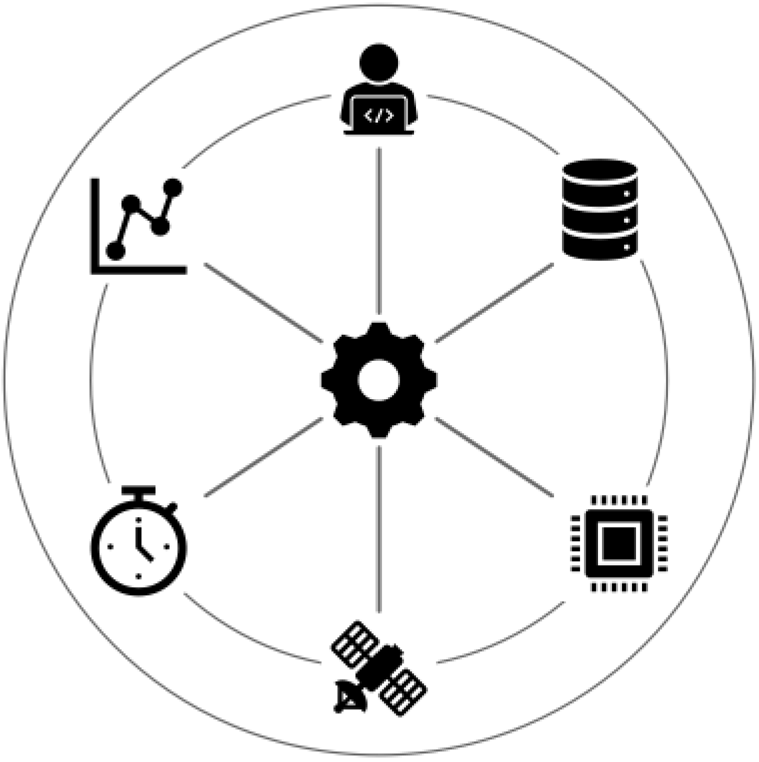

Common-EGSE

Interface Control Document

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Chapter 1. TODO

- [ ] Describe the format of the FITS files containing CCD data
- [ ] Describe the format of the HDF5 files containing SpaceWire data from the N-FEE
- [ ] Describe the interface to the Storage, i.e. the expected keys for the dictionaries that are passed like `prep` and `item`…

Chapter 2. Abstract

This document describes the software and hardware interfaces for the PLATO Common-EGSE, which is used at CSL and the test houses at IAS, INTA and SRON.

This ICD defines all the connections between the components in the instrument test setup that interface with the Common-EGSE. It defines these interface in terms of hardware, i.e. cables, connectors, electrical properties, and in terms of software, i.e. communication protocols, message buffers, timing, data formats etc.

Chapter 3. The Storage Data Interface

The Storage Manager

Table 1. Top-level keys that are mandatory or optional in the 'item' argument of the following Storage methods.

key	register	unregister	new_registration	read	save	get_filenames
origin	required	required	required	required	required	required
prep	required		required	required	required	required
persistence_class	required		required			
persistence_objects	created [1]	used[2]		used[2]	used[2]	used[2]
persistence_count[3]	optional					
data					required	
filename[4]	optional					
select				required		

[1] — The persistence_objects key is created during registration and used internally to manage all the persistent objects that are associated to the item.
[2] — This key which was created during registration is used to perform an action on the persistent objects associated with this item.
[3] — When the persistent_count is provided in the item, the file is treated specially. The file will not be cloned when an observation is started, nor will it be cycled when a new day is started. Basically, the file is created once and not cloned, cycled or closed. An example is the obsid-table.txt which is used by the configuration manager.
[4] — When the filename key is present, the file will be created with the given name in the folder provided by the FILE_STORAGE_LOCATION field for the Storage manager in the Settings. By default, this is the $PLATO_DATA_STORAGE_LOCATION environment variable, but that can be changed in the local settings (which is not preferred!).

In the following example you can see how to check the registrations on the Storage Manager and which persistence_objects are associated with each of the registered items. This particular example is during an observation run and therefore each registered item has a persistent object in the daily folder, and one in the obs folder for the observation 299. It is also clear that the obsid-table.txt is only in the top-level data folder because it was created with the persistence_count key.

```
[plato-data@plato-arrakis 20220701]$ sm_cs status --full
Storage Manager:
```

```
  Status: active
  Hostname: 129.175.66.182
  Monitoring port: 6101
  Commanding port: 6100
  Service port: 6102
  Storage location: /data/IAS
  Registrations: ['SYN-HK', 'SYN', 'obsid', 'CM', 'PM', 'CDAQ9184', 'FOV',
'DAQ6510', 'ZONDA',
    'KSC101', 'PTC10', 'EQ99', 'TCS', 'TCS-HK', 'DAS-PTC10', 'AEU-CRIO', 'AEU-PSU1',
'AEU-PSU2',
    'AEU-PSU3', 'AEU-PSU4', 'AEU-PSU5', 'AEU-PSU6', 'AEU-AWG1', 'AEU-AWG2', 'N-
FEE_SPW', 'DPU',
    'N-FEE-HK', 'FW8SMC4']
Filenames for all registered items:
  SYN-HK     ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_SYN-HK.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_SYN-HK_20220701_132613.csv')]
  SYN        ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_SYN.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_SYN_20220701_132613.csv')]
  obsid      ->  [PosixPath('/data/IAS/obsid-table.txt')]
  CM         ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_CM.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_CM_20220701_132613.csv')]
  PM         ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_PM.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_PM_20220701_132613.csv')]
  CDAQ9184   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_CDAQ9184.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_CDAQ9184_20220701_132613.csv')]
  FOV        ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_FOV.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_FOV_20220701_132613.csv')]
  DAQ6510    ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_DAQ6510.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_DAQ6510_20220701_132613.csv')]
  ZONDA      ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_ZONDA.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_ZONDA_20220701_132613.csv')]
  KSC101     ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_KSC101.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_KSC101_20220701_132613.csv')]
  PTC10      ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_PTC10.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_PTC10_20220701_132613.csv')]
  EQ99       ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_EQ99.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_EQ99_20220701_132613.csv')]
  TCS        ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_TCS.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_TCS_20220701_132613.csv')]
  TCS-HK     ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_TCS-HK.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_TCS-HK_20220701_132613.csv')]
  DAS-PTC10  ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_DAS-PTC10.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_DAS-PTC10_20220701_132613.csv')]
  AEU-CRIO   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-CRIO.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-CRIO_20220701_132613.csv')]
  AEU-PSU1   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU1.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU1_20220701_132613.csv')]
  AEU-PSU2   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU2.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU2_20220701_132613.csv')]
```

```
  AEU-PSU3   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU3.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU3_20220701_132613.csv')]
  AEU-PSU4   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU4.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU4_20220701_132613.csv')]
  AEU-PSU5   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU5.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU5_20220701_132613.csv')]
  AEU-PSU6   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-PSU6.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-PSU6_20220701_132613.csv')]
  AEU-AWG1   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-AWG1.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-AWG1_20220701_132613.csv')]
  AEU-AWG2   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_AEU-AWG2.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_AEU-AWG2_20220701_132613.csv')]
  N-FEE_SPW  ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_N-
FEE_SPW_01903.hdf5')]
  DPU        ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_DPU.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_DPU_20220701_132613.csv')]
  N-FEE-HK   ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_N-FEE-HK.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_N-FEE-HK_20220701_132613.csv')]
  FW8SMC4    ->  [PosixPath('/data/IAS/daily/20220701/20220701_IAS_FW8SMC4.csv'),
PosixPath('/data/IAS/obs/00299_IAS/00299_IAS_FW8SMC4_20220701_132613.csv')]
An observation is registered: IAS_00062_00299
Total disk space: 1.718 TiB
Used disk space: 183.215 GiB (10.41%)
Free disk space: 1.452 TiB (84.50%)
[plato-data@plato-arrakis 20220701]$
```

