Trigger Selection System for CBM-TOF Super Module Quality Evaluation

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I. Background

Super module (SM) detector is used in the Time-of-Flight (TOF) spectrometer for charged hadron identification at the Compressed Baryonic Matter (CBM) experiment. Each SM consists of several Multi-gap Resistive Plate Chambers (MRPCs) and provides up to 320 electronic channels in total for high-precision time measurement. During the mass production, the quality of each SM should be evaluated. For the convenience of testing and analyzing the MRPCs, the conventional frontend triggered mode is adopted. In this triggered system, the discriminated MRPC signals passing the frontend thresholds are digitized by the TDC and the digitized time data are buffered in the TDC. Around the same time, a global trigger signal is generated and distributed to the TDC for selecting the effective time data from the buffer according to their arrival time. In order to meet these requirements, we present a three-level architecture trigger selection system based on the quality evaluation system.

II. System Overview

The trigger system is organized in two hierarchies, which include Time-to-Digital Converter (TDC), the TDC readout motherboard (TRM), and the trigger module (TM), as shown in Fig. 1.The first part is data aggregation and distribution network(ADN) with star topology. In the first hierarchy, one TDC receives 32-channel hit signals from the MRPC and extracts mean-timer signals. Then the TDC sends these signals to the TRM for further processing. The TRM collects the mean-timer signals from 10 TDCs in the same sandwich TDC station (STS) through golden finger connectors. These signals are processed by the algorithms built in high density FPGA devices to generate sub-trigger information. Optical links are employed to transmit sub-trigger information to the next hierarchy, since optical fiber has the advantage of electric isolation and reducing the electro-magnetic interference (EMI). In the second hierarchy, a master-slave structure is planned. It consists of several trigger modules (TMs) and a global trigger module (GTM). Both TM and GTM are designed as 6U PXI plugins. TM receives the sub-trigger information from the TRM and forwards it to the GTM transparently. These sub-trigger information is aggregated in the GTM for generating a global trigger signal with a proper selection algorithm. Then the global trigger signal is distributed to TDCs for selecting the effective time data from the raw hit data buffer.

