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Level–1 Calorimeter Trigger: DAQ and CMM cabling

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1 Introduction

The purpose of this note is to complete the documentation of the crates and cabling for the Level–1 Calorimeter Trigger system. The bulk of the cable naming conventions and connectivity are already well documented in a previous note [1]. That note presents all the information relating to the individual tower signals, right from detector input cables through to the digitised information going into the processor modules. This note should cover all the remaining necessary cables.

In the previous note, the layout and most of the connectivity of the receiver, pre-processor and processor crates were documented. However, there are three other crates in the system. Two are ROD crates which contain several Readout Driver (ROD) modules providing the readout of the trigger system. The other crate will contain all of the TTC interface to the central trigger system and the ROD Busy logic. The layout and connectivity of these crates will be covered in this note. The ROD crates need DAQ inputs from the processor modules, and this is done via high speed connections transferring data using the HP Glink protocol. The RODs output data to the standard ATLAS DAQ framework via optical Slink outputs. The TTC crate must be connected to all the other crates to provide the timing information, and also that crate must be connected to the RODs to form the BUSY network.

All crates are connected to one or two CANbus networks, which are controlled by a single CAN PC. The connectivity of these CANbus cables will also be covered.

Finally, each processor crate also contains merger modules (CMMs) which form the trigger bits which make up the final real–time output of the trigger system. To perform the final merging task, these modules require some inter–connectivity via cables which plug into the back of the modules via the backplane. Some of these CMMs also have to be connected to the CTP to provide it with the calorimeter trigger bits to use for its level–1 decision. These cables will also be documented here.

[1] Please send any comments and corrections to Stephen Hillier.

2 ROD Crate Layout

The overall distribution of RODs in the two ROD crates can be found in the ROD specification document [2]. There are 10 RODs in each crate, with each crate taking data from approximately half of the system. There is a slight imbalance in that some of the processor system crates produce some extra RoI outputs, which are processed by the 'system' ROD crate 1. The 10 RODs consist of 4 to take data from PPM crates, 2 from the DAQ outputs of two CP crates, 2 from the RoI outputs of two CP crates, and one ROD for each of the DAQ and RoI outputs of a Jet/Energy crate. Each crate also contains a CPU and a TCM. The slot assignment is shown in table 1, and the number of glink inputs and slink outputs in each case is also shown. The number in brackets refers to the system ROD crate, which takes the extra RoI glink inputs.

Crate Slot	Function	Source Crates for ROD crate 0 / 1	Glinks	Slinks
1	CPU			
3	PPM DAQ	0 / 1	16	4
5	PPM DAQ	2 / 3	14	4
7	PPM DAQ	4 / 5	16	4
9	PPM DAQ	6 / 7	16	4
11	CP DAQ	0 / 1	16	2
13	CP DAQ	2 / 3	16	2
15	J/E DAQ	4 / 5	18	4
17	CP RoI	0 / 1	14	2
18	CP RoI	2 / 3	14	2
19	J/E RoI	4 / 5	16 (18)	2
21	TCM			

Table 1: Slot Assignment and glink/slink numerology for RODs

The assignment of source crates to each ROD is governed by two considerations. For PPMs, one ROD crate should deal with all the data from positive eta, and one negative eta. The PPM crates with numbers 0, 2, 4 and 6 are positive eta, and go into ROD crate 0. The rest go into ROD crate 1. For the CP and Jet processing crates, it is convenient to gather all the data from two quadrants into one ROD crate. Since Jet/Energy crate 4 processes data from quadrants 1 and 3, the data from CP crates 0 and 2 should be contained in the same ROD crate, as shown in the table.

3 TTC Crate Layout

Very little has been decided about this yet, so there is not much to say for now except to give a general overview. This crate will probably contain an LTP, a TTCvi and a TTC fanout module of some description and two BUSY modules. The LTP and TTCvi will have to be connected in such a way that both local and global partition runs can be performed and also there will probably be some special calibration partition(s) for running with the calorimeters. The TTC fanout will have to produce 16 optical TTC streams. The BUSY modules will be connected to all of the RODs in the system, and produce an overall BUSY signal to be sent back to the CTP. The two BUSY modules are assigned one per ROD crate.

