GEM Electronics Review

Charge

Guidance and a recommendation has been requested whether preference should be given to the INFN/MPD or to the CERN/SRS readout system for the rear GEM tracker of the SBS setup.

- Cost comparison is given in the report. Are there missing costs (such as licensing fees)?
- Are the timelines reasonable?
- Capability and integration into JLab standard DAQ software (CODA)?
- Does it meet the technical requirements of 5kHz DAQ rate with 50% occupancy and noise charge of less 3500 e (RMS) averaged over the module.
- Support needed from outside groups to maintain system.
- Ability to upgrade and use in future experiments.

Remarks

Both systems (SRS and MPD) are fairly mature and have been demonstrated to work well within certain bounds. Both systems seem to perform with similar quality. Both systems need to be modified to deal with the higher design data rates and data volumes. Some of the most significant problems affect both readout systems, namely the required development of fast optical links in order to provide sufficiently high readout speed.

The SRS system has been advocated within the RD51 collaboration, which is a broad community. The large-scale version has been licensed to a company (EicSys GmbH) which plans to implement outstanding tasks to make the system more scalable and faster. The timelines for some of these upgrades however need to be made shorter if the system is used for SBS.

The MPD system has been a development by INFN dedicated to the SBS project. It is the same system that is used for the front tracker, which is the responsibility of INFN. Also here the production of the hardware is provided by a company (EES), however the hardware support and firmware development expertise lies within the collaboration (INFN). Regardless of the decision which system to prefer for the rear tracker, all of the issues and R&D tasks identified for the MPD system will be worked out and implemented in any case.

The development of the optical connection to Jlab/SSP modules could still be implemented in a later phase. The distance of the VME system can be up to 20m, compared to 5m for the ATCA blades. The APV voltage regulators for the MPD version are already radiation-hard.

Cost

There is not much difference in the anticipated cost to build either readout system (SRS and MPD). There are some additional costs to provide the R&D in case of SRS. It is not clear if there are fees involved to provide support for the SRS system in the further course of the project. Most of the R&D required for the MPD system is already covered under the front tracker activities.

Speed

In either case (SRS or MPD), some R&D is needed to provide the ultimate readout speed of 5-10 kHz at 100% occupancy and 3-frame APV readout. For a readout speed of 5 kHz at 100% occupancy (no zero suppression) and 3 APV frames, one APV produces 6 MB/s. A total of 480 APVs for the rear tracker will produce a data volume of 2880 MB/s. There are several 1Gb/s (128 MB/s) limits consituting bottlenecks at present in both the SRS and MPD systems.

One MPD processes 15 APVs = 90 MB/s per MPD module. In the present layout, 11 MPD modules are hosted in a VME64x crate, however the bus limit here is 200 MB/s. The upgrade concept is to use FPGA resources on the MPD to use the optical link on the MPD as a 10 Gb/s ethernet connection, i.e. the data will be transferred to JLab SSP modules via optical cable. The VME-hosted SSPs with VXS extension have a 5 Gb/s or 640 MB/s limit, i.e. one needs 5 SSP/VXS combinations in total.

One SRS/ATCA blade processes 48 APVs = 288 MB/s per blade. Currently the connection from the ATCA blade to the SRU is limited to 1 Gb/s = 128 MB/s which limits the rate to 2.2 kHz. It is planned to increase this link to 10 Gb/s. The SRU to DAQPC (or CODA ROC) connection is 10 Gb/s. Up to four ATCA blades will be read out by one SRU to stay below this limit. A total of 10 ATCA blades (for 480 APVs) then requires three SRU/PC combinations.

Noise

The noise levels of the MPD system seem to be slightly worse than with the SRS system, although it is hard to tell exactly when comparing the noise behavior under the same condition (that of the final geometry!) is not possible at this time. Under idealized conditions the noise levels of both systems seem adequate.

The noise in the MPD system does not seem to be dominated by the cable length, but with channels near the edges of the APV chips or the connectors which can exceed the average rms noise by factors. This can result in local inefficiencies for identification of charge clusters. (In OLYMPUS, which had used an earlier version of the APV frontend board with four 32-channel Panasonic connectors, increased noise has been seen in channels near the edges of these connectors.) I recommend that the noise results for both SRS and MPD be presented for a configuration as close as possible to the final version (long HDMI cable for the MPD, relocated ADCs for the SRS system), upgrades with optical links. It would be great if it was possible to prototype the proposed upgrades in order to study the ultimate noise in both systems.

Future use

The ATCA infrastructure for SRS is less common at JLab as opposed to the VME64x technology used for MPD. Since the MPD technology will be used in any case for the front tracker, it is easier to build the local expertise at JLAb to utilize and support the system, and to consider its further use. It would save some manpower to make work and optimize only one system instead of two. So it seem that the VME-based MPD system is more optimized for the JLab environment. There is more experience and support. It requires less manpower.

The MPD system has been a dedicated development for the SBS project. The system has worked well in an earlier version realized for the GEM detectors in OLYMPUS. There are noise-related issues that provide the main challenges to the operation and performance of GEMs. The readout speed is an issue for both the MPD and SRS systems but reasonable plans are in place to sustain 5kHz of readout rate at 50% occupancy without zero suppression.

The SRS sytem will likely be further developed by RD51 to adopt the new VMM chip favored by ATLAS.

It is therefore timely to complete the necessary R&D for the SRS APV readout as soon as possible, given that there are uncertainties in the priorities of SRS developments. One can also argue that participating in the SRS R&D effort for SBS provides a path forward with access to new developments.

There is already substantial expertise for the SRS system present with the UVa group with Dr. Gnanvo and graduate students. Interfacing to the CODA system requires additional manpower with guidance from the local expert Dr. Camsonne.

Conclusion

Overall the required R&D amount seems less with the MPD system. It is mostly FPGA firmware development. Sustained support for the MPD system can be expected since the INFN group is a core member of the SBS collaboration and already responsible for the front tracker. Further support by CERN or the licensed company (EicSys GmbH) may or may not result in further costs. Direct support by CERN is questionable since the hardware system has already been licensed out.

I am usually supporting diversity and am favoring heterogenous systems in order to avoid single point of failures. However, I can see more advantages with the MPD system than disadvantages. Therefore, I am leaning toward preferring the MPD system. Since the MPD system is already used and will be supported by the INFN collaborators, doubling of the R&D work can be avoided by choosing the MPD system.