Chapter 4. Data Format

4.1. The format of the FITS files

During the camera tests, the DPU will be configured such that a specific part of the E- and/or F-side of the selected CCDs will be transmitted (in the form of SpW packets) for a specified number of cycles. The following information will be reconstructed from these SpW packets and stored in FITS files:

- transmitted image data of the selected side(s) of the selected CCDs, for all cycles;
- transmitted serial pre-scan data of the selected side(s) of the selected CCDs, for all cycles;
- transmitted serial over-scan data of the selected side(s) of the selected CCDs, for all cycles;
- transmitted parallel over-scan data (if any) of the selected side(s) of the selected CCDs, for all cycles.

While the SpW packets come in, the individual exposures are stored in individual extensions in FITS files that carry "images" in their name. This type of data arrangement is called a "flat structure". When there’s a change in crucial parameters, a new FITS file will be constructed (with "cube" in its name), based on the flat-structure FITS file, in which the exposures are aggregated into cubes. The original, flat-structure file will be removed from the system. For analysis, only the FITS files with the cubes will be available, and therefore only the structure of these will be discussed in the section below.

Each of the extensions (apart from the `PRIMARY` extension) will occur only once and comprise a 3D data array and a header with the metadata that is specific to that extension. The name of an extension will reflect what type of data product it comprises (e.g. image data of the F-side of CCD2, serial pre-scan data of the E-side of CCD3, etc.). The following extensions can be included in the FITS files:

- [ ] descibe the slicing strategy and how this is handled in the commanding

4.1.1. Crucial Parameters

4.1.2. FITS Filenames

4.1.3. Slicing Strategy

4.2. The format of the HDF5 files

The HDF5 files contain the raw data that is read out from the camera through the spacewire interface that is connected to the front-end-electronics (FEE).

In contrast to the FITS files, which are organised around the image data, the HDF5 files are organised around the readout sequence and the telemetry that is sent out by the camera. Each

HDF5 file contains exactly one readout sequence, i.e. four frames in external sync mode and one frame for internal sync. The data is not processed, but the raw data packets are saved as an Numpy array of type `uint8`, all values are unsigned integers of 8 bits, i.e. a byte.

Inspecting the HDF5 files can be done with the `h5py` module or you can use the CGSE module `egse.h5` which provides convenience functions to work with HDF5 files. We normally use the CGSE module to explore the HDF5 files, but will provide equivalent code for inspection with the `h5py` module where possible.

egse.h5

```
>>> from egse import h5
```

h5py

```
>>> import h5py
```

Let's take an example file from IAS taken on 7th February 2023. The file is loaded with the `h5.get_file()` function and we can visualize the top level structure as follows:

egse.h5

```
>>> h5_fd = h5.get_file("20230207_IAS_N-FEE_SPW_06174.hdf5")
>>> h5.show_file(h5_fd)
[G] 0
[G] 1
[G] 2
[G] 3
[D] dpu (104 bytes)
[D] obsid (104 bytes)
[D] register (2.109 KB)
[G] versions
Total size of Group = 159.597 MB
Total size of attributes: 0 bytes
```

h5py

```
>>> h5_fd = h5py.File("20230207_IAS_N-FEE_SPW_06174.hdf5")
>>> [x for x in h5_fd]
['0', '1', '2', '3', 'dpu', 'obsid', 'register', 'versions']
```

We can see that there are five top-level groups and three datasets. This is data taken in external sync mode, so we have four readouts per cycle. The data from each readout is in the groups 0, 1, 2, and 3. These numbers correspond to the frame number. Each of these groups has the following structure:

egse.h5

```
>>> h5.show_groups(h5_fd["/0"], max_level=1)
[G] data
[D] hk (266 bytes)
[D] timecode (104 bytes)
Total size of Group = 39.899 MB
```

h5py

```
>>> [x for x in h5_fd["/0"]]
['data', 'hk', 'timecode']
```

The `data` group contains all the SpaceWire packets that have image data, i.e. normal data packets and overscan packets. The `data` group also has the following attributes that are used to decode the SpaceWire packets into image data arrays. We will describe the `data` groups into more detail later in this section.