4 Glink Cables

The main processing modules all provide read-out data on each level–1 accept, and these data are transferred to RODs to be packaged into the standard ATLAS protocol. This data transfer is achieved by using the HP Glink high speed serial data protocol over optical cables. Each ROD can take up to 18 glink inputs, and all processor modules (PPMs, CPMs, JEMs and CMMs) produce one DAQ (or slice) glink output. Some also produce an RoI glink output, which is also handled by the RODs.

The numbering of the glink cables is based on the source module. The label is constructed as ‘mctnn’ where:

- m = module type, P for PPM, C for CPM, J for JEM, M for CMM
- c = crate number, 0–7 for PPM crates, 0–3 for CP crates, and 4–5 for JEP crates
- t = data type, D for DAQ and R for RoI
- nn = module number, 0–15 for PPMs, 1–14 for CPMs, 0–15 for JEMs and 0–1 for CMMs

The source of each glink cable is obvious from the name, giving the crate location and the logical id of the module (relating to slot number). For the processor crates, these glink cables come out of the module front panels and the DAQ and RoI outputs are clearly labelled. Each pre-processor module has its glink output on a rear transition module plugged into the back of the crate. The connectivity of the glinks going into the ROD crate is more complex (there are about 160 glinks per crate) and the full specification is given in appendix A. There are 18 glink input connectors on the ROD front panel.

5 Slink Cables

The ROD processes the DAQ and RoI data, and formats it into the ATLAS standard Slink protocol. This data is then sent out of the ROD on optical cables via a rear transition module which can contain up to four Slink optical outputs. Not all of the slink outputs are used on all RODs. As a general rule, RODs handling DAQ data require more bandwidth, and therefore most have four slink outputs to spread the data load, the exception being the CPM DAQ which is small enough to fit into two Slinks. RODs handling RoI data have to transmit far less data, and this can be packed into one slink output. However, RoI data has to be sent to two different destinations, the ATLAS ROS and the RoI builder for level–2. Therefore these RODs have two slink outputs, which both send out identical data.

The naming scheme is similar to that of the glink inputs in using the type and number of crate feeding the ROD and the data type. The label has the form 'mcts' where:

- m = crate type, P for PP, C for CP, J for JEP
- c = crate number, 0–7 for PPM crates, 0–3 for CP crates, and 4–5 for JEP crates
- t = data type, D for DAQ and R for RoI
- s = slink output, A, B, C or D

The slink outputs are labelled A–D corresponding to slink outputs 1–4 in the numbering conventions in the ROD specifications [2]. Letters are used to distinguish them from the glink inputs. The destination of all the slinks is the ATLAS ROS, except for the second copy of the RoI outputs (cables labelled C*RC or J*RC) which go to the RoI builder. The details of the slink connectivity at the back of the ROD crate is given in appendix A.

6 ROD busy cables

Each ROD produces a BUSY signal to indicate that its data buffers are filling, and so the L1As must be stopped to allow time for the RODs to catch up. A logical OR of these busy signals must be sent to the CTP in order to achieve this vetoing of triggers. This is done via two ROD busy modules in the TTC crate. Each of the 20 RODs in the system has a two pole LEMO output, and this is connected to a ROD busy module. The BUSY modules can receive up to 16 cables, but the BUSY modules are assigned one per ROD crate, so just use 10 of their inputs in each case.

The cables will be labelled in a similar way to the slink cables (using the partial form 'mct', where the meaning of the letters in the same as in section 5). The connectivity of the BUSY module inputs is shown in table 2.