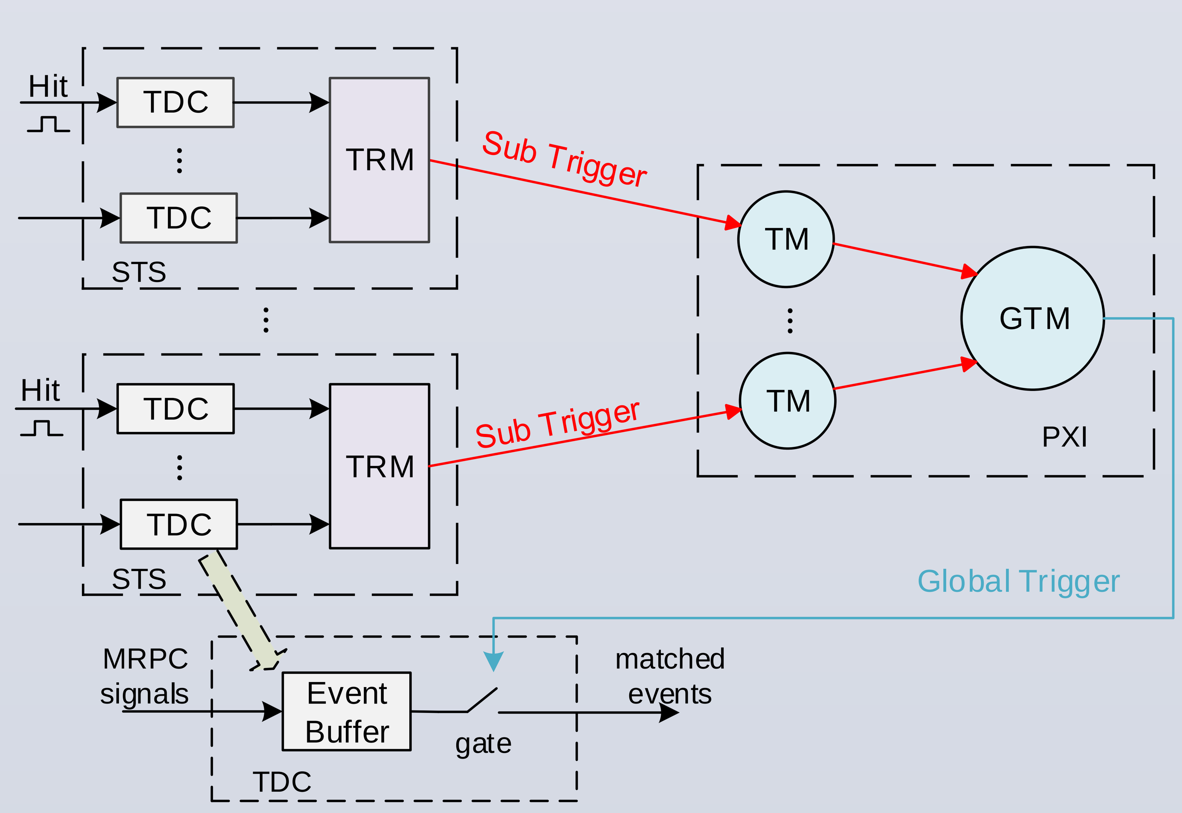

Fig. 1.Structure of the evaluation software

Though the TM and the GTM play different roles in the distribution network, they have similar architecture. In order to simplify the design, the TM and the GTM can be implemented in one board and share the same circuit design. According to the architecture of quality evaluation system, a prototype of the TM is designed as a standard PXI-6U plugin, as show in Fig. 2. The PXI-Trigger bus is used to transfer sub-trigger signals from the TM to the GTM. By using the backplane trigger bus, it will save front panel space and reduce the number of connectors, making the system much more flexible and compact. Besides, TM and GTM also provides the function of clock and global trigger distribution for quality evaluation system.