egse.h5

```
>>> h5.show_attributes(h5_fd["/0/data"])
DG_en: 0 (32 bytes)
ccd_mode_config: 5 (32 bytes)
ccd_read_en: 1 (32 bytes)
ccd_readout_order: 228 (32 bytes)
digitise_en: 1 (32 bytes)
h_end: 2294 (32 bytes)
int_sync_period: 2500 (32 bytes)
n_final_dump: 0 (32 bytes)
sensor_sel: 3 (32 bytes)
sync_sel: 0 (32 bytes)
v_end: 4539 (32 bytes)
v_start: 0 (32 bytes)
Total size of attributes: 384 bytes
```

h5py

```
>>> [x for x in h5_fd["/0/data"].attrs]
[
    'DG_en',
    'ccd_mode_config',
    'ccd_read_en',
```

```
    'ccd_readout_order',
    'digitise_en',
    'h_end',
    'int_sync_period',
    'n_final_dump',
    'sensor_sel',
    'sync_sel',
    'v_end',
    'v_start'
]
```

The two datasets in group `'/0'` contain the timecode and the housekeeping information that is sent on every sync pulse. The `timecode` dataset contains the timecode itself and the timestamp when this timecode was received by the DPU Processor. Remember the timecode is an integer from 0 to 63. The `timecode` dataset is an array with one integer element, the timestamp is an attribute of the `timecode` dataset. The `timecode` dataset and the timestamp can be visualised as follows.

egse.h5

```
>>> h5.get_data(h5_fd["/0/timecode"])
array(53)
>>> h5.get_attribute_value(h5_fd["/0/timecode"], "timestamp")
'2023-02-07T15:13:10.397+0000'
```

h5py

```
>>> h5_fd["/0/timecode"][()]
53
>>> h5_fd["/0/timecode"].attrs["timestamp"]
'2023-02-07T15:13:10.397+0000'
```

The raw content of the `hk` dataset can be shown as follows. The `hk` dataset has no attributes currently.

egse.h5

```
>>> h5.get_data(h5_fd["/0/hk"])
array([ 80, 240,   0, 144,   5, 130,  24,  29,   0,   0, 128,   0, 128,
         0, 128,   0, 128,   0, 128,   0, 128,   0, 127, 255, 127, 255,
       127, 255, 127, 255, 127, 255, 127, 255, 127, 255, 127, 255, 127,
       255, 128,  21,   0,   0, 128,  88, 128,  87, 128,  88, 128,  88,
       128,  88, 128,  87, 128,  88, 128,  88, 128,  85, 128,  86, 128,
        86,  57, 191, 252, 138, 250, 233, 128,  87, 128,  88,  26, 159,
```

```
       231,  93,  25, 121, 231, 110,  26, 140, 223,  53,  26, 128,  83,
       191,  64, 186,   7,  68, 251, 124,  58, 236,  10, 181,   0,   0,
       128,  87, 128,  88, 148, 193, 128,  85, 128,  89, 148, 193, 128,
        88, 128,  88, 148, 186, 128,  86, 128,  89, 148, 202, 128,  86,
       128,  87, 128,  85, 128,  89, 128,  90,   0,  53,   0,   1,  24,
        29,   0,   0,   0,   0,   0,   0,   0,   0,   0,  24], dtype=uint8)
```

h5py

```
>>> h5_fd["/0/hk"][()]
array([ 80, 240,   0, 144,   5, 130,  24,  29,   0,   0, 128,   0, 128,
         0, 128,   0, 128,   0, 128,   0, 128,   0, 127, 255, 127, 255,
       127, 255, 127, 255, 127, 255, 127, 255, 127, 255, 127, 255, 127,
       255, 128,  21,   0,   0, 128,  88, 128,  87, 128,  88, 128,  88,
       128,  88, 128,  87, 128,  88, 128,  88, 128,  85, 128,  86, 128,
        86,  57, 191, 252, 138, 250, 233, 128,  87, 128,  88,  26, 159,
       231,  93,  25, 121, 231, 110,  26, 140, 223,  53,  26, 128,  83,
       191,  64, 186,   7,  68, 251, 124,  58, 236,  10, 181,   0,   0,
       128,  87, 128,  88, 148, 193, 128,  85, 128,  89, 148, 193, 128,
        88, 128,  88, 148, 186, 128,  86, 128,  89, 148, 202, 128,  86,
       128,  87, 128,  85, 128,  89, 128,  90,   0,  53,   0,   1,  24,
        29,   0,   0,   0,   0,   0,   0,   0,   0,   0,  24], dtype=uint8)
```

The CGSE provides a module to inspect and work with PLATO SpaceWire packets. The above housekeeping packet can be inspected using the `HousekeepingPacket` class from the `egse.spw` package:

egse.h5

```
>>> from egse.spw import HousekeepingPacket
>>> hk_data = h5.get_data(h5_fd["/0/hk"])
>>> hk = HousekeepingPacket(hk_data)
>>> print(hk)
print(hk)
HousekeepingPacket:
  Logical Address = 0x50
  Protocol ID = 0xF0
  Length = 144
  Type = mode:FULL_IMAGE_MODE, last_packet:True, CCD side:E, CCD number:0,
Frame number:0, Packet Type:HOUSEKEEPING_DATA
  Frame Counter = 6173
  Sequence Counter = 0
  Data =
b'\x80\x00\x80\x00\x80\x00\x80\x00\x80\x00\x80\x00\x7f\xff\x7f\xff\x7f\xff\x7
f\xff\x7f\xff\x7f\xff\x7f\xff\x7f\xff\x7f\xff\x80\x15\x00\x00\x80X\x80W\x80X\
x80X\x80X\x80W\x80X\x80X\x80U\x80V\x80V9\xbf\xfc\x8a\xfa\xe9\x80W\x80X\x1a\x9
f\xe7]\x19y\xe7n\x1a\x8c\xdf5\x1a\x80S\xbf@\xba\x07D\xfb|:\xec\n\xb5\x00\x00\
```

```
x80W\x80X\x94\xc1\x80U\x80Y\x94\xc1\x80X\x80X\x94\xba\x80V\x80Y\x94\xca\x80V\
x80W\x80U\x80Y\x80Z\x005\x00\x01\x18\x1d\x00\x00\x00\x00\x00\x00\x00\x00\x00\
x18'
```

h5py

In this case only the retrieving of the `hk_data` is different:

```
>>> hk_data = h5_fd["/0/hk"][()]
```

