STJ List-Mode Specification

In list mode each MPX-32D's on-board SRAM is configured as two 1M x 16 independent memory buffers. As one (active) buffer is filled, the other (inactive) buffer is available for read-access from the host computer. When the active buffer becomes full, the two buffers are swapped and then the Handel driver reads the inactive buffer from each MPX-32D module in the system and appends the data to a binary file.

List mode is enabled by setting MAPPINGMODE=3. ProSpect automatically sets MAPPINGMODE=3 whenever the Mapping tab is selected, and sets MAPPINGMODE=0 whenever the MCA tab is selected.

Handel Binary File Specification

The binary file contains buffers from each MPX-32D in the system, concatenated. The read order is determined by the module numbers as identified in the INI file. A system of N MPX-32D modules with Z events in each buffer will append the following structure to the binary file each time the active buffer becomes full:

Length	Contents
256 + 8Z (max 2 Mbyte)*	Module1: Buffer X
256 + 8Z (max 2 Mbyte)	Module2: Buffer X
256 + 8Z (max 2 Mbyte)	Module3: Buffer X
…	
256 + 8Z (max 2 Mbyte)	ModuleN: Buffer X

*Note that in reality Z will vary for each module

Buffer Specification

A single buffer contains a buffer header and Z event records, up to 2 MBytes total.

Length	Contents
256	Buffer Header
8	Event Record 1
8	Event Record 2
…	
8	Event Record Z

Buffer Header

Updated for DSP CODEREV==10 on September 11, 2017!

Each buffer starts with a 256-word buffer header. The contents of the header are defined below. Note that the buffer header specification has evolved over time. The format can be keyed to the DSP code revision and variant, located at locations 13 and 14, respectively.

Word Number	Contents
0	Header Tag Word 0: 0x55AA
1	Header Tag Word 1: 0xAA55
2	Buffer Header Size (=256)
3	Mapping Mode: 3: General List-Mode
4	Run Number
5-6	Sequential Buffer Number (low word first)
7	BufferID: 0 or 1, representing the 2 1Mx16 SRAMs
8	Number of Events in buffer
9-10	Starting Event Number (low word first)
11	Module #
12	AMREV – STJ Preamplifier CPLD revision
13	CODEREV==10 – MPX-32D DSP code revision
14	CODEVAR==0 – MPX-32D DSP code variant
15	SYSREV – MPX-32D System FPGA revision
16	SYSVAR – MPX-32D System FPGA variant
17	FIPPIREV – MPX-32D Pulse-Processor FPGA revision
18	FIPPIVAR – MPX-32D Pulse-Processor FPGA variant
19	Sampling Interval (TRACEWAIT+1) in 20 ns units (only relevant when LISTMODEVAR = 8 or 9) **…or in 8*MUXPERIOD*20 ns units (LISTMODEVAR=10)**
20	**UltraLo_TPC_MUX8 only**: MUXPERIOD – multiplexer clock interval in 20 ns units. Sub-channel sampling interval is 8*MUXPERIOD*20 ns, e.g. 800 ns (1.25 MHz) for the default MUXPERIOD=5.
21-24	Reserved (set to 0)
25-26	Total number of words in buffer, not including buffer header (least significant word first)
27-31	Reserved (set to 0)
32-63	SETSTJDAC – STJ bias voltage (per-channel, signed 2's complement with 0.25 μV units)
64	List-mode variant: 2 (Energy + Time Stamp) 3 (Energy + Interval Time Stamp) 8 (Trace Readout)
65	Words per Event (for now always 8)
66	Number of Events in buffer (same as word 8, for Handel compatibility)
67	POLARITY (global)

