

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>Spec. Cl. No.</b>	<b>Specification Clause</b>	<b>Railway / Vendor Comments</b>	<b>RDSO Remarks</b>
<b>0.0</b>	<b>FOREWORD</b>		
0.1	This specification is issued under the fixed serial number RDSO/SPN/211 followed by the year of adoption as standard or in case of revision, the year of latest revision.		No alteration suggestion / Remarks
0.2	Whenever, reference to any specification appears in this document, it shall be taken as a reference to the latest version of that specification unless the year of issue of the specification is specifically stated		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>1</b>	<b>SCOPE</b>		
1.1	<p>This specification covers the technical and operational requirements of the Fail-Safe Network Multiplexer for exchanging vital signaling <b>interlocking</b> information using Dual redundant OFC / reliable wireless communication media in a fail - safe (SIL-4) manner. <del>It also encompasses the need of control and resolving interlocking logic in a fail - safe (SIL-4) manner for execution of Signaling interlocking functions for the LC Gates, IBS, Block working, ABS application only.</del></p>	<p><b><u>WCR :</u></b></p> <p>The limited interlocking feature has been eliminated in draft d9 which was quite prominently included in draft d7. The elimination of interlocking feature will make this draft specification quite comparable to already issued specification by RDSO for Universal Fail Safe Block Interface vide IRS: S--104/2012 Version 0. Duplication on specification for similar items may lead to confusion among Railway. At the same time, it will deprive the Railway with interlocking logics which would have come with the product at no extra cost.</p> <p>In case logic resolving capabilities are available with improved multiplexing features of FNmux, it would be beneficial for Railways from both execution and maintenance point of view particularly for mid-section Interlocked LC Gates, Intermediate Block signalling &amp; Automatic Block Signalling.</p>	<p><b>RDSO remarks:</b> Not Agreed. <b>Reason: (i)</b> The interlocking logic has been removed to avoid contradiction with existing specifications of EI which already have features of interlocking logic. There should not be multiple specifications with interlocking logic. <b>(ii)</b> Interlocking system ensures safety in train running and worldwide only proven technologies like EI/RRI/PI are being used. There is nothing like limited interlocking</p>

**16.09.2022**

			<p>features as these systems are very vital for safe running of trains and in case of wrong side failure, unsafe situation may take place.</p> <p><b>(iii)</b> FNmux as name indicates is fail safe multiplexer whose primary function is transferring data in fail safe manner. To have interlocking feature the system must comply various clauses of EI specification also. This will make system more complex.</p> <p><b>(iv)</b> The size of UFSBI equipment with only 16 I/O is very bulky while</p>
--	--	--	--

**16.09.2022**

		<p><b><u>SECR:</u></b> The projects unit of SECR is involved in execution of Automatic Section in a large scale in Nagpur and Bilaspur divisions using MSDAC or HA-SSDAC / SSDAC. In Gondia – Gudma auto section of Nagpur Division, HA-SSDAC axle counter and fail-safe UFSBI mux was used on OFC for exchange of signal and track information between Auto Huts. Following limitations were faced in it, Requirement of Q-series relays used in, signal interlocking at Auto Hut was too high to be widely adopted. Without reducing the interlocking relays, the scheme was not feasible for further adoption in SECR. No interlocking feature for ABS was available in UFSBI</p> <p>a) Necessity of generating a physical relay output at every Auto-Hut and reading it again for carrying it forward to next Auto-Hut, was</p>	<p>FNmux with 256 I/O can be accommodated even in location boxes.</p> <p><b>RDSO remark:</b> Same remarks as para 1.1</p>
--	--	---	---

**16.09.2022**

		<p>an additional requirement, as drop and insert facility was not available in UFSBI</p> <p>b) No arrangement of remote diagnostics and failure analysis was possible in UFSBI. Hence needed Datalogger / RTU at every hut.</p> <p>c) Bulky size of the UFSBI mux, based on old technology, needed much bigger room size that is costly and time taking to build and maintain in block section.</p> <p>d) Location box mounting compact design at foot of every signal to minimize copper usage was not actually possible with UFSBI</p> <p>The features defined in the FN-Mux Spec. No. RDSO/SPN/211/2022 version 1.0 d7 (final draft) including interlocking of ABS / IBS was sufficient to cater to all the above limitation faced during project execution with UFSBI. Hence, in our understanding the final draft (d7) should be more comprehensive rather than draft d9 for large-scale adoption.</p> <p><b><u>SCR:</u></b></p> <p>a) It is observed that the prominent feature of interlocking logic handling feature of FN-Mux Specification Ver 1.0 d7 (final draft) for IBS, ABS &amp; LC Gate has been removed and the new specification Ver 1.0 d9 (draft) without</p>	<p><b>RDSO remark:</b> Same remarks as para 1.1</p>
--	--	--	---

**16.09.2022**

		<p>above feature has been released. In fact, the capability of logic implementation through Fn MUX was making the equipment unique and more useful than the similar equipments in use as on date and would have effectively contributed towards expeditious implementation of capacity enhancement works.</p> <p>b) FN-Mux with Interlocking capabilities for application like IBS/ ABS and LC Gate etc can minimize the number of relays / wirings used to a great extent and improving the reliability and project implementation pace as the size of huts to accommodate the equipments will reduce being a compact system.</p> <p><b><u>Remark:</u></b></p> <p>In view of above, SCR is of opinion that FN-Mux as per Version 1.0 d9 will not be of much use except replacing existing UFSBI equipment and hence the specification Version d7 (final draft) should be finalized including the forward looking features as above.</p> <p><b><u>NER:</u></b></p> <p><b>1.</b> In the Draft Specification No. RDSO/SPN/211/2022 version 1.0 d9 of FNMux, limited interlocking feature has been removed whereas this feature was available in draft specification of version d7. It is recommended that limited interlocking feature should be available in the device with SIL-4 feature to take care of small interlocking applications.</p>	<p><b>RDSO remark:</b> Same remarks as para 1.1</p>
--	--	--	---

**16.09.2022**

		<p><b>2.</b> All vital I/O multiplexing-based applications require some interlocking either for signal cascading or block working and FN-Mux with interlocking feature may be effectively utilized for such applications.</p> <p><b>3.</b> Without Interlocking logic, the specification of FN-Mux will be similar to UFSBI for which specification &amp; RDSO approved vendors already exist. It is appropriate to keep one specification for one type of product to avoid confusion during implementation in the field.</p> <p>In view of above, it is recommended that specification of FN-Mux may be finalized retaining the Interlocking features as available in RDSO/SPN/211/2022 version 1.0 d7 following all the safety norms.</p>	
--	--	---	--

**16.09.2022**

		<p><b><u>ER:</u></b></p> <ol style="list-style-type: none"><li>1) FN Mux new draft specification is floated after assimilating Railway Comments and launching a Final Draft specification. Our comments vide our Letter No.: SG.203/3/SPCN/FNMUX/ 340 dtd. 10/11/2017 may please be reviewed.</li><li>2) The old draft specification was helpful for achieving the stiff Automatic Block Signalling targets.</li><li>3) The removal of the interlocking logics which would have come with the product at no additional cost (as the vital I/O exchanged for multiplexing could be locally reused for logic resolving) has to be achieved with either Electronic Interlocking or Q-series relays thereby increasing both work involvement and cost outlay.</li><li>4) Further, it is also unclear why a fresh MUX specification needs to be published when time tested products and approved vendors are available as per. IRS:S-104/2012 Ver.0. If deemed necessary, this specification maybe amended as required to achieve the point to multipoint or event-logging features over the basic systems which are operational and time-tested. This may encourage wider participation.</li></ol> <p>Our zonal observation to conclude will be that, if a new specification needs to be launched at all it</p>	<p><b>RDSO Remark:</b> Same remarks as para 1.1</p>
--	--	---	---



