0.1 Strips Off-detector Readout/Control Electronics and Interfaces to TDAQ

0.1.1 Scope

The Strips readout and control electronics are part of the common ITk DAQ system, shared with Pixels and detailed in the Common DAQ section **??**. This section deals with Strip-only functionality, and finer details of the Strip system.

Strips have their own FE chipset, data transfer protocols and link archtecture. Strips also send DCS data on their readout links.

0.1.2 Strips Architecture

On the detector, within a module, a hybrid hosts 10-14 ABC ASICs connected to the silicon strips. After receiving a trigger, the ABC ASICs they pass their data to an HCC ASIC at the end of the hybrid, where it is aggregated, formatted, 8B/10B encoded and transmitted via 640Mb serial e-links to the GBTx(s) at the end of the structure (EoS). Data sent from an HCC consists of variable length packets - each containing a single data type (and a single event for the event-data type), with lengths expected to be less than 50 bytes, averaging between 15 and 30 bytes. The predominant type (by bandwidth) will be event-data, but other types include register-readback, calibration data, DCS data and warnings/alerts.

For readout purposes, each HCC operates as an independent unit, transferring data when ready, without any awareness of the other HCCs and sending data using its own e-link. This means that, because of variations in occupancy, and regional readout, events will not be transferred at the same time, and are therefore not aligned in time.

The LpGBTx aggregates up to 14 640Mb e-links onto a 10Gb optical fibre [1], transporting the data to the counting room using the CERN VL+ optical transmission system. The physical transmission and protocol used are internal to LpGBT/VL+ chipsets and detailed elsewhere **??**.

DCS data from the HCC and ABC ASICs is also transported over these links. Further DCS data will also travel from the modules using a different route, but ultimately by the via the GBTx and readout fibre.

During power up, power ASICs on the modules will need to be setup to apply power to the HCC and the the ABCs. This communication is via the GBTx, via the downlink fibres, but under the control of DCS. Once the HCC is up, more detailed DCS information can be opbtained, allowing the ABCs to powering to be co-ordingated. [Peter really should look at this!]

Connection off-detector is via the FELIX.

0.1.3 Strips-FELIX

The the FELIX provides a generic platform for multi-function, multi-detector use. In the Strips case, it provides the only, with the exception of interlocks, path for controlling and monitoring the detector. FELIX makes provision for sub-detector specific firmware and interfaces, and will need to be able to provide a reliable path to DCS, and mechanisms for decoding Strips specific data.

As Strips will be using the GBT/VL+ physical links and protocols, the Strips-FELIX provides end-to-end GBT- to Ethernet-protocol conversion.

The GBT frames are then passed to Strips specific firmware for expansion into the component e-links, decoding of the custom data encoding/format and processing.

Strips expects 4-8k GBT uplinks, and each FELIX is expected to handle about 100 links, so we expect to have 40-80 FELIX units in the system.

0.1.4 Strips-FELIX Functions

FE-frame interface, decoding: With use of a CERN library (GBT-FPGA [1]) it is expected that FELIX core firmware will decode the bulk GBT frames, making the error detected/corrected data available via a standardised interface. The first stage of the Strips-FELIX firmware will be to demultiplex the GBT frames into their component e-links.

Data-type handling: In most cases data flows through FELIX to the Data Handler, but with a few important exceptions. In addition to the data-types detailed in the common DAQ section **??**, Strips have 2 more:

- **DCS data:** This is considered high priority (although not critical) for detector safety [better way of saying this DCS not DSS?]. This data will be queued separately from other data, and be passed to the DCS subsystem (external to FELIX) via a dedicated and/or prioritised connection. Data will need to be formatted for DCS handling as per the DCS spec ([**?**]) [need to check with DCS regarding (OPC-UA?)

ODB?? servers etc.] More in the Monitoring section in nthe common part (**??**).

- **L1Track data:** When a regional trigger is used, high priority data for L1Track will arrive with its own type. This will need to make use of a DOLL (zzz) path to the L1Track formatters. This type of data can optionally be duplicated and also be sent on as standard data to the Data Handler. Once physics event-data has been separated from the other types of data coming from the on-detector electronics, the data from events and regions identified as useful to L1Track must be filtered and copied from the main data-stream and sent to the L1Track processor. This data-path has the tightest latency requirement in the readout system.

0.1.5 Calibration

As per common, but Strips calibration may be able to benifit from hit counters inside the ABC

Calibration Data Volume: Much of the time spent in calibration is in changing registers on the front-end ASICs. For Strips this is about 128 registers per chip (32 bit, but taking about 60 bits to send). So with 10 chips per barrel hybrid, 2 hybrids per module and 14 modules per stave side (similar size for petals), the configuration sent to each of the GBTs totals about 2.2Mbit.

Histogram data volume: the output of each burst can be stored in 1-4 bytes per channel, 72k per barrel stave. A calibration sequence will be made up of 100s of these bursts. It is not decided whether this raw data need be stored vs only a summarised version (fitted S-curves).

0.1.6 Bandwidth Estimations

Need to detail occupancy -¿ data volume, to total links etc.

0.1.7 Link Architecture and FE protocols

More on the links, including protocols.

0.1.8 L1Track Considerations

RoI readout triggers (e.g. R3) will need to be assembled and generated at more than one stage inthe system. Globally the Level-0 Trigger will broadcast RoIs, and then this list will be refined as the signalling moves closed to the physical downlink.

LTI R3 generation:

FELIX R3 generation:

References

[1] CERN GBT Team. Gbt information website. http://cern.ch/proj-gbt.