BUSY Module Input Number	BUSY Cable for Module 1	BUSY Cable for Module 2
1	P0D	P1D
2	P2D	P3D
3	P4D	P5D
4	P6D	P7D
5	C0D	C1D
6	C2D	C3D
7	J4D	J5D
8	C0R	C1R
9	C2R	C3R
10	J4R	J5R
11–16	—	—

Table 2: BUSY module cable inputs

7 TTC Fanout Cables

The TTC fanout will have to produce (at least) 16 optical TTC streams. The number 16 comes from the need for a TTC signal to feed the TCMs in eight pre-processor crates, four cluster processing crates, two jet/energy processing crates and two ROD crates. The naming of these optical cables will come from the crate type and number, and so look like 'mc' where:

- m = crate type, P for PP, C for CP, J for JEP, R for ROD
- c = crate number, 0–7 for PPM crates, 0–3 for CP crates, 4–5 for JEP crates, and 0–1 for ROD crates

8 CMM to CMM cables

The final step of the real-time processing is performed in the Common Merger Modules (CMMs) which add up hit and energy sums. In order to add results across the whole system, CMMs in different crates need to communicate between each other. This is achieved by assigning one CMM of each type to be a 'system' CMM, which performs the final sums. System CMMs are connected to all the other CMMs of the same type by cables which connect to a rear transition module plugged into the back of the CMM. The four system CMMs are all located in CP crate 3 and JEP crate 5.

The rear transition module has three connectors, allowing up to three cables to be plugged into the CMM. These can act as either transmitters (for non-system CMMs) and receivers (for system CMMs). The connectors, numbered 1–3 as in the CMM documentation [3], are standard SCSI connectors, allowing simple standard SCSI cables to be used for CMM–CMM connections. The exact connectivity depends on CMM type (cluster processing, jet processing or energy processing), and in all there are 11 of these cables needed in the complete system. The source and destination connectivity is shown in table 3, along with the cable names.

Cable Name	Source CMM Crate/ID	RTM Connector	Destination CMM Crate/ID	RTM Connector	Function
th0	0 / 0	1	3 / 0	1	tau/hadron
th1	1 / 0	1	3 / 0	2	tau/hadron
th2	2 / 0	1	3 / 0	3	tau/hadron
eg0	0 / 1	1	3 / 1	1	e/gamma
eg1	1 / 1	1	3 / 1	2	e/gamma
eg2	2 / 1	1	3 / 1	3	e/gamma
en0	4 / 0	1	5 / 0	1	energy
en1	4 / 0	2	5 / 0	2	energy
jt0	4 / 1	1	5 / 1	1	jet
jt1	4 / 1	2	5 / 1	2	jet

Table 3: Inter–CMM cable names and connectivity

9 CMM to CTP cables

After the level–1 calorimeter trigger has produced all of its real-time trigger outputs, they have to be transmitted to the CTP for the final level–1 decision. The output bits are produced on the CMM front panels on one or two SCSI connectors. Only the system CMMs produce these outputs, and only in the case of the Jet CMM are both of the two connectors needed. There are four system CMMs in all, two for the CP system crate, and two for the JEP system crate, one of which is the jet processing CMM. Thus five cables are needed in all. The definition of which pins are used for which bits can be found in the CMM specifications [3]. The five cables will be labelled according to function, separated by cp and jep crates:

- cp1 — output of e/gamma CMM in crate/id 3/1
- cp2 — output of tau/hadron CMM in crate/id 3/0
- jep1 — normal jet output of CMM in crate/id 5/1 (socket #4)
- jep2 — forward jet output of CMM in crate/id 5/1 (socket #5)
- jep3 — output of energy CMM in crate/id 5/0

10 CANbus cables

To provide safety information (temperatures, voltages etc), all crates and modules are connected to a CANbus network, which is monitored and controlled by a single Level-1 CAN PC. The L1Calo system requires three CANbus networks. One is dedicated to the Receiver crates, and their control crates. One is for the L1Calo crate power supply and fan tray CAN interfaces. The final bus is for the L1Calo internal module CAN monitoring, which is connected via the TCM in each of the 16 main L1Calo crates. The number of cables needed in each case is 10, 17 and 16 respectively. Each of these chains of cables is terminated suitably at the far end from the CAN PC.