**16.09.2022**

		<p>must be with interlocking features (as finalized in "Final Draft d7") pertaining to the requirement of Zonal Railways and not to have multiple specification of the same product which will be confusing to users.</p> <p><b><u>Ex. ED/TELE/RDSO:</u></b></p> <p>This specification covers the technical and operational requirements of the Fail-Safe Network Multiplexer for exchanging vital signaling information using Dual redundant OFC / reliable wireless communication media in a fail - safe (SIL-4) manner. It also encompasses the need of control and resolving <b>application</b> logic in a fail-safe (SIL-4) manner for <b>mapping inputs and outputs as well as for execution for optimization of outputs.</b></p>	<p><b>RDSO Remarks :</b> Same remarks as para 1.1</p>
--	--	---	---

**16.09.2022**

	<p><b><u>DELTRON:</u></b></p> <ol style="list-style-type: none"><li>1) We feel that the removal of logics from the earlier specification is not in line with the initial plan of requirement of the product for mainly block applications like ABS, IBS, mid-section LC gates and block instrument applications.</li><li>2) It's evident that for ABS / IBS some logics need to be resolved that is realized by either relay or Electronic interlockings. The logics are mainly similar in nature because of its positioning in the block sections with no points and crossovers. The same acknowledged by RDSO through amendment of product scope in Cl. 1.1 in RDSO/SPN/211/2017 Ver. 1.0 d3 dated 17.10.2017 following the minutes of meeting vide Letter No. STS/E/FnMux Vol II dated 10.08.2017. This was further refined by deleting the Point logic feature (as it was not required in block sections) in RDSO/SPN/211/2017 Ver. 1.0 d7 (final draft) dated 02.03.2022.</li><li>3) FN-Mux will mainly realize Vital I/O exchange replacing existing vital multiplexers. But if it also executes IBS/ABS logics at no additional hardware or cost (as safe I/O's sensed for exchanging, will be re-used in interlocking), whatever budget we plan for interlocking will be saved. This is a big cost benefit to Railways, as explained below with a short case study.</li></ol> <p>The above statement may be verified from the</p>	<p><b>RDSO Remarks :</b> Same remarks as para 1.1</p>
--	---	---

**16.09.2022**

		<p>annexed technical schematics of proposed ABS implementation from NER and NFR where the EI-OC is used in ABS interlocking whereas UFSBI Mux is used for exchange of vital relays states between unlike makes EI/relay interlocking at adjacent stations.</p> <p>If FN-Mux as per RDSO/SPN/211/2017 Ver. 1.0 d7 (final draft) was available all the EI-OC, UFSBI, RTU activities could have been combined into a single product using it's logic resolving, I/O exchange and data level status sharing with station Datalogger, features respectively. Moreover, reduction of number of discrete gears would have saved largely on Railway installation and AMC costs, envisaged by Railway Board.</p> <p>Undoubtably, this would have been a great benefit to the Railway exchequer.</p> <p>4) Vital MUX specification without interlocking is already available with RDSO (IRS:S-104/2012 Ver.0) and multiple approved Part-I vendors are catering to the requirements. Moreover, indigenous axle counter manufacturers are working with 2 out of 3 systems, can easily adhere to the UFSBI specification. In case some event-logging or other peripheral functionalities are envisaged be added to the mux it would be simpler to amend the existing spec. with vendor base rather than a new product with the similar features. Having multiple similar specifications may be confusing to Railway users.</p> <p>We have already faced similar problems in Axle</p>	
--	--	--	--

**16.09.2022**

		<p>Counters (having 3 specifications SSDAC, HA-SSDAC &amp; MSDAC) and Block Panel with UFSBI /SSBPAC where the process of merging of specifications is in progress. Hence having multiple similar specification may kindly avoided.</p> <p>To conclude with, we feel that, if a new product as envisaged by RDSO more than 5 years back and discussed innumerable times across platforms, needs to be developed, it should come with in-built logic resolving capabilities and not just another multiplexing equipment which cannot add value to the existing solutions.</p> <p><b><u>SR:</u></b></p> <p>Version: 1.0 d9 of Specification No. RDSO/SPN/211/2022 has been issued by deleting the functionality of providing limited interlocking logic in a fail - safe (SIL-4) manner for LC Gates, IBS, Block working and ABS applications. The capability of performing limited interlocking logic functions will facilitate easy execution of the above works. Since the FNmux equipment available in the Market are already having the above functionality, it is suggested that the same may be retained in the specification.</p> <p>Hence, it is recommended to withdraw the version: 1.0 d9 of the Specification and retain the previous version viz. 1.0 d8 as the final</p>	<p><b>RDSO Remarks :</b> Same remarks as para 1.1</p>
--	--	---	---

**16.09.2022**

		<p>Specification.</p> <p><b><u>EX.ED/TELE/RDSO:</u></b></p> <ol style="list-style-type: none"><li>1. The draft specifications (version-d9) referred above, issued for comments due to revision for working of system without interlocking logic. A Multiplexer without any application logic basically defeats the very purpose of framing a new specification for introduction of a failsafe networked multiplexer for Indian Railways. Specifications and the product for point-to-point multiplexer is already available.</li><li>2. It is observed that in the proposed revised draft specification (version-d9), the word "interlocking logic/application logic" has been replaced with "Executive software". In fact, the executive software of any system is fixed and cannot be changed locally, and is used to drive the hardware of system. Change in Executive software is not possible at site. Application logic is different from Executive Software.</li><li>3. It is further stated in the specification (d9) that executive software can be manually loaded in the system, which itself is wrong concept. Executive software is fixed and preloaded software with a fixed version no. and checksum and is already certified by ISA. Any programmable device is certified SIL-4 with its executive software version. Thus, when any module/card is tested, it</li></ol>	<p><b>RDSO Remarks :</b> Same remarks as para 1.1</p>
--	--	---	---

**16.09.2022**

		<p>is already having a preloaded executive software. This executive software is independent of its application.</p> <p>4. In any case, no programmable device can work without application logic. The FNmux specification (d9) also requires application logic, as the FNmux (d9) is not a universal device and each input and output need to be programmed. The various inputs received from several FU's need to be delivered as outputs through several other FU and therefore programming is to be done as which output corresponds to which input. This mapping can only be done by programming the FNmux unit, which is specifically applicable to the particular application; hence this specific programming is "application logic" of the system.</p> <p>5. FNmux (d9) in the specification is defined to be capable of minimum of 256 I/O. When such large number of inputs are controlled by system, there may not be requirement of as many Outputs as equal to inputs, since some of the inputs can be interlocked within the SIL-4 certified multiplexor system. This considerable reduces the number of outputs and along with it reduces the Output cards, relays and associated wiring. This can be achieved only by carrying out the programming for the local application, hence application logic is essential to be part of the FNmux. Else, the</p>	
--	--	---	--

**16.09.2022**

		<p>entire FNMux becomes bulky and costlier. This can easily be understood from the fact that in any EI, number of outputs are always lower than the number of inputs, due to feature of logic.</p> <p>6. In case, FNmux is proposed to work based on a fixed program (without application logic), then perhaps this specification is not required, as existing specification of UFSBI covered in RDSO/SPN/104 are already working on fixed input and output. Perhaps, a small change of "from point to point" "to multi point to multi point" in this RDSO/SPN/104 will serve the purpose and does not warrant issue of a new specification.</p> <p>7. In case, it is expected in this draft specification (d9) that application logic/ interlocking logic shall be an external part, then the interlocking shall be achieved either by Relays or by EI. This provision of external interlocking will make the system unnecessary costly, bulkier. Even Relay interlocking may not be suitable considering the future requirement of CTC, TCAS etc.</p>	
--	--	---	--

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>2</b>	<b>TERMINOLOGY</b>		
2.1	For the purpose of this specification, the terminology given in IRS: S23 and RDSO/SPN/144 shall apply.		No alteration suggestion / Remarks
2.2	ABBREVIATIONS		No alteration suggestion / Remarks



