|  |
| --- |
|  |
|  |
|  |
|  |
|  |
|  |
|  |
|  |
|  |
|  |
|  |

|  | Name | **Role/Title** |
| --- | --- | --- |
| **Owner** | Andreas Jansson | Review Secretary |
| **Reviewer** | Manfred Wendt | External Reviewer |
| **Approver** |  |  |

**MEBT Strip-line BPM CDR**

**24October 2017**

**Report**

**Committee:**

*Present at the review:*

Manfred Wendt, CERN (external reviewer)

Andrei Shishlo, ORNL (external reviewer)

Simone Scolari, ESS Vacuum

Andreas Jansson, ESS BI (review secretary)

Edgar Sargsyan, ESSLinac

Thomas Shea, ESS BI

**General:**

Critical Design Review of the ESS MEBT BPM Pickup design.

The agenda, presentations and supporting documentation can be found on the Indico page <https://indico.esss.lu.se/event/845/>

**Findings (Summary)**

A strip-line type beam position monitor (BPM) pickup was selected as optimal design choice, to meet the tight real-estate requirements in the MEBT, while supplying sufficient signal levels and position sensitivity under all operational conditions. Some details of the manufacturing process and preliminary mechanical and electrical measurements of a prototype have been presented, trying to enable the full production quantity of 8+1 BPM.

Unfortunately, the prototype BPM does not meet minimum requirements, a feedthrough broken during the welding procedure prevented a thorough leak test

A: The feedthrough did not break during welding, but during ancillary dis-assembly. Leak tests were performed during the different stages (see documentation MEBT-BI-BP93-01). Only last vacuum test was missing.

Moreover, some important electrical characteristics have not measured in a way that theperformance of the BPM pickup can be judged. At this stage of the prototype results it would be overly risky to give the go ahead to produce the full production quantity. Instead, a more detailed analysis of the welding assembly and the related mechanical construction details, preferable with help of an experienced, external expert is highly recommended.

A: Neither welding assembly procedure nor mechanical construction details were part of the CDR data package. And it was not under revision.

**Answers to review questions:**

*1. Does the design fulfil all requirements and respect all interfaces, and is the design sufficiently mature and level of documentation appropriate to start manufacturing/procurement?*

Unfortunately, no! The prototypestrip-line BPM revealed substantial welding issues, causing a feedthrough to break. These issues may be originated by underlying mechanical constructions problems, the details need to be worked out.

A: We believe the **DESIGN** *fulfils all requirements and respect all interfaces. In fact a prototype was presented to show the maturity of the design. And to show that* we are aware of the issues and already working on them.

*2. Is the planning appropriate and consistent with the overall ESS plans and milestone?*

The strip-line BPM production schedule presented would meet the MEBT beam commissioning milestone in 1Q 2019. However, the presented schedule does not reflect the problems and delays experienced during the assembly of the prototype, also no solution details for these issues have been provided. In short words, the assembly of a first, not functional prototype took about 12 month, while only a 9-monthproduction schedule is foreseenfor manufacturing and testing 8+1 strip-line BPMs, that looks pretty unrealistic.

A: We believe the time required to optimise welding machine parameters, optimization of ancillaries and different toolings, reception commercial pieces, acceptance test procedures is an investment. Once these are well known, the time required for the actual manufacturing (welding and testing) shall be substantially reduced.

*3. Is the verification strategy appropriate?*

A verification strategy for production was not presented.

A: Please read the data package reports(MEBT-BI-BP93-01) and presentation. Verification strategy is presented in the page 26 for Prototype and final series.

*4. Have reliability aspects been considered in the design choices?*

Reliability aspects have been only briefly discussed. The thermal investigation presented could not verify a reliable operation of the BPM under thermal stress as there was no before / after leak check of the feedthroughs performed.

A: This is not part of the requirements. Our purpose was to show the s-parameters sensitivity to temperature. Reliability aspects were presented in the PDR presentations.

*5. Were any other issues identified during the review?*

The discussion was focused on construction and assembly details between feedthrough and strip-line. The design foresees a ceramic spacer which was questioned in terms of vacuum (virtual leaks), electrical (impedance matching), and mechanical (uncontrolled stress during welding).

On the more general view, the choice of strip-line type BPM vs. a button type BPM was brought up, with different opinions on performance and integration aspects, see also the comments below.

A: Construction and assembly details between feedthrough and strip-line was not part of the scope of review, if that would be the case, mechanical personnel would have participate.

**Comments:**

* The presented comparisons to button-style BPMs using beam simulations do not include all possible versions of button BPMs.(A: based on the current design of quadruple and physical constraints, we provided a comparison analysis between stripline and button. Every design must consider the mechanical limitations, MEBT beam parameters and the requirement for electronics. This was part of PDR)
* The S-parameter measurements have not been verified by EM simulations.
* Details on the welding procedure have not been presented, therefore it is difficult to understand the issues. Thegeometry looks over constrained, causing stress on the feedthrough ceramics during the welding procedure. The function of the cylindrical ceramic spacers also remains unclear, very similar constructions, e.g. at CERN (LHC) don’t use them.(A: Ceramic spacer has been used to secure the distance between strip and wall. This method is used also in J-parc MEBT striplines.)
* There is no sliding contact at the tip of the feedthrough pin, therefore temperature differences between body and strip-line will cause unwanted stress on the feedthrough.(A: That is very good idea, but in that case we would lose the positioning and precision)
* Metrology requirements and results from the prototype have not been presented.(A: They are stopped due to problem of one strip during dis-assembly of ancillaries)

**Recommendations:**

* The mechanical construction, and in particular the welding procedure should be reviewed by an experienced, external expert, e.g. S. Vilcins (DESY), Ch. Boccard (CERN).
* After welding, a vacuum leak test should be the next verification step in line! (A: in every step during welding the vacuum leak test has been in plan. Please read the documentation, MEBT-BI-BP93-01)
* The distance between strip-line and housing (ground) is critical. A broadband (18 GHz) step function TDR analysis of each strip before and after welding will directly show characteristic impedance vs. distance and immediately discover problems with tolerances and deformations. (A: we have used the s-parameters measurement for this purpose and found to be Ok. However our network analyzer does not provide TDR analysis)
* S-parameter measurements between strip-lines need to be supported by EM simulations to demonstrate how well the electromagnetic behavior is understood and that it meets the requirements.(A: It will be considered during final 8 striplines delivery documentation, however the goal is to produce the strip-lines which meet the requirements which are indicated in the agreed specification document)
* A production of the series is not recommended before the mentioned issues are not fully understood and mitigated.(A: Ok. But please consider there is high risk of delays)
* As of the tight schedule, a button-style BPM alternative for the MEBT should be investigated as plan B.(A: We support the idea of modification of fabrication process of stripl-line as plan B. We believe Changing the principle of design is a long process including electromagnetic design, mechanical design, prototyping, verification and series production)