6 - 14 Report on the Improvement of MPS in ADS Linear Accelerator

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The precursory project of ADS proton linear accelerator is the device to provide intense proton beams for the entire transmutation system, which has the figures of intense beam and high energy. As a result, a continuous deflected beam with a certain intensity would decline the performance of the accelerator devices or even make damages within 20 µs. In order to prevent this kind of problem, an integrate machine protection system with functions of state monitoring and timely beam cutting is required to protect accelerator devices.

The Machine Protection System (MPS) was built in 2015 and has been implemented until now, as well as improved several times. It can be seen that in Fig. 1 is the principle block diagram of MPS, in which there are Fast Machine Protection System (FMPS) and PLC interlock protection two parts. The FMPS is the core of entire MPS, while the PLC interlock protection is the backup and complement of FMPS.

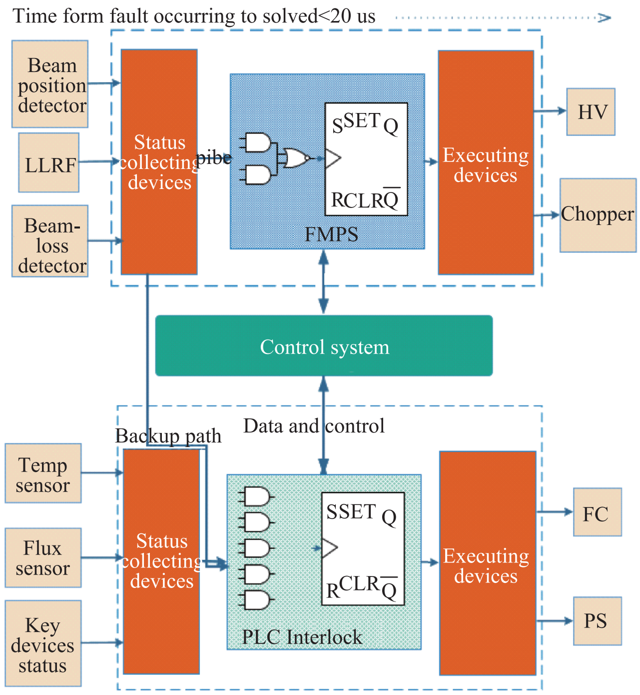

Fig. 1 Principle Block Diagram of MPS.

Although the MPS could meet the basic requirement of implementation, there still were drawbacks in FMPS and PLC. The FMPS was built based on FPGA and connected directly with devices. The state signal of devices were transmitted by cables and uploaded by serial servers. Therefore, there were three main problems emerged, which were insufficient device interface, low capability of anti-interference and incomplete failure log record. Regarding to PLC interlock protection system, due to the frequent and nonstandard design, there were also multiple issues. As for hardware, the function partitioning of cabinets were illogical and wiring diagrams were not matched with cables, which would lead to be hard to find certain cables. As for software, the main problem that the status of fault signals cannot be locked, led inconvenience in maintenance. In conclusion, the reliability and availability of the entire system were reduced by all these factors, and an improvement was required as soon as possible.

The entire system were improved roundly in 2016. The new FMPS, based on the MIS control system developed by SINAP (Shanghai Institute of Applied Physics, Chinese Academy of Sciences), aimed to collect status of key devices, cut beam with chopper and enable relevant protection devices. Sub-system developed by control department took the responsibility of pre-processing the status information received from devices and uploading them to MIS in one signal, as well as uploading the real-time processing information by internet. Photoelectric conversion modules located on the basic layer transmitted the fault signals of devices in two ways, one way to FMPS to cut beam, another to PLC, which can be seen clearly in Fig. 2. The system is developed in tree structure with fibers distribution that benefitted from expandability of the tree structure, reliability and anti-electromagnetic interference of fiber transmission. MIS received signals of sub-system, and sent order to chopper to cut the beam, as well as operated IS and other protection devices, such as setting HV to zero and inserting the FC. Operations of filtering, reset and bypass of master control system and sub-system could all be implemented on PC interface by operators through the internet.