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>3</b>	<b>APPLICABLE DOCUMENTS</b>		
3.1	<ol style="list-style-type: none"><li>1. EN50126</li><li>2. EN 50128</li><li>3. EN 50129</li><li>4. EN50159</li><li>5. EN 50121-4</li><li>6. EN 50124-1</li><li>7. EN 50125-1</li><li>8. EN 50125-3</li><li>9. EN 50155</li><li>10. IEC 62236-2</li><li>11. RDSO/SPN/144</li><li>12. IRS: S 36</li><li>13. IRS: S:23</li><li>14. RDSO/SPN/192</li><li>15. IRS: S-104/2012</li><li>16. IEEE 802.3, 802.3u, 802.3x, 802.1d, 802.1w, 802.1p, 802.1Q</li></ol>	<p><b><u>FRAUSCHER :</u></b></p> <p>EN 50155 is applicable for electronics onboard a rolling stock and not applicable for electronics on the station or trackside. All applicable environmental conditions (including vibration and shock) for electronic signalling equipment near trackside are available in EN 50125-3, hence these references for EN 50155 need to be removed.</p>	<p><b>RDSO Remark:</b> Not agreed.</p> <p><b>Reason:</b> EN 50155 is required for vibration effect. EN 50125-3 is for shock effect.</p>

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>4</b>	<b>GENERAL REQUIREMENTS</b>		
4.1	The system and its accessories shall comply with the requirements of signaling circuits using electronic equipment as laid down in Signal Engineering Manual IRSEM Issue July 2021 and as stipulated in RDSO/SPN/ 144/2006 or latest.		No alteration suggestion / Remarks
4.2	The system shall comply with the specification no. RDSO/SPN/ 144/2006 or latest for safety, reliability and environmental/climatic requirements of Electronic Signaling equipment.		No alteration suggestion / Remarks
4.3	The system shall be capable of working in non air-conditioned environment ambient temperature varying from -10°C to +70°C. The system shall be able to be used in indoor/outdoor environment.		No alteration suggestion / Remarks.
4.4	The equipment shall be so constructed as to prevent unauthorized access to the system.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

4.5	The system shall be fully tested to ensure that it is free of systemic errors at the time of commissioning		No alteration suggestion / Remarks
4.6	Interface equipment shall be so designed that no modification, either technical or operational is required in the equipment, which are interfaced.	<b><u>WCR :</u></b> If above 1.1 is considered, then this para need to be modified to include the option for technical and operational modification in the interface equipment as per site condition (software part) duly protected by user authorization and identification. If required a separate sub para may be added.	<b>RDSO Remark:</b> 1.1 is not considered.
4.7	The termination of wires and housing rack shall be constructed to comply with requirements stipulated in RDSO/ SPN/ 144/2006 or latest.		No alteration suggestion / Remarks
4.8	Insertion of PCB in wrong card slots should not be possible.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

4.9	Suitable lightning and surge protectors shall be provided as per RDSO/SPN/144/2006 and RDSO/SPN/215/2018 Ver.2.0 or latest.		No alteration suggestion / Remarks
4.10	MTBF of the individual equipment shall be better than 100000 hours.		No alteration suggestion / Remarks
4.11	The equipment shall offer ergonomic ease in its operation and maintenance.		No alteration suggestion / Remarks
4.12	It shall be IP65 compliant.	<b><u>FRAUSCHER :</u></b>  IP65 requirement for electronic boards is not relevant. IP rating is for enclosures and housings not for electronic systems. Other specs like EI mention about dust proof housing but they do not mention any IP rating. This need to be modified accordingly.	<b>RDSO Remark:</b> IP rating is required.
4.13	The size of the FU equipment shall be such that will be able to accommodate in full location boxes in the field.		No alteration suggestion / Remarks

**16.09.2022**

<p><b>5.</b></p>	<p><b>FUNCTIONAL REQUIREMENTS</b></p>		
	<p>Failsafe Network Multiplexer system will consist of distributed multiplexer modules, connected in a network, constituting a network of fail-safe multiplexer modules for exchange of vital digital I/O information. The system architecture shall allow the formation of a scalable centralized unit of modules (FNmux Central Unit -CU) to concentrate I/O from the distributed field modules (FNmux Field Unit -FU). Furthermore, the network protocol and addressing technique adopted shall be such that any pair of vital modules, either in the central unit or in the field unit can be virtually connected from any point to any point. Vital cards can be used for non-vital I/O information also. The system should also be able to communicate with Data Logger.</p>	<p><b><u>FRAUSCHER :</u></b></p> <p>Both CU and FU are equally vital from safety or reliability point. Why there is difference in given architecture of two. For ex.</p> <p><b>(i)</b> CU is required with hot standby, but FU is not.</p> <p><b>(ii)</b> CU is supposed to be scalable up to 256 I/O and FU up to 64 I/O.</p> <p>These kinds of conditions will unnecessarily increase the complexity of the system. Anyway, purchaser will have to specify how many I/O's are required to be exchanged and that number will drive the cost. If we specify too high a number as I/O's in basic configuration then it will always be under utilised, and railway will incur unnecessary extra cost.</p> <p>Many paras of Spec also talk about possibility of transmission between two FUs or two CUs etc that clearly shows that CU does not have any different role in system than a FU.</p> <p><b><u>We suggest</u></b> having same modularity and architecture for all CU / FU, i.e., minimum 4 to 6 I/O's and scalable up to any number of required I/O's. We can always add another CU/FU if</p>	<p><b>RDSO remark:</b></p> <p>One CU will be connected to many FUs hence CU must be hot standby &amp; should have more capacity than FU.</p>

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

		required to add additional I/O's. The purchaser must specify maximum number of I/Os required for application.	
--	--	---	--

**16.09.2022**

5(a)	<p><b><u>FNmux Central Unit (CU):</u></b> The Central Unit will consist of a variable number of vital modules. Central Unit shall have CENELEC SIL- 4 compliant fail-safe <b>2oo2</b> architecture in standalone mode or <b>2oo3</b> architecture as per EN 50129. However, the system shall be provided with hot standby configuration for enhanced reliability. Other module of the central unit shall have CENELEC SIL-4 compliant fail-safe architecture with minimum 8/16 digital I/O scalable to 256 I/O or as per purchaser's requirement for transferring of vital signal, tracks and other similar vital relay status. The Central Unit should be modular in nature and expandable up to minimum 256 digital I/Os or as per purchaser's requirement. The system must maintain safety level of SIL-4 even during the failure/ removal of all redundancies. It should be capable of transmitting and receiving information from CU to CU and CU to FUs (multipoint).</p> <p>The removal and plugging of redundant processor module</p>	<p><b><u>WCR :</u></b> FNmux Central unit (CU) This may be required to be modified as per para 1.1 above, if application logic (software) would be under consideration.</p> <p><b><u>FRAUSCHER :</u></b> Hot standby for CU is described in para 5 a) but again CU is described in para 5.1 and the hot standby architecture is missing. This needs to be resolved and CU shall be defined at one place only, why to create different statements at different places for same module. It is also required to be clarified if the 2oo2 hot standby or 2oo3 architecture is only for main processor boards of central processing unit or this architecture is also required for I/O boards.</p> <p><b><u>We suggest</u></b> either removing all hot standby requirements as this will drive the cost and complexity. If hot standby is still felt to be necessary, then at least clarify that 2oo2 hot standby or 2oo3 architecture is only required for main boards carrying configuration data in central processing unit and not for other boards.</p> <p><b><u>SECR:</u></b> The replacement of the phrase "interlocking logic" with "Executive software", as seen in draft d9, must be reviewed, since the later is fixed firmware</p>	<p><b>RDSO Remarks :</b> Same remarks as para 1.1</p> <p><b>RDSO Remark:</b> Hot standby is required.</p> <p><b>RDSO Remark:</b> Will be suitably modified.</p>
------	---	---	---

**16.09.2022**

<p>must be hot swappable and should not require shutting down of system. The redundant processor module when inserted in the system should have preferably self-learning feature and may not require independent loading of <del>application—logic</del> <b>executive software</b>. The <del>application—logic</del> <b>executive software</b> may be transferred from running processor to standby processor automatically. However in case of manual loading of <del>application—logic</del> <b>executive software</b> in standby processor the OEM must ensure the correctness of same <del>application—logic</del> <b>executive software</b> in both the processors.</p> <p>It shall be possible to place redundant processor module at two different and independent places without affecting the performance, safety and reliability of the system. There shall be possibility of placing the central unit in field location boxes <del>for interlocking</del> in case of emergency.</p> <p><del>It shall be capable of performing</del></p>	<p>for a particular SIL-4 embedded product and cannot be modified now and then without permission from safety validator.</p> <p><b><u>Ex. ED/TELE/RDSO:</u></b></p> <p>The removal and plugging of redundant processor module must be hot swappable and should not require shutting down of system. The redundant processor module when inserted in the system should have preferably self-learning feature and may not require independent loading of <b>application</b> software. The <b>application</b> software may be transferred from running processor to standby processor automatically. However, in case of manual loading of <b>application</b> software in standby processor the <del>OEM</del> <b>Railway</b> must ensure the correctness of same <b>application</b> software in both the processors.</p>	<p><b>RDSO Remark:</b> Application logic has been removed.</p>
--	--	--