Thus far we have explored the following format of the HDF5 file:

```
h5_file
  ├──────── 0
  │      ├──────── data
  │      ├──────── hk
  │      └──────── timecode
  ├──────── 1
  │      ├──────── data
  │      ├──────── hk
  │      └──────── timecode
  ├──────── 2
  │      ├──────── data
  │      ├──────── hk
  │      └──────── timecode
  ├──────── 3
  │      ├──────── data
  │      ├──────── hk
  │      └──────── timecode
  ├──────── dpu
  ├──────── obsid
  ├──────── register
  └──────── versions
         └──────── format_version
```

We haven't inspected the `versions` group yet, it currently contains only one dataset, `format_version`. This version describes the changes in the HDF5 file with respect to available groups, datasets and attributes. The format version can be accessed as follows.

egse.h5

```
>>> h5.show_attributes(h5_fd["/versions/format_version"])
major_version: 2 (32 bytes)
minor_version: 4 (32 bytes)
Total size of attributes: 64 bytes
```

h5py

```
>>> list(h5_fd["/versions/format_version"].attrs)
['major_version', 'minor_version']
>>> h5_fd["/versions/format_version"].attrs["major_version"]
2
>>> h5_fd["/versions/format_version"].attrs["minor_version"]
4
```

Up to now, the format versions have changed from 2.0 to 2.4 as follows:

```
2.0 - introduced the format_version
2.1 - Added obsid as a dataset to the HDF5 file
2.2 - Multiple commands can now be saved under the same frame number
2.3 - introduced /dpu/num_cycles attribute
2.4 - introduced /dpu/slicing_num_cycles attribute
```

Before we dive into the `data` groups, let's first inspect the three remaining datasets `dpu`, `obsid` and `register`. The `obsid` dataset contains the full observation identifier where this HDF5 file belongs to as a bytes object. If the `obsid` is empty, no observation was running.

egse.h5

```
>>> h5.get_data(h5_fd["/obsid"]).item()
b'IAS_00088_00938'
```

h5py

```
>>> h5_fd["/obsid"][()]
b'IAS_00088_00938'
```

The `dpu` dataset contains DPU Processor specific parameters that are needed to properly process the data. These parameters are available as attributes to this dataset and are mainly used by the FITS generation process.

egse.h5

```
>>> h5.show_attributes(h5_fd["/dpu"])
num_cycles: 10 (32 bytes)
slicing_num_cycles: 0 (32 bytes)
Total size of attributes: 64 bytes
```

h5py

```
>>> list(h5_fd["/dpu"].attrs)
['num_cycles', 'slicing_num_cycles']
>>> h5_fd["/dpu"].attrs["num_cycles"]
10
```

Finally, the `register` dataset is a Numpy array that is a mirror of the register memory map in the N-FEE at the time of the sync pulse.

egse.h5

```
>>> h5.get_data(h5_fd["/register"])
array([ 17, 187,   0, ...,   0,   0,   0], dtype=uint8)
```

h5py

```
>>> h5_fd["/register"][()]
array([ 17, 187,   0, ...,   0,   0,   0], dtype=uint8)
```