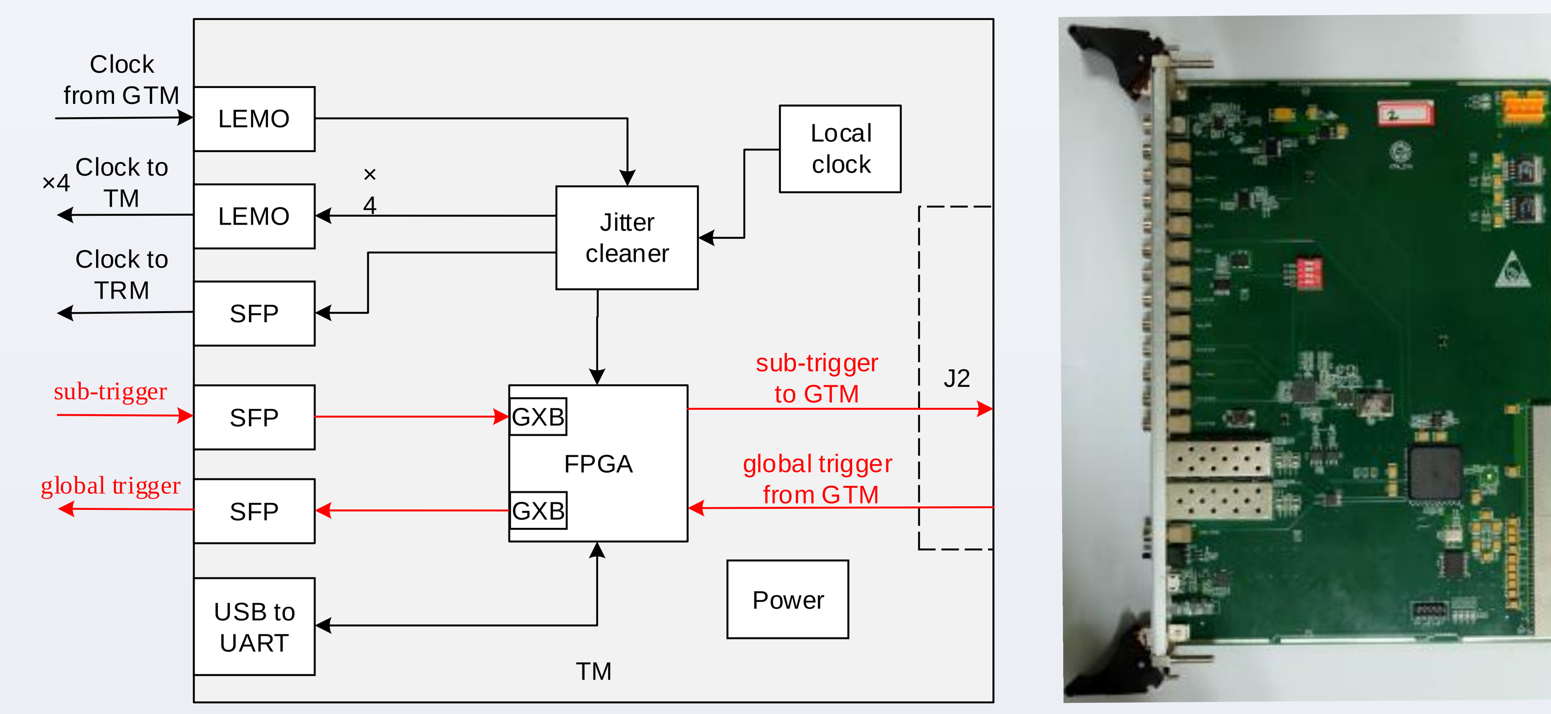

Fig. 2. Left: Block diagram of the TM. Right: Photograph of the TM

When there is only one STS system, sub-trigger signal is equivalent to global trigger signal for quality evaluation system. But if there are multiple STS systems, we can generate global trigger from sub-trigger signals by the same way in which we generate sub-trigger signal from hit signals.

III. Process of The System

In the SM detector, every MRPC includes 32 readout strips. When a particle strike on one strip of the MRPC, two hit signals will be collected by the front-end electronics on the both ends. Because of the different transmission distance, the arrival time of two hit signals is different with each other. The maximum transmission delay between the two hit signals is approximately 1.35 ns, according to the 27 cm length of strip and the 50 ps/cm transmission speed of signal on strip. In order to eliminate this delay, we designed a expand logic to expand every hit signal to 10 ns, and generate a mean-timer signal through "AND" logic. In one TDC, there are 16 mean-timer signals, which are transmitted to TRM for further processing. Each TRM collects these mean-timer signals from 10 TDCs in the same STS, and every 32 mean-timer signals from two adjacent TDCs are processed by an "OR" logic to generate a hit effective signal. After summing the number of hit effective signals within several time periods (can be user defined), a hit number signal is generated which will be encoded to generate sub-trigger signal. The coding algorithm depends on the location of MRPCs. Because MRPCs in our SM detector are placed vertically, a sub-trigger signal will be generated only when hit number is equal to 5.

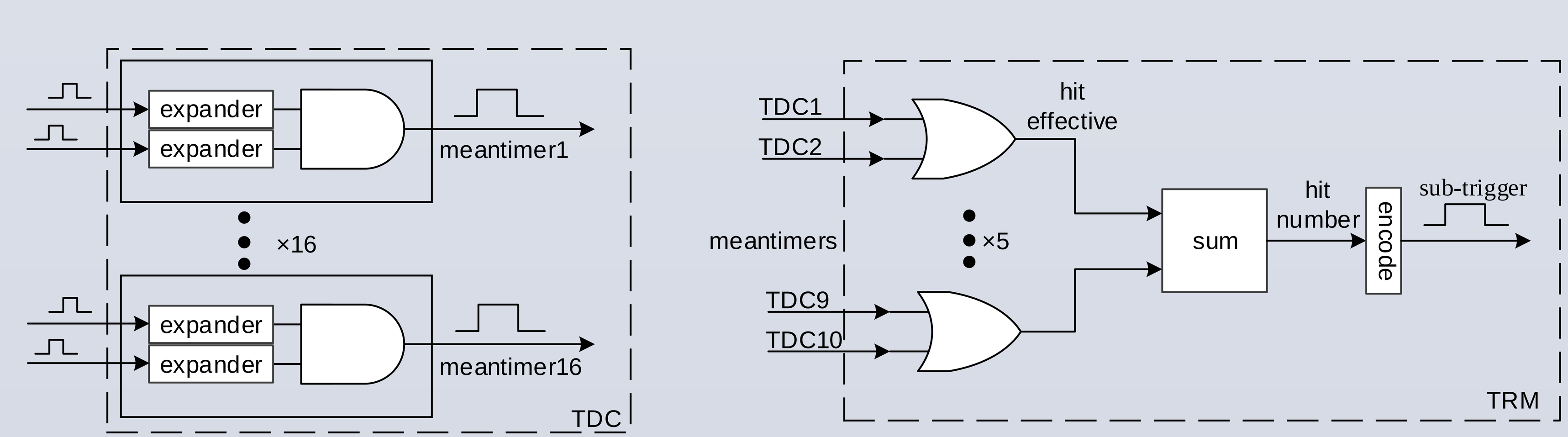

Fig. 3. Left: Trigger processing in TDC. Right: Trigger processing in TRM

IV. Conclusion

A hierarchical structure trigger selection system has been designed for CBM-TOF Super Module Quality Evaluation. The overall trigger selection function is organized in two hierarchies, which makes it easy to further extend the system. We also conducted laboratory tests and initial commissioning tests with the detectors to validate the trigger selection function, and the results indicate that this system works well.

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