Merlin protocol extensions for University of Manchester XBPM at B21

# Command extensions

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| **Command** | **Type** | **Format** | **Description** |
| Image correction | | | |
| BCKGRND | SET/GET/CMD | 0 - 128 | Number of frames to average when collecting a background (dark) image. Currently, only power-of-2 values are supported. If a non-power-of-2 value is passed, the highest power-of-2 value smaller than the passed value will be used. Zero value is treated as one – a single background frame will be acquired.  CMD command starts background image acquisition. The set number of images will be collected, averaged and saved in the internal memory. The final background image will be sent back to the client in the standard way via the data channel.  Use BCKGRNDCORRECTION command to enable background correction. |
| BCKGRNDCORRECTION | SET/GET | 0 - 1 | Enables (1) or disables (0) background correction of the collected images. Corrected images are the result of subtraction of the background image from the raw image. |
| DETECTORSTATUS | GET | Unsigned integer. | Bit 0 – detector idle (0) / busy (1)  Bit 1 – pressure normal (0) / high (1)  Bit 2 – cooling ok (0) / failed (1)  Bit 3 – FBK ok(0) / out-of-range (1)  Bit 4 – HV ok (0) / failed (1))  Bit 5 – detector ok (0) / failed to configure properly (1)  Bit 6 – background valid (0) / invalid (1)  For B21 XBPM, bits 1, 2, 3, 4 are always 1. Bit 6 indicates whether the collected background image is valid in respect to selected image ROI and acquisition time. |
| IMAGESTOSUM | SET/GET | 0 – 128 | Number of frames to sum before sending the result to the client. This command will have effect during image (STARTACQUISITION) and profile (PROFILES) acquisition. Use 0 or 1 to avoid summing. |
| IMGAVERAGE | SET/GET | 0 – 1 | Enables (1) or disables (0) frame averaging. This command will have effect during image (STARTACQUISITION) and profile (PROFILES) acquisition. Number of frames to average is specified by IMAGESTOSUM. Currently, only power-of-2 values are supported. If a non-power-of-2 value is passed, the highest power-of-2 value smaller than the passed value will be used. |
| Image size | | | |
| ROI | SET/GET | 4 space separated (ASCII code 0x20) unsigned 16-bit integers in format  <X> <Y> <W> <H> | Contains location and size of image ROI:  X – first pixel in horizontal direction (column, 0 – sensor width – 1)  Y – first pixel in vertical direction (row, 0 – sensor height – 1)  W – width, number of columns (1 – sensor width)  H – height, number of rows (1 – sensor height) |
| SENSORSIZE | GET | 2 space separated (ASCII code 0x20) unsigned 16-bit integers in format <W> <H> | Contains sensor size in pixels:  W – width, number of columns  H – height, number of rows |

# Data channel extensions

Support of different sensor sizes, bit depth and ROI requires including extra information in the Data Frame Header which would allow for correct identification of the image data received from the Merlin protocol compliant system. Therefore, two additional frame types are suggested: IMG frames will be sent if acquisition is started with either STARTACQUISITION or BCKGRND commands and PRF frames will be sent if the PROFILES command is used. It is also suggested that the acquisition header is expanded due to the new acquisition modes introduced by the command extensions presented in this document.

Note that the Medipix3 specific fields are kept in IMG and PRF frame headers in attempt to keep them compatible with that sensor. It might be worthwhile to consider making these frame formats as generic as possible – in case more Merlin-like systems appear with various sensor configurations.

## Acquisition Header

The changes listed below will be made in the Acquisition Header.

1. Acquisition Type will include the summation and averaging modes, for example “normal sum” will indicate that image summation is active and “profile average” will respectively indicate that profiles of averaged images are calculated.
2. Frames Summed is the new field that will indicate how many images are summed or averaged. This field will be added between Frames in Acquisition and Trigger Start fields.
3. Correction field will indicate if any corrections are applied to the data. Currently the values “none” and “background” will be implemented. This field will be added between Dead Time File and Acquisition Type fields.

## IMG frame type

It is a generic image data frame. The Data Frame Header has the following structure:

<frame\_number>,<counter\_number>,<start\_time>,<duration>,<x>,<y>,<width>,<height>,<depth>,<pixel\_size>,<Th0>,<Th1>,<DAC001>,<DAC002> … <DAC025>

where

<frame\_number>, <counter\_number>, <start\_time>, <duration>, <Th…> and <DAC…> fields are as described in TDI-CTRL-TNO-0041 “Single Chip Medipix Software Design” document and the same as in 12B, 24B, P12 and P24 headers,

* <x> and <y> are the coordinates of the top left pixel of an image (start of the region of interest) in ASCII representation of the unsigned 16-bit integer (max 5 digits),
* <width> and <height> are the size of the ROI in ASCII representation of the unsigned 16-bit integer (max 5 digits),
* <depth> is the ASCII representation of pixel depth in bits (unsigned integer, max 3 digits),
* <pixel\_size> is the ASCII representation of pixel size in bits (unsigned integer, max 3 digits).

The Data Frame Header is followed by pixel data in the binary little-endian format with the number of bytes per pixel equal to <pixel\_size>/8.

## PRF frame type

It is a generic profile data frame. The Data Frame Header has the following structure:

<frame\_number>,<counter\_number>,<start\_time>,<duration>,<x>,<y>,<width>,<height>,<depth>,<pixel\_size>,<Th0>,<Th1>,<DAC001>,<DAC002> … <DAC025>,<profile\_select>

where

* <profile\_select> is as described in “MEDIPIX3-based X-ray Beam Profiler” design specification, i.e. it is a 5 characters wide ASCII representation of 16-bit unsigned integers whose bits set to 1 indicate which data is included in the data load as follows: Bit 0 – image, Bit 1 – raw X profile, Bit 2 – raw Y profile, Bit 3 – I0 (image sum),
* other fields are as defined in the “IMG frame type” section.

If Bit 0 of <profile\_select> is set to 1 then the image data included in the data load are formatted as described in the “IMG frame type” section.