**16.09.2022**

	<p><del>certain — interlocking — logic functions as defined in the scope of the specification.</del></p> <p>The transfer to hot standby system should be seamless, without affecting safety &amp; ongoing operations.</p>		
5(b).	<p><b><u>FNmux Field Unit (FU):</u></b></p> <p>Each module shall have CENELEC SIL-4 compliant fail-safe architecture, configuration with at least 8/16 (or as per purchaser's requirement) digital I/O (in same chassis / box size of 3U/42T) or (comparable/similar) dimensionally suitable to be installed in field location box for transferring of vital signal, tracks and other similar vital relay status. FNmux Field Unit shall be able to transfer vital information to CU. This should be DIN Rail or with any other suitable mountable device along with Power supply and communication switch.</p> <p>This should be DIN Rail mountable along with Power supply and communication switch.</p>		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5 (c)	Communication architecture shall comprise of dual redundant single mode OFC (AS PER IRS/TC/55/2006 OR LATEST) Ring network, suitable for Ethernet traffic up to distance of 30 Kms at 10/100/1000 Mbps with maximum response time of less than 1 second.		No alteration suggestion / Remarks
5 (d)	It shall be having local & remote diagnostic features for monitoring the health of the system		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.1	<p><b><u>FNmux Central Unit (CU):</u></b>                  FNmux Central Unit shall have Safety Integrity Level of 4 (SIL-4) and will be used for transferring vital signaling information. <del>and for performing certain vital signaling functions that can be used for interlocking functions of LC Gates, IBS, Block working, ABS applications only.</del></p>	<p><b><u>WCR :</u></b>                  This may be required to be modified as per para 1.1 above, if application logic (software) would be under consideration.</p> <p><b><u>Ex. ED/TELE/RDSO:</u></b>                  FNmux Central Unit shall have Safety Integrity Level of 4 (SIL-4) and will be used for transferring vital signaling information <b>and for performing logical functions.</b></p>	<p><b>RDSO Remarks :</b>                  Same remarks as para 1.1</p>
5.1.1	<p>The equipment shall be compatible with 12V/24V/60V DC (+20% to -30%) signal driven systems like relays, indication lamps etc.</p>	<p><b><u>WCR :</u></b>                  The requirement of 12V compatibility may be reviewed as mostly 24V/60V DC signal driven systems are prevalent in most of the Railways.</p>	<p>Some relays are of 12V also.</p>
5.1.2	<p>The module shall be able to communicate over any reliable full duplex dual ring Ethernet network on OFC / reliable wireless communication media. The communication network shall necessary be a Closed Network with the following properties:</p>		<p>No alteration suggestion / Remarks</p>

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

	<p>Only approved access is permitted. There is a maximum and known number of connectable participants. Transmission properties should be known and fixed.</p>		
5.1.3	<p>The system shall work on 24V DC, 110V DC (+20% to -30%) or 110V, 50Hz (+20% to -30%) as specified by the purchaser.</p>		<p>No alteration suggestion / Remarks</p>
5.1.4	<p>The FNmux Central unit shall cater minimum 8/16 inputs and 8/16 outputs (or as per purchaser's requirement) &amp; shall be scalable up to minimum 256 Inputs and 256 outputs (or as per purchaser's requirement) by addition of modules. Each output port shall be capable to drive signaling relays using internal power supply, for the purpose of sensing inputs, potential free contacts of relays shall be used.</p>		<p>No alteration suggestion / Remarks</p>

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.1.5	Each output/Input shall have suitable protection for back E.M.F./Short ckt /Overload etc		No alteration suggestion / Remarks
5.1.6	The equipment shall be capable of working on full Duplex Ethernet port provided over OFC / radio, simultaneously on redundant ports. Best quality gold plated RJ45 connector with LED indication type reliable Ethernet port or FX port must be provided.	<p><b><u>M/s PHOENIX CONTACT:</u></b></p> <p>The equipment shall be capable of working on full Duplex Ethernet port provided over OFC / radio, simultaneously on redundant ports. Best quality gold plated RJ45 connector shall be suitable for Industrial application to transmit data up to 10 Gbit/s with Bi-Color LEDs and Halogen-free V0 material, shall sustain vibration level up to 2KHz (20g) and shock up to 50g/11ms, and withstand temperature variation from -40°C to 105°C type reliable Ethernet port or FX port must be provided.</p> <p><b>Reason for Suggestion:</b></p> <p>For better and reliable connectivity ,it is preferred to For Better and Reliable connectivity, it is preferred to use connector which shall sustain vibration level up to 2KHz (20g) and shock up to 50g/11ms.</p> <p>Additionally, for faster data transmission connector shall be capable to send the data at the speed of 10 Gbit/s.</p> <p>For the adverse Indian climate conditions, the connector shall withstand temperature variation from <b>-40°C to 105°C</b>.</p> <p>The RJ45 Jack shall have Bi-Colour LEDs to identify the status of Power and Data separately.</p>	Agreed for industrial grade.

**16.09.2022**

		<p>The above suggested parameter will ensure the long-term performance of the data communication in the system.</p>	
--	--	---	--

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.1.7	In case of disruption of communication link between two nodes or failure of the equipment, all the output of the affected nodes or equipment must go low in not more than 1 seconds.		No alteration suggestion / Remarks
5.1.8	The pair of equipment shall be transparent to the signaling circuit / equipment connected through them.		No alteration suggestion / Remarks
5.1.9	Each module shall have a unique address, which shall be stored in the system. Address of the equipment shall be either hardwired or unique ID or MAC IP or IP Address or DIP switches.		No alteration suggestion / Remarks
5.1.10	The information exchanged between the pair of the interface equipment shall contain the source & destination address.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.1.11	FNmux Central Unit (CU) shall be self-diagnostic system and shall be capable of interfacing with maintenance terminal or any PC to fetch the required information.		No alteration suggestion / Remarks
5.1.12	It should be capable of transmitting and receiving information from CU to CU and CU to FUs (multipoint).		No alteration suggestion / Remarks
5.1.13	LED indications shall be provided on modules for all inputs and outputs to indicate its status and errors.		No alteration suggestion / Remarks
5.1.14	The CU shall preferably be located in the station building, Relay hut or Gate lodge. However the dimension of CU should be such that in case of non-availability of building/room/space or in case of emergency, it can be located in field location boxes also. Therefore the Central Unit FNmux must comply with EN 50121- 4 (Electromagnetic compatibility), EN 50124-1		No alteration suggestion / Remarks



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

	(Insulation coordination), EN 50125-1 (Environmental condition), EN 50125-3 (Environmental condition), EN 50155 (Vibration).		
<b>5.2</b>	<b><u>FNmux Field Unit (FU):</u></b>	<b><u>WCR :</u></b> This may be required to be modified as per para 1.1 above, if application logic (software) would be under consideration.	<b>RDSO Remarks :</b> Same remarks as para 1.1
5.2.1	This system shall have Safety Integrity Level of 4 (SIL-4) and will be used for transferring vital signaling Functions with CU that can be utilized for interlocking at required location.		No alteration suggestion / Remarks
5.2.2	The equipment shall be compatible with 12V/24V/60V DC (+20% to -30%) signal driven systems like relays, indication lamps etc.	<b><u>WCR :</u></b> The requirement of 12V compatibility may be reviewed as mostly 24V/60V DC signal driven systems are prevalent in most of the Railways.	Some relays are of 12 V also.