The content of the `register` dataset can be inspected using the `RegisterMap` class from the CGSE. If you are using a slightly older version of the CGSE, your output might looks different, i.e. not in a nicely formatted table. The content is however the same.

```
>>> import rich
>>> from egse.reg import RegisterMap
>>> reg_data = h5.get_data(h5_fd["/register"])
>>> reg = RegisterMap(name="N-FEE", memory_map=reg_data)
>>> rich.print(reg)
┏━━━━━━━━━━━━━━━━┳━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━┳━━━━━━━━━┓
┃ Register       ┃ Parameter                     ┃ HEX     ┃
┡━━━━━━━━━━━━━━━━╇━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━╇━━━━━━━━━┩
│ reg_0_config   │ v_start                       │ 0x0     │
│ reg_0_config   │ v_end                         │ 0x11bb  │
│ reg_1_config   │ charge_injection_width        │ 0x64    │
│ reg_1_config   │ charge_injection_gap          │ 0x64    │
│ reg_2_config   │ parallel_toi_period           │ 0x36b   │
│ reg_2_config   │ parallel_clk_overlap          │ 0xfa    │
│ reg_2_config   │ ccd_readout_order             │ 0xe4    │
│ reg_3_config   │ n_final_dump                  │ 0x0     │
│ reg_3_config   │ h_end                         │ 0x8f6   │
│ reg_3_config   │ charge_injection_en           │ 0x0     │
```

```
| reg_3_config  | tri_level_clk_en               | 0x0    |
| reg_3_config  | img_clk_dir                    | 0x0    |
| reg_3_config  | reg_clk_dir                    | 0x0    |
| reg_4_config  | packet_size                    | 0x7d8c |
| reg_4_config  | int_sync_period                | 0x9c4  |
| reg_5_config  | Trap_Pumping_Dwell_counter     | 0x30d4 |
| reg_5_config  | sync_sel                       | 0x0    |
| reg_5_config  | sensor_sel                     | 0x3    |
| reg_5_config  | digitise_en                    | 0x1    |
| reg_5_config  | DG_en                          | 0x0    |
| reg_5_config  | ccd_read_en                    | 0x1    |
| reg_5_config  | conv_dly                       | 0xf    |
| reg_5_config  | High_precision_HK_en           | 0x0    |
| reg_6_config  | ccd1_win_list_ptr              | 0x0    |
| reg_7_config  | ccd1_pktorder_list_ptr         | 0x0    |
| reg_8_config  | ccd1_win_list_length           | 0x0    |
| reg_8_config  | ccd1_win_size_x                | 0x0    |
| reg_8_config  | ccd1_win_size_y                | 0x0    |
| reg_8_config  | reg_8_config_reserved          | 0x0    |
| reg_9_config  | ccd2_win_list_ptr              | 0x0    |
| reg_10_config | ccd2_pktorder_list_ptr         | 0x0    |
| reg_11_config | ccd2_win_list_length           | 0x0    |
| reg_11_config | ccd2_win_size_x                | 0x0    |
| reg_11_config | ccd2_win_size_y                | 0x0    |
| reg_11_config | reg_11_config_reserved         | 0x0    |
| reg_12_config | ccd3_win_list_ptr              | 0x0    |
| reg_13_config | ccd3_pktorder_list_ptr         | 0x0    |
| reg_14_config | ccd3_win_list_length           | 0x0    |
| reg_14_config | ccd3_win_size_x                | 0x0    |
| reg_14_config | ccd3_win_size_y                | 0x0    |
| reg_14_config | reg_14_config_reserved         | 0x0    |
| reg_15_config | ccd4_win_list_ptr              | 0x0    |
| reg_16_config | ccd4_pktorder_list_ptr         | 0x0    |
| reg_17_config | ccd4_win_list_length           | 0x0    |
| reg_17_config | ccd4_win_size_x                | 0x0    |
| reg_17_config | ccd4_win_size_y                | 0x0    |
| reg_17_config | reg_17_config_reserved         | 0x0    |
| reg_18_config | ccd_vod_config                 | 0xeef  |
| reg_18_config | ccd1_vrd_config                | 0xe65  |
| reg_18_config | ccd2_vrd_config                | 0x65   |
| reg_19_config | ccd2_vrd_config                | 0xe    |
| reg_19_config | ccd3_vrd_config                | 0xe65  |
| reg_19_config | ccd4_vrd_config                | 0xe65  |
| reg_19_config | ccd_vgd_config                 | 0x9    |
| reg_20_config | ccd_vgd_config                 | 0xb1   |
| reg_20_config | ccd_vog_config                 | 0x19a  |
| reg_20_config | ccd_ig_hi_config               | 0xfff  |
| reg_21_config | ccd_ig_lo_config               | 0x0    |
| reg_21_config | trk_hld_hi                     | 0x4    |
```

```
│ reg_21_config │ trk_hld_lo                  │ 0xe     │
│ reg_21_config │ cont_rst_on                 │ 0x0     │
│ reg_21_config │ cont_cdsclp_on              │ 0x0     │
│ reg_21_config │ ccd_mode_config             │ 0x5     │
│ reg_21_config │ cont_rowclp_on              │ 0x0     │
│ reg_21_config │ reg_21_config_reserved      │ 0x0     │
│ reg_21_config │ clear_error_flag            │ 0x1     │
│ reg_22_config │ r_cfg1                      │ 0x7     │
│ reg_22_config │ r_cfg2                      │ 0xb     │
│ reg_22_config │ cdsclp_lo                   │ 0x9     │
│ reg_22_config │ adc_pwrdn_en                │ 0x1     │
│ reg_22_config │ reg_22_config_reserved_1    │ 0x0     │
│ reg_22_config │ cdsclp_hi                   │ 0x0     │
│ reg_22_config │ rowclp_hi                   │ 0x0     │
│ reg_22_config │ rowclp_lo                   │ 0x2     │
│ reg_22_config │ reg_22_config_reserved_2    │ 0x0     │
│ reg_23_config │ ccd1_last_Epacket           │ 0x0     │
│ reg_23_config │ ccd1_last_Fpacket           │ 0x0     │
│ reg_23_config │ ccd2_last_Epacket           │ 0x0     │
│ reg_23_config │ reg_23_config_reserved      │ 0x0     │
│ reg_24_config │ ccd2_last_Fpacket           │ 0x0     │
│ reg_24_config │ ccd3_last_Epacket           │ 0x0     │
│ reg_24_config │ ccd3_last_Fpacket           │ 0x0     │
│ reg_24_config │ reg_24_config_reserved      │ 0x0     │
│ reg_25_config │ ccd4_last_Epacket           │ 0x0     │
│ reg_25_config │ ccd4_last_Fpacket           │ 0x0     │
│ reg_25_config │ Surface_Inversion_counter   │ 0x64    │
│ reg_25_config │ reg_25_config_reserved      │ 0x0     │
│ reg_26_config │ Readout_pause_counter       │ 0x7d0   │
│ reg_26_config │ Trap_Pumping_Shuffle_counter │ 0x3e8  │
└───────────────┴─────────────────────────────┴─────────┘
```

The last group to inspect is the `data` group which is part of each of the readout groups. The `data` group contains all the SpaceWire packets that contain the CCD image data. The packets contain the serial prescan, serial overscan, the actual image data and the parallel overscan (if present). From the attributes of the `dpu` dataset we learned that `h_end=2294`, `v_start=0` and `v_end=4539`. The `h_end` attribute defines what is in the row data. The value `h_end=2294` means 25 pixels of serial prescan, 2255 pixels of image data, and 15 pixels of serial overscan data. Each packet in the `data` group is a Numpy array of type `uint8`, but the actual pixel data is a 16bit integer. The header of a SpW data packet is 10 bytes, so from this information we can calculate that there are 7 lines contained in each packet of length 32140. We also have data packets of 9190 bytes which contain only two rows of data.

```
>>> (32140-10)/2/2295
7.0
>>> (9190-10)/2/2295
```

```
2.0
```

We requested 4540 rows (`v_end - v_start + 1`) which is a full CCD of 4510 rows + 30 rows parallel overscan data. Image data and overscan data are sent in separate packets, so we have 644 + 1 packets of image data and 4 + 1 packets of parallel overscan data.