68	DECIMATION (global, Slow Filter Decimation Factor)
69	BLFILTERLEN (global, # samples in the Baseline Average)
70	SLOWLEN (global, sets the Peaking Time) Peaking Time = $2^{DECIMATION}$ * SLOWLEN * 20 ns
71	SLOWGAP (global, sets the Gap Time) Gap Time = $2^{DECIMATION}$ * SLOWGAP * 20 ns
72	PEAKINT (global, sets the Pileup Inspection Interval) Pileup Inspection Interval = $2^{DECIMATION}$ * PEAKINT * 20 ns
73	PEAKMODE (global, sets the Peak Sampling Mode) Peak Sampling Mode = 0 (sensing) or 1 (sampling)
74	PEAKSAM (global, sets the Sampling Time if PEAKMODE=1) Pileup Inspection Interval = $2^{DECIMATION}$ * PEAKSAM * 20 ns
75	FASTLEN (global, sets the Fast Peaking Time) Fast Peaking Time = FASTLEN * 20 ns
76	FASTGAP (global, sets the Fast Gap Time) Fast Gap Time = FASTGAP * 20 ns
77	MAXWIDTH (global, set the Maximum Width pileup constraint) Maximum Width = MAXWIDTH * 20 ns
78-79	Reserved (set to 0)
80	BANK0CHANENA – Bitwise enables for channels 0-7, e.g. 0xFF means channels 0-7 are enabled for list-mode data acquisition
81	BANK1CHANENA – Bitwise enables for channels 8-15
82	BANK2CHANENA – Bitwise enables for channels 16-23
83	BANK3CHANENA – Bitwise enables for channels 24-31
84	BANK0TRACEENA – Bitwise trace enables for channels 0-7, e.g. 0xA5 means trace acquisition is enabled for channels 0,2,5 and 7 (only relevant when LISTMODEVAR = 8 or 9)
85	BANK1TRACEENA – Bitwise trace enables for channels 8-15
86	BANK2TRACEENA – Bitwise trace enables for channels 16-23
87	BANK3TRACEENA – Bitwise trace enables for channels 24-31
88	BANK0ADCGAIN – Sets the Analog Gain for channels 0-7 Analog Gain = 0.5*10^((BANKnADCGAIN – 5)/20)
89	BANK1ADCGAIN – Sets the Analog Gain for channels 8-15
90	BANK2ADCGAIN – Sets the Analog Gain for channels 16-23
91	BANK3ADCGAIN – Sets the Analog Gain for channels 24-31
92	BANK0ADCNYQ – Sets the Nyquist frequency for channels 0-7, 2 (7 MHz), 6 (10 MHz), 10 (14 MHz), 14 (filter disable)
93	BANK1ADCNYQ – Sets the Nyquist frequency for channels 8-15
94	BANK2ADCNYQ – Sets the Nyquist frequency for channels 16-23
95	BANK3ADCNYQ – Sets the Nyquist frequencyfor channels 24-31
96-127	STJZERO – STJ zero offset voltage (per-channel, signed 2's complement with 0.25 μV units)
128-159	THRESHOLD – Fast Filter Threshold (per-channel, arbitrary

	units)
160-191	SLOWTHRESH – Slow Filter Threshold (per-channel, arbitrary units)
192-223	RCTAU – Preamplifier Decay Time (per-channel, integer μs units)
224-255	RCTAU – Preamplifier Decay Time (per-channel, fractional μs units, i.e. RCTAU/65536) e.g. RCTAU = 6, RCTAUFRAC = 32768 → Decay Time = 6.5 μs

Event Record

The event data begins right after the buffer header, starting with an Event Tag Word. For simplicity we'll use verbose event records, which are easy to use but inefficient. We're running at relatively low count rates so it shouldn't matter much. The verbose event record length is 8 16-bit words, allowing for up to 131,040 events per buffer. Note that the number of events per buffer can be set to a lower value such that the host switches buffers before the active buffer is full. The list-mode variant is set via the parameter LISTMODEVAR in the DSP Parameters window.

List-Mode Variant 2: Energy + Real Time Stamp

LISTMODEVAR=2

Each event record includes an event energy and a real timestamp, i.e. the time elapsed since the run was started, along with channel identification and status info.

Word Number	Contents
0	Event Tag Word 0: 0xEEEE
1	Channel identifier
2	Status, i.e. external logic input state
3	Energy
4 to 7	**Real** Time Stamp: 64-bit value with 20 ns units, least significant word first

List-Mode Variant 3: Energy + Interval Time Stamp

Updated September 8, 2017!

LISTMODEVAR=3

Each event record includes an event energy and an interval timestamp, i.e. the time elapsed since the last rising edge on the exernal logic (GATE) input, along with channel identification and status info. This mode also supports an additional (new) setting: A user programmable blanking interval after each GATE edge, during which input events are ignored, can be imposed by setting the DSP parameter "GATEWAIT" non-zero. It's a 16-bit value with microsecond units, so the maximum supported blanking time is ~65.5 ms. Note that the setting can be saved manually to the INI file by adding the following live above "END 0" in the [default definitions] section:
GATEWAIT = X
where X is the blanking time in microseconds, ranging from 0 (default) to 65535 (6.5535 ms)

Word Number	Contents
0	Event Tag Word 0: 0xEEEE
1	Channel identifier
2	Status, i.e. external logic input state
3	Energy
4 to 5	**Interval** Time Stamp: 32-bit value with 20 ns units, least significant word first (maximum interval is 85.9 seconds)
6 to 7	GATE ID: 32-bit value, least significant word first (the number of GATE rising edges detected since run started)

List-Mode Variant 8: Trace Readout

LISTMODEVAR=8

Each event record includes the channel and event identifier and a triggered trace of the selected type and length. Note that traces are captured as quickly as possible, but by no means are all events captured even at moderate input count rates.