**16.09.2022**

5.2.3	<p>The module shall be able to communicate over any reliable full duplex single / dual ring network using safe Ethernet Protocol on OFC / reliable wireless media. The safe Ethernet protocol must be as per CENELEC standard EN 50159 to make the complete system SIL-4 certified as per CENELEC EN 50129. The module shall be suitable to be used in a closed communication network with the following properties:</p> <p>Only approved access is permitted.</p> <p>There is a maximum and known number of connectable participants.</p> <p>Transmission properties should be known and fixed.</p>		No alteration suggestion / Remarks
-------	--	--	---------------------------------------

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.2.4	The system shall work on 24V DC, 110V DC (+20% to -30%) or 110V, 50Hz (+20% to -30%) as specified by the purchaser.		No alteration suggestion / Remarks
5.2.5	Field Unit (FU) shall have CENELEC SIL-4 compliant fail-safe architecture. Each Vital Trackside Module shall have at least 8/16 inputs scalable to 64 inputs and 8/16 outputs scalable to 64 outputs (or as per purchaser's requirement) using single or scalable modules. Each output port shall be capable to drive all type of signaling Q Series/12/24/60V DC Signaling relays and using internal power supply for the purpose of sensing inputs, potential free contacts of relays shall be used. This should be DIN Rail or with any other suitable mountable device along with power supply and communication switch.		No alteration suggestion / Remarks
5.2.6	Each output/Input shall have suitable protection for back E.M.F./Short ckt /Overload etc.		No alteration suggestion / Remarks

**16.09.2022**

5.2.7	<p>The equipment shall be capable of working on full Duplex Ethernet port provided over OFC / reliable wireless media, simultaneously on redundant ports. Best quality gold plated RJ45 connector with LED indication or reliable Ethernet port or FX port must be provided in each Vital I/O modules in FU and CU.</p>	<p><b><u>M/s PHOENIX CONTACT:</u></b></p> <p>The equipment shall be capable of working on full Duplex Ethernet port provided over OFC / radio, simultaneously on redundant ports. Best quality gold plated RJ45 connector shall be suitable for Industrial application to transmit data upto 10 Gbit/s with Bi-Colour LEDs and Halogen-free VO material, shall sustain vibration level upto 2 KHz (20g) and shock upto 50g/11ms, and withstand temperature variation from -40°C to 105°C or reliable Ethernet port or FX port must be provided in each Vital I/O modules in FU and CU.</p> <p><b>Reason for Suggestion:</b></p> <p>For Better and Reliable connectivity, it is preferred to use connector which shall sustain vibration level up to 2KHz (20g) and shock up to 50g/11ms. Additionally, for faster data transmission connector shall be capable to send the data at the speed of 10 Gbit/s.</p> <p>For the adverse Indian climate conditions, the connector shall withstand temperature variation from -40°C to 105°C.</p> <p>The RJ45 Jack shall have Bi-Colour LEDs to identify the status of Power and Data separately. The above suggested parameter will ensure the long term performance of the data communication in the system.</p>	<p>Such details are not required as specification is generic in nature. However industrial grade is agreed.</p>
-------	---	--	---

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.2.8	In case of disruption of communication link between two locations (Nodes) or failure of the equipment, all the output of the affected peers or equipment must go to fail-safe state without affecting the availability of system adversely.		No alteration suggestion / Remarks
5.2.9	Each module shall have a unique address, which shall be stored in the system. Address of the equipment shall be either hardwired or unique ID or MAC IP or IP Address or DIP switches.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.2.10	The information exchanged between the Nodes (field to cluster or field to field) of the interface equipment shall contain the source & destination address.		No alteration suggestion / Remarks
5.2.11	The Field Unit FNmux must comply with EN50121-4(Electromagnetic compatibility), EN50124-1(Insulation coordination), EN50125-1 (Environmental condition), EN 50125-3 (Environmental condition), EN50155 (Vibration)	<b><u>FRAUSCHER :</u></b>  EN50155 (Vibration) is used for electronics onboard a rolling stock and hence it is not relevant for FNMUX. EN 50125-3 has all the environmental requirements for signalling equipment including vibration and shock. Hence this reference for EN 50155 need to be removed.	Not agreed. Reason: EN 50155 is required for vibration effect. EN 50125-3 is for shock effect.

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>5.3</b>	<b><u>OTHER REQUIREMENTS:-</u></b>		No alteration suggestion/ Remarks
5.3.1	The modules shall be designed to facilitate following functions: (a) Decoding of the incoming message and transmission of the relevant information to the corresponding relay output module. (b) Receiving of the message from the relay-input module, encoding the message telegram and communicating with other module.		No alteration suggestion / Remarks
5.3.2	<b><u>RELAY INPUT MODULES</u></b> Relay input module shall be so designed that it senses the relay contacts (front contacts in case of metal to carbon relay, and both front and back in case of metal to metal). The relay input module shall be capable to be isolated, double break input with the facility of double cutting.		No alteration suggestion / Remarks

**16.09.2022**

5.3.3	<b><u>RELAY OUTPUT MODULES:</u></b> Relay output modules shall be capable of driving the output relay (both + and -) using Internal power supply with suitable protection .The Relay output module shall drive isolated output.		No alteration suggestion / Remarks
5.3.4	<del>In case Central unit (CU) is used to control signaling logics then</del> The read back facility should be provided to monitor the status of the relay vis-à-vis the CU's <del>commands</del> information.	<b><u>FRAUSCHER :</u></b>  Read back is generally a requirement when there is module specifically generating the voltage for driving the external relay but now, we also have systems that provide potential free contact on vital boards. Any external relay can be wired through these potential free contacts using external power supply.  This clause can either be deleted since system will be certified for SIL-4, or a suitable modification as suggested below:  "For systems having relay driver board (generating voltage for driving an external relay) a read back facility shall be provided. For systems having potential free contact onboard, this readback is not required".	Read back facility is required.



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.4	<b><u>NETWORK ARCHITECTURE</u></b>		No alteration suggestion / Remarks
5.4.1	<p>The system comprised of the vital modules shall be capable to work on dual redundant OFC Ring Network using Managed Layer 2 Ethernet switch with applicable protocol suite, with 10/100/1000 Mbps Ethernet or any other suitable and proven protocol for safety systems.</p> <p>The Ethernet switch shall work on the same power supply as that of the CU/FU itself.</p> <p><b>Schematic block diagram is given in figure-1.</b></p> <p>The Central Unit (CU) or the Field Unit (FU) having -</p>		No alteration suggestion / Remarks
5.4.1. (i)	<p>The network elements shall be mutually interchangeable and compatible across manufacturers. It should comply with deterministic nature &amp; class of service as specified by IEEE 802.1p.</p>		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.4.1.(ii)	Wide Temperature operation: -10 °C to +70 °C .		No alteration suggestion / Remarks
5.4.1.(iii)	All the network elements used with the system shall be compliant to EN-50159.	<b><u>FRAUSCHER :</u></b> Network elements like switches/ modems are not required to be compliant to 50159. It is FNMUX that should be compliant to 50159 as the safety of communication lies with end devices and not communication network itself.	Compliance to EN 50159 is must.
5.4.2	The network elements shall be capable of working in same electrical and climatic condition for temperature, shock, free-fall and vibration (in compliance with RDSO/SPN/144/2006 or Latest.) as that of the I/O modules and shall have similar MTBF.	<b><u>FRAUSCHER :</u></b> The electronic network elements like switches shall be industrial grade and compliant to EN50121-4 or its equivalent IEC standard.	Industrial grade is agreed. Relevant EN/IEC standards will be applicable.
5.4.3	It shall be possible for an authorized user having necessary permissions / password to add or delete a pair of modules.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.4.4	Internal data logger facility shall be provided for failure analysis. Information of all the Inputs and Outputs sensed or driven by an FN-MUX network (either through the Central Unit or remote Field Units) must be available at the FN-MUX Central Unit, in an Open or Standard protocol for easy connectivity to Network Datalogger (for diagnostic purposes) either directly or through suitable protocol converters.		No alteration suggestion / Remarks
5.4.5	The remote monitoring software shall be browser based and shall be transparent across the makes. Remote Diagnostics terminal should be available for each FN-MUX network installed, where all the health parameters, error messages and I/O's of each remote Field Unit and the Central Unit can be monitored.		No alteration suggestion / Remarks
5.4.6	Seamless change over from one path to another path or from one medium to another medium shall be possible.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.5	<b><u>POWER SUPPLY MODULE</u></b>		No alteration suggestion / Remarks
5.5.1	The power supply module shall work with input voltage of 24 V DC / 110 V DC / 110 VAC as specified in with following stipulation;		No alteration suggestion / Remarks
5.5.1.(i)	The ripple voltage in the output shall not exceed 40 mv peak to peak for +5V supply at 40 MHz bandwidth. The output ripple voltage (peak to peak) of other than +5V output shall not be more than 1% of the rated output voltage at full load.	<b><u>M/s Phoenix:</u></b> The ripple voltage in the output shall not exceed <b>50mv peak to peak and MTBF should be more than 500000 hrs. at 40°C.</b> <b><u>Reason for Remark:</u></b> For better result, more MTBF value means more reliable system. So, MTBF should be more than 500000 hrs. at 40°C (considering Indian Environment). And to improve the accuracy of output supply the ripple voltage should be less than 50mv peak to peak. So, that the downstream component will perform better, and overall system service life would increase.	MTBF of the draft spec is ok. Ripple voltage shall not be more than 1% of the rated output voltage at full load.
5.5.1.(ii)	Monitored hot standby module shall be provided for better reliability.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.5.1.(iii)	Glass fuses of proper rating shall be provided to protect the equipment.		No alteration suggestion / Remarks
5.5.1.(iv)	The power supply module shall have self re-setting type protection from under voltage of AC/DC input, over voltage of AC/DC input, over load of DC output & short circuit of DC output.		No alteration suggestion / Remarks
5.5.1.(v)	Voltage regulation shall be less than 1% of output rated voltage.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