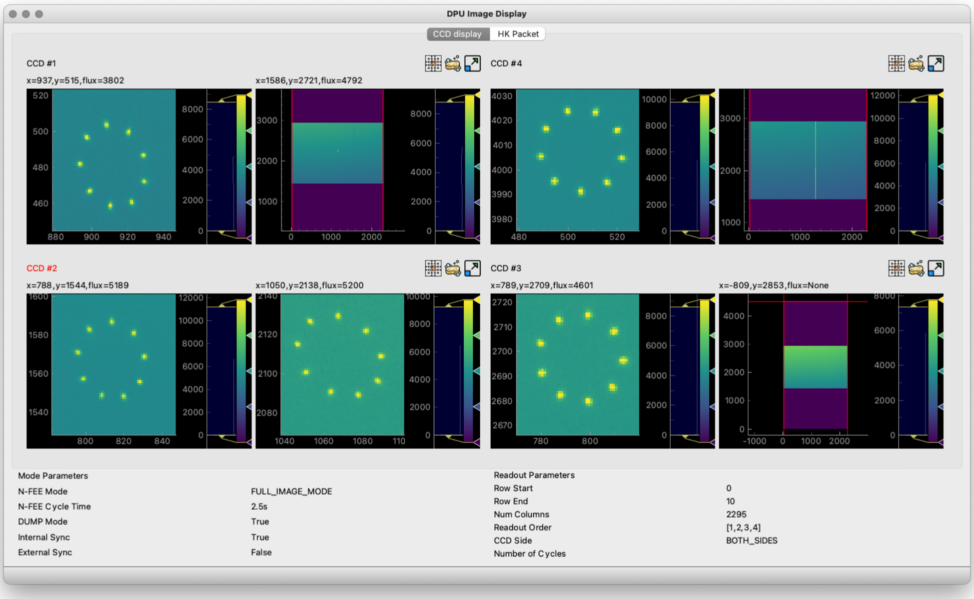
```
>>> 644*7 + 1*2  # 644 packets of 32140 bytes + 1 packet of 9190 bytes
4510
>>> 4*7 + 1*2  # 4 packets of 32140 bytes + 1 packet of 9190 bytes
30
```

This gives us a total of 650 packets for one side of the CCD, but since we requested both sides of the CCD (see `sensor_sel=3` in the `dpu` attributes or the `register` dataset above), we end up with a total of 1300 packets (datasets) in each of the `data` groups in `/0`, `/1`, `/2`, and `/3`.

```
>>> len(h5_fd["/0/data"])
1300
```

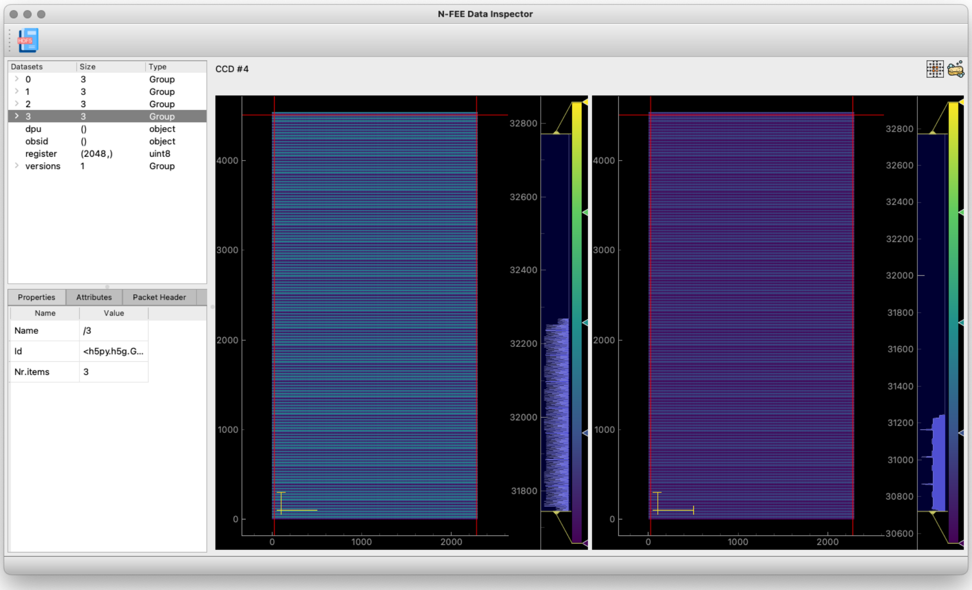
4.3. Inspecting HDF5 files with the toolset from the CGSE

So far, we have been inspecting the HDF5 files using code entered in the Python REPL. The Common-EGSE however also provides a nice GUI to visualise all groups, datasets and attributes from the PLATO HDF5 files. If you were involved in camera testing, you have probably seen the DPU Image Display GUI that in real-time updates the image data and other metadata received from the camera. The life data is constructed from the SpaceWire data packets on-the-fly, not from an HDF5 file. An example of a measurement at CSL during alignment is given in the screenshot below.

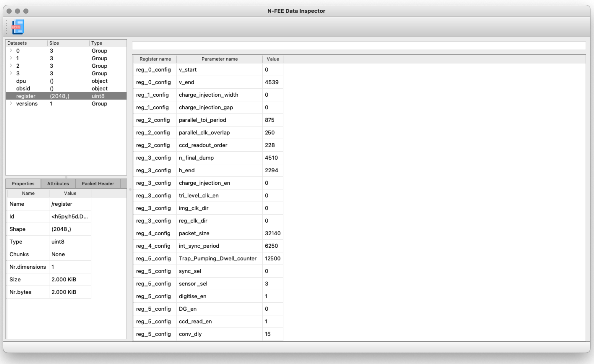


The same visualisation is provided by the stand-alone application `hdf5_ui` that can be started from the terminal. This N-FEE Data Inspector GUI re-uses parts of the code from the DPU Image Display GUI, only the data that is shown is now read from an HDF5 file. Let's explore the functionality provided by the HDF5 GUI using a dataset that was taken at CSL during Short Functional Tests (SFT), i.e. data taken with the N-FEE simulator instead of the real instrument. When the GUI starts up, select the dataset '3' which will show the simulated image data as in the screenshot below.

```
$ hdf5_ui 20221222_CSL1_N-FEE_SPW_00433.hdf5
```