Note that all of the trace settings from the Scope panel apply here as well:

Trace Type, Sampling Interval, Trigger Type and Trigger Position

Also the Trace Length can be modified via the DSP Parameter TRACELEN (default 4096 points, valid 512-8192 points)

Finally note that the system can easily be overwhelmed by data at moderate input count rates if many channels are enabled. Channels can be disabled by setting bits 0-7 of BANKnTRACEENA to zero. For example to enable traces on channels 0 and 11 only, set:

BANK0TRACEENA = 0x01

BANK1TRACEENA = 0x08

BANK2TRACEENA = 0x00

BANK3TRACEENA = 0x00

Word Number	Contents
0	Event Tag Word 0: 0xEEEE
1	Channel identifier
2,3	Event Identifier: 32-bit value, least significant word first
4 to TRACELEN+3	Trace Data: TRACELEN data words

List-Mode Variant 9: UltraLo TPC → Trace Readout + Timestamp

LISTMODEVAR=9

Each event record includes the channel, event identifier, 64-bit time-stamp and a triggered trace of the selected type and length.

Trace Length can be modified via the DSP Parameter TRACELEN (default 4096 points, valid 512-8192 points)

Word Number	Contents
0	Event Tag Word 0: 0xEEEE
1	Channel identifier
2-3	Event Identifier: 32-bit value, least significant word first
4-7	Time Stamp: 64-bit value (always 320 ns units!), least significant word first
8 to TRACELEN+7	Trace Data: TRACELEN data words

List-Mode Variant 10: UltraLo TPC MUX8 → Trace Readout + Trigger Status + Timestamp

LISTMODEVAR=10

Each alpha generates 8 event records, each of which includes the MPX-32D channel, event identifier, 64-bit time-stamp, 64-bit trigger status, and a triggered compound trace comprising de-multiplexed, sequential, data of the selected type and length from the 8 sub-channels.

- Three triggering scenarios are supported:
  - Triggered by fast-filter only (THRESHOLD set properly, Trigger Type set to "Threshold", LISTDEBUG set to 0)
  - Timeout enabled, such that in the absence of alphas non-triggered traces are acquired at ~1.34 second intervals (THRESHOLD set properly, Trigger Type set to "Threshold", LISTDEBUG set to 1)
  - Triggering disabled, such that non-triggered traces are acquired as fast as possible (Trigger Type set to "Triggering Disabled")
- Trace Length can be modified via the DSP Parameter TRACELEN (default 8192 points, valid 512-8192 points)
- Note that Total Number of Pixels is in the same units as Event Identifier, whereas Mapping Pixels Per Buffer is in units 8* smaller, e.g. with 16-bit x 1M capacity, each buffer can contain a maximum of 15 events, which corresponds to Mapping Pixels Per Buffer = 120.
- Note that the buffer header has been modified to add MUXPERIOD at word number 20 (after TRACEWAIT+1 at word number 19). The per-channel sampling interval is:
  8*MUXPERIOD*(TRACEWAIT+1)*20ns
  In terms of the Scope window, real time is the displayed time multiplied by 8*MUXPERIOD.
- Standard settings (MUXPERIOD=5, TRACEWAIT=0) → 800 ns (1.25 MHz)
  With default TRACELEN=8192 → Length of each channel trace is 819.2 us
- Because the data are multiplexed, each sub-channel (SC) is digitized at a slightly different time, e.g.:
  - SC0, SC8, SC16…SC56 are digitized at time t
  - SC1, SC9, SC17…SC57 are digitized at time t+ MUXPERIOD*(TRACEWAIT+1)*20ns
    …
  - SC7, SC15, SC23…SC63 are digitized at time t+ 7*MUXPERIOD*(TRACEWAIT+1)*20ns

Word Number	Contents
0	Event Tag Word 0: 0xEEEE
1	Channel identifier
2-3	Event Identifier: 32-bit value, least significant word first
4-7	Time Stamp: 64-bit value (always 320 ns units!), least significant word first
8-11	Trigger Status: 64-bit value that is the bit-wise result of sub-channels that triggered during the global trigger coincidence window for the current event
12 to TRACELEN+11	Trace Data: TRACELEN data words