The connectivity of these three CANbuses is shown below, using the following abrieviations — RX=Receiver Crate, PP=Preprocessor crate, CP=Cluster Processing Crate, JEP=Jet/Energy Processing crate, ROD=Rod Crate:

- Receiver Bus — CAN PC, Receiver Control Crate (C-side), RX 4, RX 2, RX 6, RX 8, RX 5, RX 7, RX 3, RX 1, Receiver Control Crate (A-side)
- Power Supply Bus — CAN PC, PP 5, PP 7, PP 3, PP 1, ROD 1, ROD 0, TTC crate, JEP 1, JEP 0, CP 1, CP 0, CP 3, CP 2, PP 2, PP 0, PP 4, PP 6
- Module CAN Bus — CAN PC, PP 5, PP 7, PP 3, PP 1, ROD 1, ROD 0, JEP 1, JEP 0, CP 1, CP 0, CP 3, CP 2, PP 2, PP 0, PP 4, PP 6

A Rod Cabling, Glinks and Slinks

This appendix contains the full specification of the input and output cables to both of the ROD crates. Each ROD receives up to 18 glink inputs on the front panel, and sends out up to four Slink outputs from a rear transition module plugged into the back of the crate. For the purpose of the figures in this section, the glink inputs are numbered 1–18, and the Slink outputs are labelled 1–4, consistent with the numbering in the ROD document [2]. Note that for DAQ RODs, the slink outputs are functionally equivalent, each sending out a fraction of the data handled by the ROD, and all of these are sent directly to the ATLAS ROS. However, for RoI RODs, there are only two outputs used, and these both send out exactly the same data — each containing ALL the data for that ROD. The reason for having two identical slink output streams is that the two are sent to different destinations. One goes to the ATLAS ROS, as with DAQ data, the other is sent to the RoI Builder for level–2. It is assumed that slink output 1 goes to the ROS, and slink output 3 goes to the RoIB.

References

[1] L1Calo Group, Cable Mappings and Crate Layouts from Analogue Inputs to Processors, ATL-DA-ES-0038
`https://edms.cern.ch/document/399348`

[2] L1Calo Group, ATLAS Level–1 Calorimeter Trigger Read-out Driver, DRAFT
`http://hepwww.rl.ac.uk/Atlas-L1/Modules/ROD/ROD_spec-9U-version1_0.pdf`

[3] I.P.Brawn, C.N.P.Gee, Specification of the Common Merger Module, ATL-DA-ES-0021
`https://edms.cern.ch/document/321069`

ROD crate 0: PPM +Z, CP/JEP quadrant 1/3

Input Glink Cable	Slot Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1			P0D0				P4D0		P6D0						J4D0				J4R0		
2			P0D1		P2D1		P4D1		P6D1		C0D1		C2D1		J4D1		C0R1	C2R1	J4R1		
3			P0D2		P2D2		P4D2		P6D2		C0D2		C2D2		J4D2		C0R2	C2R2	J4R2		
4			P0D3		P2D3		P4D3		P6D3		C0D3		C2D3		J4D3		C0R3	C2R3	J4R3		
5			P0D4		P2D4		P4D4		P6D4		C0D4		C2D4		J4D4		C0R4	C2R4	J4R4		
6			P0D5		P2D5		P4D5		P6D5		C0D5		C2D5		J4D5		C0R5	C2R5	J4R5		
7			P0D6		P2D6		P4D6		P6D6		C0D6		C2D6		J4D6		C0R6	C2R6	J4R6		
8			P0D7		P2D7		P4D7		P6D7		C0D7		C2D7		J4D7		C0R7	C2R7	J4R7		
9			P0D8				P4D8		P6D8		C0D8		C2D8		J4D8		C0R8	C2R8	J4R8		
10			P0D9		P2D9		P4D9		P6D9		C0D9		C2D9		J4D9		C0R9	C2R9	J4R9		
11			P0D10		P2D10		P4D10		P6D10		C0D10		C2D10		J4D10		C0R10	C2R10	J4R10		
12			P0D11		P2D11		P4D11		P6D11		C0D11		C2D11		J4D11		C0R11	C2R11	J4R11		
13			P0D12		P2D12		P4D12		P6D12		C0D12		C2D12		J4D12		C0R12	C2R12	J4R12		
14			P0D13		P2D13		P4D13		P6D13		C0D13		C2D13		J4D13		C0R13	C2R13	J4R13		
15			P0D14		P2D14		P4D14		P6D14		C0D14		C2D14		J4D14		C0R14	C2R14	J4R14		
16			P0D15		P2D15		P4D15		P6D15						J4D15				J4R15		
17											M0D0		M2D0		M4D0						
18											M0D1		M2D1		M4D1						
Slink Output			PPM positive eta								CP/JEP Data						CP/JEP RoI				
1			P0DA		P2DA		P4DA		P6DA		C0DA		C2DA		J4DA		C0RA	C2RA	J4RA		
2			P0DB		P2DB		P4DB		P6DB						J4DB						
3			P0DC		P2DC		P4DC		P6DC		C0DC		C2DC		J4DC		C0RC	C2RC	J4RC		
4			P0DD		P2DD		P4DD		P6DD						J4DD						
BUSY cable			P0D		P2D		P4D		P6D		C0D		C2D		J4D		C0R	C2R	J4R		