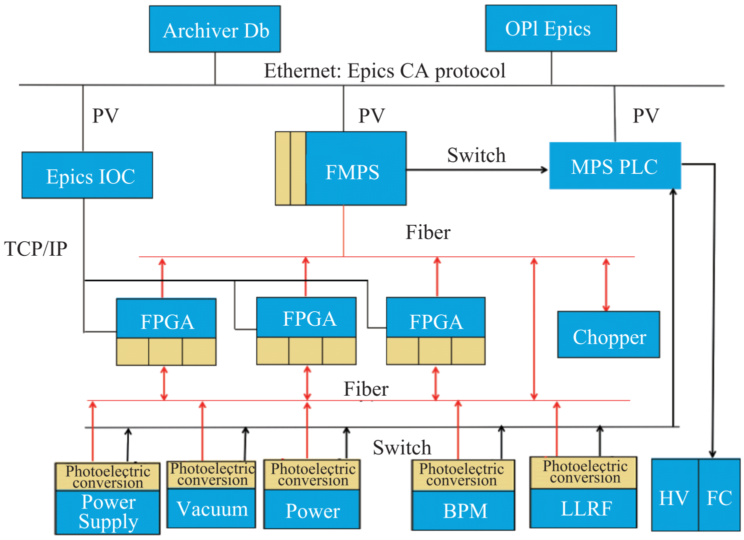

Fig. 2 FMPS Layout.

The improvement of PLC interlock mainly focused on cable reorganization and program optimization. As for hardware, there are three main improvements. Firstly, reorganizing layouts of cabinets based on the functions and firming to ensure devices correct and firm. Secondly, standard wiring and label, as well as re-drawing cabinet drawing to make it convenient to check. Last but not least, reorganizing cables out of cabinets with rules of as short as possible and one point grounding to reduce interference signals. Regarding to software, four parts of optimizing are implemented. First is signal locking function that means that once fault signal was received it will be locked, only if unlocking it manually after the problem solved. Second improvement is debounce function. Some signals with frequent jitter were designed to alarm only if it beyond the limit for a certain time, which could be set manually, that increased the availability of the system. This improvement were also applied in sub-system of FMPS. Thirdly, faults signals will be sent as soon as detected, instead of sending in period. Last one is BYPASS function that fault signals could be bypassed remotely to avoid disturbance of experiment.

The verification results of FMPS improvement is shown in Fig. 3. It can be seen that the time from receiving fault signals to implementation of beam cutting is less than 3.1 μs (3.08 μs is measured), which is less than the requirement of 10 μs. The improvement of MPS was verified in 25 MeV experiment, which included locating fault source quickly, convenient operation, less system recovering time and timely and exact reaction.

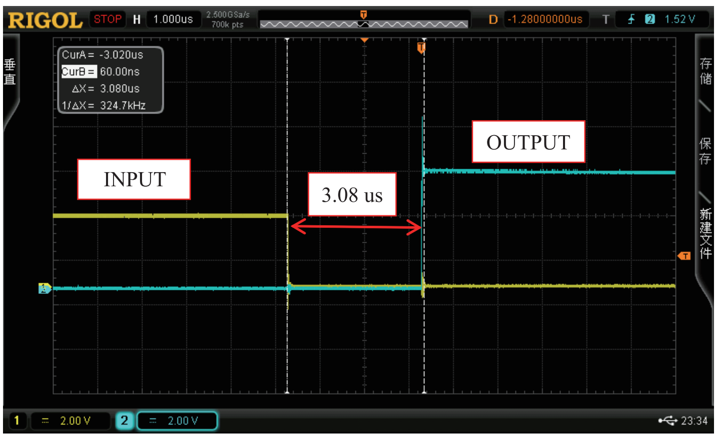

Fig. 3 Response Time of FMPS.

In conclusion, after this optimizing, the reliability and availability were both improved obviously, that could meet the requirements preliminarily. Nevertheless, there still are some capabilities could be improved, such as multiple operation models and more functions of sub-board of FMPS. All these work will be the improvement direction and where our effort will focus on.