5.5.1.(vi)	<p>Class-C &amp; Class-D Surge Protection Devices for power line from reputed makes like OBO, Phoenix, DHEN or similar or any other RDSO recommended makes must be adopted. SPD provided shall be as per specification no. RDSO/SPN/215/2018 Ver.2.0 &amp; relevant IEC standards.</p>	<p><b><u>M/s PHOENIX CONTACT:</u></b>                  Type-2 ( Class-C ) &amp; Type-3 (Class-D) Surge Protection Devices for power line from reputed makes like OBO, Phoenix, DHEN or similar or any other RDSO recommended makes must be adopted. SPD provided shall be as per specification no. RDSO/SPN/215/2018 Ver.2.0 &amp; relevant IEC standards.</p> <p><b>Remark:</b>                  All SPD's must be in accordance to IEC latest standards i.e., IEC 61643-11-2011.</p> <p>As per BIS / IEC 61643-11-2011 / NBC-2016, Type/Class of SPD must be written on SPD housing and it should be like Type-1 (T1), Type-2 (T2) and Type-3 (T3).</p> <p>Now, SPD should be read as:                  Class-B is now Type-1                  Class-C is now Type-2                  Class-D is now Type-3</p>	<p>SPD provided should be as per RDSO specifications no.- RDSO/SPN/215/2018 Ver.2.0 &amp; relevant IEC standards.</p>
5.5.1.(vii)	<p>The complete FNmux system vital field modules and that of Central cluster shall be connected to the existing earthing system of other signaling equipments.</p>		<p>No alteration suggestion / Remarks</p>

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>6</b>	<b>FAIL-SAFETY REQUIREMENTS:</b>		No alteration suggestion / Remarks
6.1	The FNmux shall assign specific addresses to each Instrument/ System (by unique ID) and ensure that the message/ telegram sent is received by the FNmux module for which it is meant.		
6.2	The coding of signal information shall take care of type of noise generally encountered in the transmission system and ensure safety in operation against those noise levels.		No alteration suggestion / Remarks
6.3	Codification of input data for transmission must ensure a hamming distance of 5 or better and at least 2 out of 3 consecutive message redundancy checks must be ensured or shall be compliant to CENELEC requirements of SIL-4 safety standard.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

6.4	The information exchanged between the pair of the interface equipment shall contain all safety-related data e.g. (Sync1, source address, destination address, Data, inverted data, Redundancy Bytes etc.) or shall be compliant to CENELEC requirements of SIL-4 safety standard.		No alteration suggestion / Remarks
6.5	Wrongly addressed information packets shall be promptly rejected by the system and continuous receipt of such packets should raise an alarm and result in shutdown of the system in safe standby mode with all output getting de-energized. This will resume automatically once the proper packets are received after resuming the link.		No alteration suggestion / Remarks



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

6.6	The system shall be so designed to prevent unauthorized access. System shall shutdown in case of unauthorized interference/ forced pick up of relay.		No alteration suggestion / Remarks
6.7	With respect to the inputs the following requirements shall be satisfied: <b>(a)</b> Proper de-bouncing technique should be adopted for the input reading process. It shall be possible to have sensing either through constant 24 VDC / 60 VDC or Coded Test Pulses generated from the system itself, that ensures that only the particular Input is present and avoids any stray feed or Input electronics short-circuits <b>(b)</b> Inputs must be isolated and duly protected. <b>(c)</b> For Vital relay inputs, it shall be capable to provide double cutting arrangement.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

6.8	<p>With respect to the outputs the following requirements shall be satisfied:</p> <p><b>(a)</b> Before writing the output or setting the output latches, the processor must exchange the output set (i.e. data received from far-end FnMux field / central cluster vital modules) between them and in case of equality only, the processor shall process to output the data.</p> <p><b>(b)</b> Presence of any other unwanted signal should not lead to unsafe Conditions.</p> <p><b>(c)</b> For relay output, it shall be isolated output driving the relay.</p>		No alteration suggestion / Remarks
6.9	<p>In the event of a failure of any component/ module/ sub-system or bug in the software, the system shall revert all its vital output to the most restrictive mode of operation within 1 second and remove power from the physical output in a fail-safe manner.</p>		No alteration suggestion / Remarks

**16.09.2022**

6.10	<p>Unsafe condition shall not develop due to faults and adequate safety margins must be incorporated in the design for all modes of failure for the following:</p> <ul style="list-style-type: none"><li><b>(a)</b> High impedance and open circuit fault of a component and multi-terminal devices.</li><li><b>(b)</b> Low impedance and short circuit faults of a component and multi-terminal device.</li><li><b>(c)</b> Variation in the component values beyond their tolerable limits.</li><li><b>(d)</b> Operational faults likely to lead to unsafe condition.</li><li><b>(e)</b> "Stuck at Faults" particularly in comparator circuits, I/O circuits, controlling circuits of microprocessor etc.</li><li><b>(f)</b> Fleeting errors in memory chips data buses.</li><li><b>(g)</b> Damages to the data bus.</li><li><b>(h)</b> Back E.M.F. in case of outputs.</li></ul>		No alteration suggestion / Remarks
------	--	--	---------------------------------------

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

6.11	No single failure shall result in an unsafe condition i.e. the system shall be brought to a safe state as soon as failure occurs. The failure should be suitably indicated.		No alteration suggestion / Remarks
6.12	It must be ensured that if a failure of equipment occurs which by itself does not result in unsafe condition, but which in combination with a second or subsequent failure could result in a unsafe condition, then the first failure should be detected and negated. The probability of occurrence of a second failure, while the first failure has not been detected and negated should be negligible so that MTBWSF is compliant to SIL-4 of CENELEC Standard. Any single fault should bring system to safe state		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