Figure A.1: ROD crate 0, inputs and outputs

ROD crate 1: PPM -Z, CP/JEP quadrant 2/4

Input Glink Cable	Slot Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1			P1D0				P5D0		P7D0						J5D0				J5R0		
2			P1D1		P3D1		P5D1		P7D1		C1D1		C3D1		J5D1		C1R1	C3R1	J5R1		
3			P1D2		P3D2		P5D2		P7D2		C1D2		C3D2		J5D2		C1R2	C3R2	J5R2		
4			P1D3		P3D3		P5D3		P7D3		C1D3		C3D3		J5D3		C1R3	C3R3	J5R3		
5			P1D4		P3D4		P5D4		P7D4		C1D4		C3D4		J5D4		C1R4	C3R4	J5R4		
6			P1D5		P3D5		P5D5		P7D5		C1D5		C3D5		J5D5		C1R5	C3R5	J5R5		
7			P1D6		P3D6		P5D6		P7D6		C1D6		C3D6		J5D6		C1R6	C3R6	J5R6		
8			P1D7		P3D7		P5D7		P7D7		C1D7		C3D7		J5D7		C1R7	C3R7	J5R7		
9			P1D8				P5D8		P7D8		C1D8		C3D8		J5D8		C1R8	C3R8	J5R8		
10			P1D9		P3D9		P5D9		P7D9		C1D9		C3D9		J5D9		C1R9	C3R9	J5R9		
11			P1D10		P3D10		P5D10		P7D10		C1D10		C3D10		J5D10		C1R10	C3R10	J5R10		
12			P1D11		P3D11		P5D11		P7D11		C1D11		C3D11		J5D11		C1R11	C3R11	J5R11		
13			P1D12		P3D12		P5D12		P7D12		C1D12		C3D12		J5D12		C1R12	C3R12	J5R12		
14			P1D13		P3D13		P5D13		P7D13		C1D13		C3D13		J5D13		C1R13	C3R13	J5R13		
15			P1D14		P3D14		P5D14		P7D14		C1D14		C3D14		J5D14		C1R14	C3R14	J5R14		
16			P1D15		P3D15		P5D15		P7D15						J5D15				J5R15		
17											M1D0		M3D0		M5D0				M5R0		
18											M1D1		M3D1		M5D1				M5R1		
Slink Output			PPM negative eta								CP/JEP Data						CP/JEP RoI				
1			P1DA		P3DA		P5DA		P7DA		C1DA		C3DA		J5DA		C1RA	C3RA	J5RA		
2			P1DB		P3DB		P5DB		P7DB						J5DB						
3			P1DC		P3DC		P5DC		P7DC		C1DC		C3DC		J5DC		C1RC	C3RC	J5RC		
4			P1DD		P3DD		P5DD		P7DD						J5DD						
BUSY cable			P1D		P3D		P5D		P7D		C1D		C3D		J5D		C1R	C3R	J5R		

Figure A.2: ROD crate 1, inputs and outputs