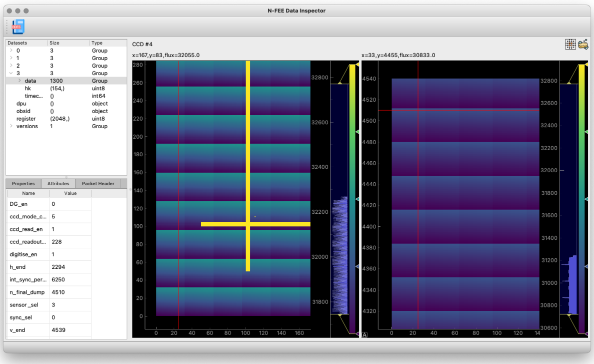


Now you can start navigating through the data by clicking and unfolding items in the upper-left panel. The screenshots below show typically some of the actions you can do and what type of data is presented.

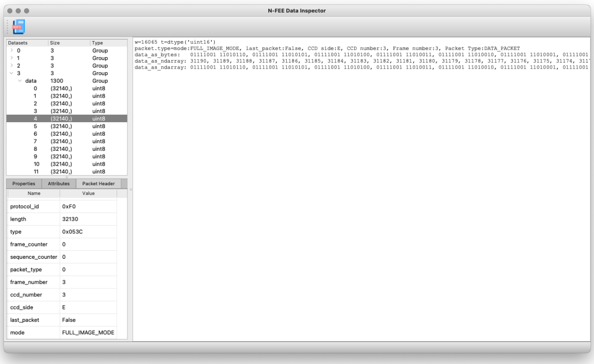


Screenshot 1 – Inspecting the Register Map

Screenshot 2 – The Housekeeping Packet



Screenshot 3 – Image zoom and data attributes



Screenshot 4 – Inspection of individual data packets

Screenshot 1 shows the Register Map for this cycle. There is only one Register Map per HDF5 file. The register map is the status at the time the timecode is sent for the first readout frame. Commanding is possible at the end of any readout, but the changes are only activated in the FPGA on a long pulse of 400ms. That is when also the register map is stored in the HDF5 file. There are two register parameters[1] that are updated on every pulse, long and short pulse. Those parameters are `sensor_sel` and `ccd_readout_order` and because of this more regular update possibility these parameters are also available as attributes in each of the `data` groups. So, in principle, the CCD side can be changed at every readout, and this will be recorded in the `sensor_sel` attribute to the `data` group. Above the register map table, you can see an empty text field. In this field you can type a string pattern to filter the parameters shown in the table. The string pattern shall be a simple string or a regular expression and it will match either the register name or the parameter name. For example, to list only parameters for register '3' enter 'reg_3_config' in this search field, to see all windowing size parameters you can enter something like `win.*size`.

Screenshot 2 shows the view of the housekeeping packet for that readout frame. The housekeeping packet is sent for each sync pulse (long and short) right after the timecode. So, you will find a `hk` dataset for each of the readout frames. The housekeeping view currently only shows the data as raw values, no conversion to engineering values like voltages or temperatures is done at this stage.

Screenshot 3 shows a combination of information. The images are zoomed in to show (1) that we have 25 serial prescan pixels, these are the pixels before the red line in the left part of the screenshot (F-side), and (2) we have 30 parallel overscan pixels, above the red horizontal line in the right part of the screenshot (E-side). We can now also clearly see that we have image pattern data (XXXX add reference here). The cross that is visible in the image data is put there by the N-FEE simulator to ease the validation of the image coordinates and pixel positions. Clicking the '3' group in the tree view will show the image data, if you expand the entry by clicking the small handle before the '3', you can then click the `data` group. This will not change the image display, but will update the details panel in the lower-left part of the screenshot. Select 'attributes' to see the specific parameters attached to this 'data' group.

In **Screenshot 4** I have further expanded the `data` group and the tree view now shows the individual SpaceWire data packets. If you click on one of them, the content of the packet is printed in different formats and also the header is printed in a human readable format. The parameter 'w' is the number of pixels in the data part of the SpW packet. As said above, we have 7 rows per packet → 16065 / 7 = 2295, which is the number op pixels per row. This view is mainly there for debugging and can change in the future.

TBW

- [ ] How can we inspect the content of the data packets → DataPackets class
- [ ] Explain when we have a commands group and what it contains
- [ ] What is the relation between the number of HDF5 files and the `num_cycles` value?
- [x] How to visualize the HDF5 files with the GUI `hdf5_ui`
- [ ] Which scripts do we have to inspect and check HDF5 files?

4.4. The Telemetry (TM) Dictionary

The `tm-dicionary.csv` file (further referred to as the "telemetry ™ dictionary") provides an overview of all housekeeping (HK) and metrics parameters in the EGSE system. It is used:

- By the `get_housekeeping` function (in `egse.hk`) to know in which file the values of the requested HK parameter should be looked for;
- To create a translation table to convert — in the `get_housekeeping` function of the device protocols — the original names from the device itself to the EGSE-conform name (see further);
- For the HK that should be included in the synoptics: to create a translation table to convert the original device-specific (but EGSE-conform) names to the corresponding synoptical name in the Synoptics Manager (in `egse.synoptics`).