6.13	<p>The design of the equipment shall cater for detection and restoration of system to a safer state in case of following faults if these are likely to result in unsafe condition:</p> <p><b>(a)</b> Variation in power supply beyond its tolerance limits, including momentary failure of the power supply module.</p> <p><b>(b)</b> Spikes in the power supply system, stray fields caused by traction vehicles or standby diesel generator sets.</p> <p><b>(c)</b> Earthing of any component or wire or a combination of such Earthing faults.</p> <p><b>(d)</b> Broken wires, damaged or dirty contacts, failure of a component to energies, loss of power supply or blown fuses etc.</p>		No alteration suggestion / Remarks
6.14	<p>System should comply with SIL- 4 of CENELEC standard or equivalent Standard.</p>		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>7.</b>	<b>TRANSMISSION OF SAFETY INFORMATION:</b>		No alteration suggestion / Remarks
7.1	In the systems requiring transmission of vital safety information, the following requirements shall be fulfilled:		No alteration suggestion / Remarks
7.1.(i)	It shall be possible to transmit the safety information over communication backbone provided over redundant optic fiber cable through any media using industrial grade Layer 2 Ethernet switches. The transmission protocol should ensure integrity of safety related information irrespective of the transmission medium.		No alteration suggestion / Remarks
7.1.(ii)	If communication fails then the last valid output data shall be held for safe duration as mentioned in safety case. For communication failure longer than that duration then the system shall assume most		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

	restrictive and fail-safe state.		
7.1.(iii)	Errors introduced or not detected at a given level in the transmission system must be detected at higher levels. Error detection methods used at any level must take into account the characteristics of the lower levels.		No alteration suggestion / Remarks
7.1.(iv)	Error detection techniques should permit the use of standard techniques of safe communication, which offers much more economic solution than the special hardware needed to implement error prevention techniques.		No alteration suggestion / Remarks
7.1.(v)	Error detecting coding shall not form the sole means of protection of transmitted information, but should be combined with other methods such as higher level procedures and protocols, and hardware redundancy or diversity.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

7.1.(vi)	Forward error correcting coding shall not be used unless precautions are taken at the higher level to prevent invalid corrections from being accepted at the higher level.		No alteration suggestion / Remarks
7.1.(vii)	The response time of the system should be adequate for the complete system up to serial data rate equivalent to 10/100 Mbps safe Ethernet backbone.		No alteration suggestion / Remarks
7.1.(viii)	Class D Surge Protection Devices for data line from reputed makes like OBO, Phoenix, DHEN or similar or any other RDSO recommended makes must be adopted. SPD provided shall be as per specification no. RDSO/SPN/215/2018 Ver.2.0 & relevant IEC standards.	<p><b><u>M/s PHOENIX CONTACT:</u></b> <b>Type-3 (Class-D)</b> Surge Protection Devices for data line from reputed makes like OBO, Phoenix, DHEN or similar or any other RDSO recommended makes must be adopted. SPD provided shall be as per specification no. RDSO/SPN/215/2018 Ver.2.0 &amp; relevant IEC standards.</p> <p><b>Remark:</b> All SPD's must be in accordance to IEC latest standards i.e., IEC 61643-11-2011.</p> <p>As per BIS / IEC 61643-11-2011 / NBC-2016, Type/Class of SPD must be written on SPD housing and it should be like Type-1 (T1), Type-2 (T2) and Type-3 (T3).</p> <p>Now, SPD should be read as:</p>	SPD provided should be as per RDSO specifications no.- RDSO/SPN/215/2018 Ver.2.0 & relevant IEC standards.



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

		Class-B is now Type-1 Class-C is now Type-2 Class-D is now Type-3	
7.1.(ix)	All communication and transmission of vital information should be compliant to CENELEC EN-50159 standard.		No alteration suggestion / Remarks
7.1(x)	FN-MUX shall be capable of interfacing with EI, Axle counter, TPWS, ETCS, TCAS (as SIL-4 RIU), Radio Block Centre & CTC/TMS (as FIU) and other advance systems using standard protocols.	<b><u>SECR:</u></b> CTC and TMS are proposed in many upcoming Auto sections. Necessary provisions should be introduced to repeat the signaling status from auto section to central location using FN-Mux over Railnet Ethernet for display and control though the operation control center.  <b><u>DELTRON:</u></b> TC-TMS/KAVACH are planned over most of the HDN route Auto sections, wherein signalling status needs to be aggregated from Station, LC Gates, ABS / IBS Goomties for display / remote control from a central location. FN-Mux can play a vital role in sharing the information already available with it in industry protocols like Modbus TCP or OPC over Ethernet available in Railways. Being SIL-4 certified FN-Mux can act as RIU of KAVACH systems	Agreed.

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

		and FIU of CTC-TMS to activate local interlocking circuits from remote instructions passed over from OCC. This will free the Railways from costly compulsion of replacing existing PI / EI (that may be fairly new) with new EI of OTC vendor just for digitizing the station and block signalling data in electronic format readable by CTC-TMS systems. It will be very COST EFFECTIVE, especially in sections where a more than 50-60% codal-life of the existing interlocking is left.	Interlocking capability will not be available in FnMux.
7.1(xi)	The FN-Mux must communicate with other signaling devices on RASTA protocol. Therefore, FNmux must be RASTA protocol ready. Till such time all other signaling devices are ready with RASTA protocol, FNmux must communicate using suitable standard international protocols available.	<b><u>FRAUSCHER :</u></b> Any reference to RAASTA needs to be removed protocol. If required then RASSTA shall be replaced with EuLynx that is more universal and open protocol.	Suitable standard international protocol is required.

**16.09.2022**

<b>8</b>	<b>SOFTWARE AND VALIDATION</b>		
8.1	<p>Software used in FNmux should have been developed in conformity with a software engineering standard issued by recognized standards body such as European Committee for Electro Technical Standardization (CENELEC) with special relevance to safety critical applications. The Software tool used for developing <del>application</del> <b>executive</b> software should be SIL-4 certified or ISA approved as per CENELEC standard. Particular software engineering standards used shall be specified and one complete set of such standards shall be made available to RDSO.</p> <p>The software shall conform to all the safety requirements of all the functionalities defined in the scope. Design shall ensure that during malfunction of the FNmux, not only power is removed from the output circuits in a fail-safe manner but also the processor is prevented from executing codes at random.</p>		

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

8.2	The software shall be developed in such a way that it is possible to test and validate each module independently.		No alteration suggestion / Remarks
8.3	The software shall be such that in case of variable data, the possibility of using incorrect data does not exist. Further the software should check and reject: (a) Use of data which is obsolete or meant for some earlier state of the system, and (b) Corrupted data.		No alteration suggestion / Remarks
8.4	As far as possible, program flow shall be independent of the input data. The program should preferably execute the same sequence of instructions in each cycle.		No alteration suggestion / Remarks
8.5	The use of interrupts shall be kept to a bare minimum.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

8.6	Software should include self-check procedures to detect faults in the hardware. The self-check should include the following: (a) Memory containing the vital software and data shall be checked periodically so that probability of corrupted software jeopardizing the safety of the equipment is minimized. (b) Components of the CPU such as general purpose registers program counters stack pointers, instruction register, instruction decoder; ALU etc. shall be checked periodically as far as practicable.		No alteration suggestion / Remarks
8.7	Self-check of the associated functional hardware as required by the hardware design should be performed periodically.		No alteration suggestion / Remarks
8.8	Critical and non-critical software should be segregated in the memory area so that special procedures to check the program flow may be adopted during the self-check process for the critical software.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

8.9	The following shall ensure: a)Error detection capability of data packets b) 2 out of 3 message redundancy c)Correspondence check between inverted and non-inverted signals. d) Any other techniques approved by ISA as per CENELEC EN 50126, EN 50128, EN 50129 and EN 50159 all combined together.		No alteration suggestion / Remarks
-----	---	--	------------------------------------

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

8.10	As specified in the software Engineering Standards, full documentation on Quality Assurance Program specially the Verification and Validation (V&V) procedures carried out in-house or by any independent agency should be made available to RDSO to check their conformity to standards. The agency selected must have previous experience of validating SIL-4 items for RDSO and must be approved by the Project Director, before assigning the validation work.		No alteration suggestion / Remarks
8.11	The software must check that a) Inputs to the processors are correct b) Program has been executed correctly c) Data tables have not changed d) Inputs and variable data are correct e) No program segments have been skipped f) The outputs are correct g) The outputs have not been changed by device failure in an unsafe manner h) Integrity of whole system (self-check)		No alteration suggestion / Remarks

