



Nuclear Physics Division
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DIRC Data Format

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14 July 2016

1. Readout Data Format

The readout data format utilizes the same encoding scheme defined for the JLAB FADC250. The word length for the readout data is 32bits. The event length is variable and depends on several factors (detector occupancy, headers, trailers, filler words).

Data Word Categories

Data words from the module are divided into two categories: Data Type Defining (bit 31 = 1) and Data Type Continuation (bit 31 = 0). Data Type Defining words contain a 4-bit data type tag (bits 30 - 27) along with a type dependent data payload (bits 26 - 0). Data Type Continuation words provide additional data payload (bits 30 - 0) for the *last defined data type*. Continuation words permit data payloads to span multiple words and allow for efficient packing of various data types spanning multiple data words. Any number of Data Type Continuation words may follow a Data Type Defining word.

Data Type List

0	Block Header
1	Block Trailer
2	Event Header
3	Trigger Time
4	Reserved
5	Reserved
6	Reserved
7	Device ID
8	TDC Hit
9	ADC
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Data Not Valid (empty module)
15	Filler Word (non-data)

Data Type: Block Header

Type: 0x0
 Size: 1 word
 Description: Indicates the beginning of a block of events. (High-speed readout of a board or a set of boards is done in blocks of events)

31	30	29	28	27	26	25	24
1	0	0	0	0	SLOTID		
23	22	21	20	19	18	17	16
SLOTID		0	0	0	0	BLOCK_NUMBER	
15	14	13	12	11	10	9	8
BLOCK_NUMBER							
7	6	5	4	3	2	1	0
BLOCK_SIZE							

BLOCK_NUMBER:

Event block number (used to align blocks when building events)

BLOCK_SIZE:

Number of events in block

SLOTID:

Slot ID (set by VME64x backplane)

Data Type: Block Trailer

Type: 0x1
 Size: 1 word
 Description: Indicates the end of a block of events. The data words in a block are bracketed by the block header and trailer.

31	30	29	28	27	26	25	24
1	0	0	0	1	SLOTID		
23	22	21	20	19	18	17	16
SLOTID		NUM_WORDS					
15	14	13	12	11	10	9	8
NUM_WORDS							
7	6	5	4	3	2	1	0
NUM_WORDS							

NUM_WORDS:

Total number of words in block of events

SLOTID:

Slot ID (set by VME64x backplane)

Data Type: Event Header

Type: 0x2
 Size: 1 word
 Description: Indicates the start of an event. The included trigger number is useful to ensure proper alignment of event fragments when building events. The 21bit trigger number (2M count) is not a limitation, as it will be used to distinguish events within event blocks, or among events that are concurrently being built or transported.

31	30	29	28	27	26	25	24
1	0	0	1	0	SLOTID		
23	22	21	20	19	18	17	16
SLOTID		TRIGGER_NUMBER					
15	14	13	12	11	10	9	8
TRIGGER_NUMBER							
7	6	5	4	3	2	1	0
TRIGGER_NUMBER							

TRIGGER_NUMBER:

Accepted event/trigger number

SLOTID:

Slot ID (set by VME64x backplane)

Data Type: Trigger Time

Type: 0x3

Size: 2 words

Description: Time of trigger occurrence relative to the most recent global reset. The time is measured by a 48bit counter that is clocked from the 250MHz system clock. The assertion of the global reset clears the counter. The de-assertion of global reset enables counter and thus sets t=0 for the module. The trigger time is necessary to ensure system synchronization and is useful in aligning event fragments when building events.

Word 1:

31	30	29	28	27	26	25	24
1	0	0	1	1	0	0	0
23	22	21	20	19	18	17	16
TRIGGER_TIME_L							
15	14	13	12	11	10	9	8
TRIGGER_TIME_L							
7	6	5	4	3	2	1	0
TRIGGER_TIME_L							

TRIGGER_TIME_L:

This is the lower 24bits of the trigger time

Word 2:

31	30	29	28	27	26	25	24
0	0	0	0	0	0	0	0
23	22	21	20	19	18	17	16
TRIGGER_TIME_H							
15	14	13	12	11	10	9	8
TRIGGER_TIME_H							
7	6	5	4	3	2	1	0
TRIGGER_TIME_H							

TRIGGER_TIME_H:

This is the upper 24bits of the trigger time

Data Type: Device ID

Type: 0x7

Size: 1 word

Description: This data type contains the RICH/DIRC FPGA device ID (usually equal to the SSP fiber port number where the device is plugged into)

Word 1:

31	30	29	28	27	26	25	24
1	0	1	1	1	DEVID		
23	22	21	20	19	18	17	16
DEVID			EVENTCNT				
15	14	13	12	11	10	9	8
EVENTCNT							
7	6	5	4	3	2	1	0
EVENTCNT							

DEVID:

0-31 – Remote device identifier, used to identify the device that following ADC/TDC data is associated with

EVENTCNT:

Event counter that can be used to identify event synchronization errors

Data Type: TDC Hit

Type: 0x8

Size: 1 word

Description: This data type identifies a TDC hit

Word 1:

31	30	29	28	27	26	25	24
1	1	0	0	0	EDGE	-	-
23	22	21	20	19	18	17	16
CHANNEL_NUMBER							
15	14	13	12	11	10	9	8
TDC_TIME							
7	6	5	4	3	2	1	0
TDC_TIME							

EDGE:

‘0’ – indicates hit is a leading edge (0->1 transition as seen by FPGA)

‘1’ – indicates hit is a trailing edge (1->0 transition as seen by FPGA)

CHANNEL_NUMBER:

0-191 – indicates which channel TDC corresponds to

TDC_TIME:

1ns TDC hit timestamp which is measured relative to the beginning of the defined readout window

Data Type: ADC

Type: 0x9

Size: 33 words

Description: This data type contains the measured ADC values for all 64 channels of a single MAROC ASIC.

Word 0:

31	30	29	28	27	26	25	24
1	1	0	0	1	-	-	-
23	22	21	20	19	18	17	16
ADC_HOLD2							
15	14	13	12	11	10	9	8
ADC_HOLD1							
7	6	5	4	3	2	1	0
ADC_MAX_BITS				-	-	MAROC_ID	

ADC_HOLD2:

MAROC HOLD2 delay in 8ns ticks

ADC_HOLD1:

MAROC HOLD1 delay in 8ns ticks

ADC_MAX_BITS:

11 – 12bit ADC mode

9 – 10bit ADC mode

7 – 8bit ADC mode

MAROC_ID:

MAROC ASIC Identifier

0	3-MAROC PCB: ASIC 0, 2-MAROC PCB: ASIC 0
1	3-MAROC PCB: ASIC 1
2	3-MAROC PCB: ASIC 2, 2-MAROC PCB: ASIC 1

Word 1-32:

31	30	29	28	27	26	25	24
0	-	-	-	ADC_UPPER			
23	22	21	20	19	18	17	16
ADC_UPPER							
15	14	13	12	11	10	9	8
-	-	-	-	ADC_LOWER			
7	6	5	4	3	2	1	0
ADC_LOWER							

ADC_UPPER:

MAROC ADC value for channel: (Word-1)*2+1

ADC_LOWER:

MAROC ADC value for channel: (Word-1)*2+0

Note: 8bit and 10bit ADC modes are left justified (i.e. lower bits of 12bit reported value are unused and set 0)

Data Type: Data Not Valid

Type: 0x14

Size: 1 word

Description: Module has no data available for readout. This can if the module is being read out too quickly after receiving (event building is in process and no data words have been put into the buffer yet) a trigger or if the module doesn't have any events to report.

31	30	29	28	27	26	25	24
1	1	1	1	0	UNDEFINED		
23	22	21	20	19	18	17	16
UNDEFINED							
15	14	13	12	11	10	9	8
UNDEFINED							
7	6	5	4	3	2	1	0
UNDEFINED							

Data Type: Filler Word

Type: 0x15

Size: 1 word

Description: Non-data word appended to the block of events. This is used to force the total number of 32-bit words read out of a module to be a multiple of 2 or 4 when

31	30	29	28	27	26	25	24
1	1	1	1	1	UNDEFINED		
23	22	21	20	19	18	17	16
UNDEFINED							
15	14	13	12	11	10	9	8
UNDEFINED							
7	6	5	4	3	2	1	0
UNDEFINED							

Example block of events from a single DMA readout transaction:

```
[BLOCK HEADER n]
  [EVENT HEADER n+0]
    [EVENT TIMESTAMP0]
    [EVENT TIMESTAMP1]
    [DEVID x] [TDCHIT] ... [TDCHIT]
    ...
    [DEVID y] [TDCHIT] ... [TDCHIT]

  [EVENT HEADER n+1]
    [EVENT TIMESTAMP0]
    [EVENT TIMESTAMP1]
    [DEVID x] [TDCHIT] ... [TDCHIT]
    ...
    [DEVID y] [TDCHIT] ... [TDCHIT]
[BLOCK TRAILER n]
```

Notes:

1. [FILLER WORD] types may appear near the end of the block, used to pad events to meet DMA memory boundary requirements
2. [DNV] may appear anywhere and would indicate an invalid data word due to event data not ready for readout (should never see this if "Block Ready" flag is set before readout).
3. There can be 1 to 255 events in a block, depending on the block size used in the DAQ configuration
4. There can be 0 to 32 [DEVID] words reported, depending on how many devices are connected to the SSP fibers
5. There can be ≥ 0 [TDCHIT] words reported after any [DEVID] word