4.4.1. The File’s Content

For each device we need to add all HK parameters to the TM dictionary. For each of these parameters you need to add one line with the following information (in the designated columns):

Column name	Expected content
TM source	Arbitrary (but clear) name for the device. Ideally this name is short but clear enough for outsiders to understand what the device/process is for.
Storage mnemonic	Storage mnemonic of the device. This will show up in the filename of the device HK file and can be found in the settings file (`settings.yaml`) in the block for that specific device/process.
CAM EGSE mnemonic	EGSE-conform parameter name (see next Sect.) for the parameter. Note that the same name should be used for the HK parameter and the corresponding metrics.
Original name in EGSE	In the `get_housekeeping` method of the device protocols, it is - in some cases (e.g. for the N-FEE HK) - possible that you have a dictionary with all/most of the required HK parameters, but with a non-EGSE-conform name. The latter should go in this column.
Name of corresponding timestamp	In the device HK files, one of the columns holds the timestamp for the considered HK parameter. The name of that timestamp column should go in this column of the TM dictionary.
Origin of synoptics at CSL	Should only be filled for the entries in the TM dictionary for the Synoptics Manager. This is the original EGSE-conform name of the synoptical parameter in the CSL-specific HK file comprising this HK parameter. Leave empty for all other devices!
Origin of synoptics at SRON	Should only be filled for the entries in the TM dictionary for the Synoptics Manager. This is the original EGSE-conform name of the synoptical parameter in the SRON-specific HK file comprising this HK parameter. Leave empty for all other devices!
Origin of synoptics at IAS	Should only be filled for the entries in the TM dictionary for the Synoptics Manager. This is the original EGSE-conform name of the synoptical parameter in the IAS-specific HK file comprising this HK parameter. Leave empty for all other devices!
Origin of synoptics at INTA	Should only be filled for the entries in the TM dictionary for the Synoptics Manager. This is the original EGSE-conform name of the synoptical parameter in the INTA-specific HK file comprising this HK parameter. Leave empty for all other devices!
Description	Short description of what the parameter represents.
MON screen	Name of the Grafana dashboard in which the parameter can be inspected.
unit cal1	Unit in which the parameter is expressed. Try to be consistent in the use of the names (e.g. Volts, Ampère, Seconds, Degrees, DegCelsius, etc.).
offset b cal1	For raw parameters that can be calibrated with a linear relationship, this column holds the offset `b` in the relation `calibrated = a * raw + b`.

Column name	Expected content
slope a cal1	For raw parameters that can be calibrated with a linear relationship, this column holds the slope `a` in the relation `calibrated = a * raw + b`.
calibration function	Not used at the moment. Can be left emtpy.
MAX nonops	Maximum non-operational value. Should be expressed in the same unit as the parameter itself.
MIN nonops	Minimum non-operational value. Should be expressed in the same unit as the parameter itself.
MAX ops	Maximum operational value. Should be expressed in the same unit as the parameter itself.
MIN ops	Minimum operational value. Should be expressed in the same unit as the parameter itself.
Comment	Any additional comment about the parameter that is interesting enough to be mentioned but not interesting enough for it to be included in the description of the parameter.

Since the TM dictionary grows longer and longer, the included devices/processes are ordered as follows (so it is easier to find back the telemetry parameters that apply to your TH):

- Devices/processes that all test houses have in common: AEU, N-FEE, TCS, Synoptics Manager, etc.
- Devices that are CSL-specific;
- Devices that are SRON-specific;
- Devices that are IAS-specific;
- Devices that are INTA-specific.

4.4.2. EGSE-Conform Parameter Names

The correct (i.e. EGSE-conform) naming of the telemetry should be taken care of in the `get_housekeeping` method of the device protocols.

Common Parameters

A limited set of devices/processes is shared by (almost) all test houses. Their telemetry should have the following prefix:

Device/process	Prefix
Configuration Manager	CM_
AEU (Ancillary Electrical Unit)	GAEU_
N-FEE (Normal Front-End Electronics)	NFEE_

Device/process	Prefix
TCS (Thermal Control System)	GTCS_
FOV (source position)	FOV_
Synoptics Manager	GSYN_

TH-Specific Parameters

Some devices are used in only one or two test houses. Their telemetry should have TH-specific prefix:

TH	Prefix
CSL	GCSL_
CSL1	GCSL1_
CSL2	GCSL2_
SRON	GSRON_
IAS	GIAS_
INTA	GINTA_

4.4.3. Synoptics

The Synoptics Manager groups a pre-defined set of HK values in a single file. It's not the original EGSE-conform names that are use in the synoptics, but names with the prefix `GSYN_`. The following information is comprised in the synoptics:

- Acquired by common devices/processes:
- Calibrated temperatures from the N-FEE;
- Calibrated temperatures from the TCS;
- Source position (commanded + actual).
- Acquired by TH-specific devices:
- Calibrated temperatures from the TH DAQs;
- Information about the OGSE (intensity, lamp and laser status, shutter status, measured power).

For the first type of telemetry parameters, their original EGSE-conform name should be put into the column `CAM EGSE mnemonic`, as they are not TH-specific.

The second type of telemetry parameters is measured with TH-specific devices. The original TH-specific EGSE-conform name should go in the column `Origin of synoptics at ...`.

4.4.4. Translation Tables

The translation tables that were mentioned in the introduction, can be created by the `read_conversion_dict` function in `egse.hk`. It takes the following input parameters:

- `storage_mnemonic`: Storage mnemonic of the device/process generating the HK;
- `use_site`: Boolean indicating whether you want the translation table for the TH-specific telemetry rather than the common telemetry (`False` by default).

To apply the actual translation, you can use the `convert_hk_names` function from `egse.hk`, which takes the following input parameters:

- `original_hk`: HK dictionary with the original names;
- `conversion_dict`: Conversion table you got as output from the `read_conversion_dict` function.

4.4.5. Sending HK to Synoptics

When you want to include HK of your devices, you need to take the following actions:

- Make sure that the TM dictionary is complete (as described above);
- In the device protocol:
  - At initialisation: establish a connection with the Synoptics Manager: `self.synoptics = SynopticsManagerProxy()`
  - In `get_housekeeping` (both take the dictionary with HK as input):
    - For TH-specific HK: `self.synoptics.store_th_synoptics(hk_for_synoptics)`;
    - For common HK: `self.synoptics.store_common_synoptics(hk_for_synoptics)`.

Please, do not introduce new synoptics without further discussion!

[1] There are actually more register parameters that are updated on every sync pulse, but those are all windowing parameters that are not used in camera testing.