**16.09.2022**

<b>9</b>	<b>MAINTENANCE, TESTING AND DIAGNOSTIC REQUIREMENTS</b>		
9.1	To ensure that the above safety criteria is maintained, the system shall have diagnostic checks carried out at frequent intervals, monitoring a condition giving appropriate indications and alarms.		No alteration suggestion / Remarks
9.2	A trouble-shooting chart should be provided indicating the action required to be taken for repair of the equipment corresponding to each error code.		No alteration suggestion / Remarks
9.3	Audio-visual alarm shall be provided in case of failure. The audio alarm should stop when acknowledged but the visual alarm should continue till the fault is rectified.		No alteration suggestion / Remarks



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

9.4	A system-reset switch be provided for starting the system operation and an electro-mechanical counter should be provided which should be incremented every time a reset operation is performed. System reset switch should have a sealing arrangement to prevent unauthorized operation.		No alteration suggestion / Remarks
9.5	Necessary provision shall be made in the hardware and software for modular expansion of the equipment.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

<b>10</b>	<b>TESTS AND REQUIREMENTS</b>		
10.1	Condition of Tests Unless otherwise specified all the tests shall be carried out at ambient atmospheric conditions.		No alteration suggestion / Remarks
10.2	For inspection of material, relevant clauses of IRS: S 23 and RDSO/SPN/144 Shall apply.		No alteration suggestion / Remarks
10.3	Test Equipment: Test equipments should be provided as per STR for Electronic Signaling equipment and should include the following: i) Dual beam oscilloscope of 20 MHz bandwidth ii) Digital multimeters – 3.1/2 digit display with facility of diode & transistor testing iii) Frequency counter iv) DC power supply ( $\pm$ 5V, 24V) v) EPROM Programmer and UV eraser Or Suitable Programmer with computer interface.  vi) Megger (500V) vii) LCR meter		No alteration suggestion / Remarks

**16.09.2022**

	viii) HV tester ix) Function Generation x) Digital IC tests		
10.4	Type Tests The following tests shall constitute type tests: a) Visual inspection as per Clause 10.7 b) Insulation Resistance tests as per Clause 10.8 c) Card-level functional and fail-safety tests on all the cards as per ISA guidelines and type test format d) System-level functional and fail-safety tests e) Environmental/climatic tests as per relevant clause of RDSO/SPN/144 (FNmux Central Unit (CU) &FNmux Field Unit (FU) shall be tested as outdoor Equipment). f) Applied high voltage test as per clause 10.9. Only a single FNmux Central unit (CU) and a single FNmux Field Unit (FU) shall be tested for this purpose. The equipment shall successfully pass all the type tests for proving conformity with this specification. If the equipment fails		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

	in any of the type tests, the purchaser or his nominee at his discretion, may call for another equipment/card(s) of the same type and subject it to all tests or to the test(s) in which failure occurred. No failure shall be permitted in the repeat test(s).		
10.5	<p>Acceptance Tests</p> <p>The following shall comprise acceptance tests:</p> <p>a) Visual inspection as per Clause 10.7</p> <p>b) Insulation Resistance tests as per Clause 10.8</p> <p>c) Card-level functional tests on one card of each type <b>as per ISA guidelines and acceptance test format</b></p> <p>d) System-level functional and fail-safety tests</p>		No alteration suggestion / Remarks
10.6	<p><b>Routine Tests</b></p> <p>The following shall comprise the routine tests and shall be conducted by manufacturer on every equipment and the test results shall be submitted to the inspection authority before inspection.</p>		No alteration suggestion / Remarks

**16.09.2022**

	<p>a) Visual inspection as per Clause 10.7                  b) Insulation Resistance tests as per Clause 10.8                  c) Card-level functional test on all the cards                  d) System-level functional and fail-safety tests                  e) Environmental stress screening test for PCB &amp; sub- systems as per relevant clause of RDSO/SPN/144/2006 or Latest.</p>		
<p>10.7</p>	<p>Visual Inspection                  The equipment shall be visually inspected to ensure compliance with the requirement of Clauses of this specification. The visual inspection will broadly include –</p> <p>i) System Level Checking:                  - Constructional details                  - Dimensional check                  - General workmanship                  - Configuration</p> <p>ii) Card Level Checking                  - PCB laminate thickness                  - General track layout                  - Quality of soldering and component mounting                  - Conformal coating &amp; shielding</p>		

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

	<ul style="list-style-type: none"><li>- Legend printing</li><li>- Green masking</li><li>iii) Module Level Checking</li><li>- Mechanical polarization</li><li>- General shielding arrangement of individual cards</li><li>- Indications and displays</li><li>- Mounting and clamping of connectors</li><li>- Proper housing of cards</li></ul>		
10.8	Insulation Resistance Test Insulation Resistance test shall be carried out as per relevant clause of RDSO/SPN/144/2006 or Latest.		
10.9	Applied High Voltage Test Applied High Voltage Test shall be carried out as per relevant clause of RDSO/SPN/144/2006 or Latest.		No alteration suggestion / Remarks
<b>11</b>	<b>QUALITY ASSURANCE</b>		No alteration suggestion / Remarks
11.1	All materials shall be of the best quality and the workmanship shall be of the highest class as per QAP standards laid down by RDSO.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

11.2	The equipment shall be manufactured as per quality assurance procedure laid down so as to meet the requirement of the specification.		No alteration suggestion / Remarks
11.3	Amongst other requirements of the specification, validation and system of monitoring of QA procedure shall form a part of type approval. The necessary Plant, Machinery and Test Instruments as given below shall be available with the manufacturer.		No alteration suggestion / Remarks

**16.09.2022**

<b>12</b>	<b>PLANT &amp; MACHINERY</b>		
	Test equipments should be provided as per STR for Electronic equipment and should include the following: i) Wave soldering station ii) Burn in chamber iii) Dry heat and Humidity chambers iv) Cold chamber v) PCB assembling zig vi) Anti-static assembly vii) EPROM/Micro-controller Programmer <b>or Suitable Programmer with computer interface</b> viii) UV Eraser if required ix) Microprocessor development system or IDE for the CPU / MCU used x) Computer aided design system		
12.1	Test Instruments: All test instruments as given in Clause 10.3 shall be available with the manufacturer. Along with the prototype sample for type test, the manufacturer shall submit the Quality Assurance Manual, Operation, Maintenance & Fault Repairing Manuals.		No alteration suggestion / Remarks



**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

13	<b>PACKING:</b> As per relevant clause of RDSO/SPN/144/2006 or Latest.		No alteration suggestion / Remarks
14	<b>INFORMATION TO BE SUPPLIED BY THE MANUFACTURER:</b>		No alteration suggestion / Remarks
14.1	Documentation as per relevant clause of RDSO/SPN/144/2006 or Latest.		No alteration suggestion / Remarks
14.2	The manufacturer should supply the following information: a) Design approach for the system; b) Functions achieved in hardware & software; c) Mode of interaction between hardware & software; d) Salient features through which fail safety has been achieved e.g. use of a watchdog timer, automatic shutdown etc. & e) Proof of safety.		No alteration suggestion / Remarks

**Reasoned Document for RDSO/SPN/211/2021 Ver-1.0(d10) of FNmux**

**16.09.2022**

15	<p><b>OPTIONS TO BE SPECIFIED BY THE PURCHASER:</b></p> <p>a) Medium on which FNMUX is intended to work single/dual OFC</p> <p>b) Depending on the inter nodal distance, the type of OFC cable (Single / Multi mode) used.</p> <p>c) Whether there shall be Dual Redundant OFC ring through diverse routes or only a single ring.</p> <p>d) Numbers of inputs &amp; outputs and application.</p> <p>e) The number of FNmux Central Unit (CU) and the number of FNmux Field Unit (FU) to be deployed.</p>		No alteration suggestion / Remarks
16	<p><b>VENDOR-CHANGES IN APPROVED STATUS:</b></p> <p>(Compliance of Document No - QO-D-8.1-11)</p> <p>All the provisions contained in RDSO's ISO procedures laid down in Document No. QO-D-8.1-11 (title "Vendor-Changes in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendors in the contracts floated by Railways to maintain quality of products supplied to Railways.'</p>		No alteration suggestion / Remarks

**16.09.2022**

Figure 1	Block Working diagram of CU with FU		No alteration suggestion / Remarks
----------	-------------------------------------	--	--