015, EDMS 1079954.

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[3] M. Gasior, T. Bogey, "The LHC Beam Presence Flag System", CERN-BE-2011-026.

[4] B. Todd, B. Puccio, "MPS Aspects of the Beam Interlock System Commissioning", LHC-OP-MPS-004.