

FG4 Multibox Manual



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1 Introduction

FG4 Multibox (aka. MGB4) is a device, whose primary purpose is capturing/generating video streams from/to specific hardware interfaces. For this the box uses FG4 PCIe cards, each one equipped with appropriate interface module (e.g. FPD3, GMSL). Both FG4 Multibox and FG4 PCIe cards are products of Digiteq Automotive.

1.1 Main Features

- Capturing video streams
- Capturing from specific hardware interface (FPDL3, GMSL)
- Optional transformations (flip, crop, scale)
- Encoding into classical video stream (H264 or H265 in MPEG-TS)
- Encoding into pure sequence of images (PNG)
- Transmitting over network (allowing multiple clients)
- Saving to storage (SATA or USB disk)
- Live preview on external HDMI monitor (up to 4K)
- Trigger marks (custom OSD texts shown upon configured event)
- Generating video streams
- Generating to specific hardware interface (FPDL3, GMSL)
- Generating from custom image files saved on storage (SATA or USB disk)
- Generating from custom video files saved on storage (SATA or USB disk)
- Generating from predefined test patterns (solid colors, color bars, etc.)
- Live preview on external HDMI monitor (up to 4K)
- Capturing CAN messages
- CAN 2.0A (11-bit ID), CAN 2.0B (29-bit ID)
- CAN FD (flexible data rate), RTR (remote request)
- Custom filters (able to act as trigger sources)
- Encoding into CAN-UTILS ascii compact format
- Transmitting over network (allowing multiple clients)
- Saving to storage (SATA or USB disk)
- Trigger system
- Multiple trigger sources
 - Hardware inputs (on change of voltage)
 - CAN filters (on match)
 - Timers (on shot)
 - API (on invocation of dedicated action)
- Multiple trigger sinks
 - Change of whatever configuration property (at API level)
 - Invoke of whatever action (at API level)
- Triggers may be transmitted over network (allowing multiple clients)
- Triggers may be saved to storage (SATA or USB disk)
- Unified timestamping
- Captured video frames
- Captured CAN messages
- Triggers
- Remote control
- HTTP API (RESTlike)
- GUI (Web application)

1.2 Hardware overview

1.2.1 Main components

- System on Module (SOM)
- Mainboard

- PCIe switch board

1.2.1.1 System on Module (SOM) System on Module (SOM) provides the main computing power. Currently [Nvidia Jetson TX2](#) is used as SOM. It contains Dual-Core Nvidia Denver 2 and Quad-Core ARM Cortex-A57 CPUs, 256-core Nvidia Pascal GPU, 8GB LPDDR4 RAM and 32GB eMMC storage. It also contains many peripherals, but not all are used or they are used in specific configuration.

1.2.1.2 Mainboard Mainboard interconnects all participated electronic components into one functional unit. Except connectors it also contains many other active elements, like power supply, power management IC (PMIC), RTC battery, CAN drivers, etc. Especially the PMIC is very important, as it controls the onboard power supply, power on/off sequences and also external triggers. It also provides the ability to automatically power-on the FG4 Multibox, either when it gets connected to power supply or when configured events occur on external triggers.

1.2.1.3 PCIe switch board PCIe switch board expands the Jetson TX2 single PCIe 2.0 x4 interface and allows to use up to five PCIe cards.

1.3 Software overview

FG4 Multibox is Linux based device. The behavior of all subsystems (e.g. system time, video, network, CAN), the way of connecting storage devices or handling system logs, all that stuff is Linux based and this fact is clearly reflected in behavior of API. So it is quite common, that the API provided by FG4 Multibox noticeably resembles the API provided by underlying Linux operating system. Also the behavior of internal services (e.g. http server, ntp client, secure shell), the list of supported features (e.g. file systems) or the list of supported external devices (e.g. CAN or network cards) are all closely dependent on used Linux distribution and kernel.

Used Linux distribution:

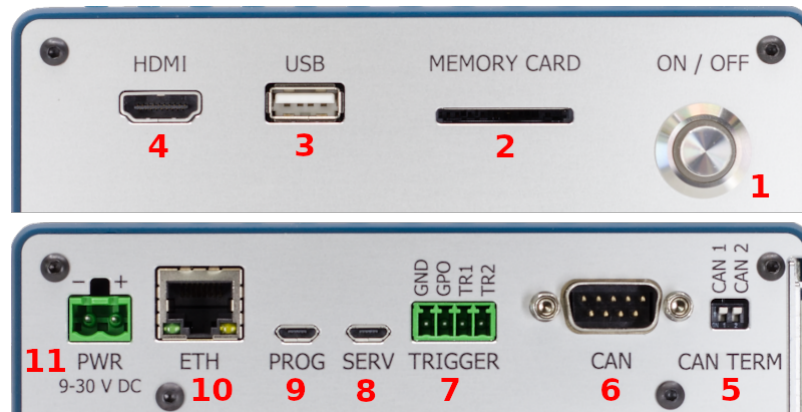
Customized Ubuntu 18.04 (Bionic Beaver)

Used Linux kernel:

GNU/Linux 4.9.201-mgb4 aarch64, customized kernel based on [Nvidia Tegra Linux](#), tag *tegra-l4t-32.5*

Although there are running many Linux services, only a **few of them** expose their API and also form the core FG4 Multibox functionality.

2 Hardware interface



- 1 - Power button
- 2 - SD card
- 3 - USB
- 4 - HDMI
- 5 - CAN termination
- 6 - CAN
- 7 - External triggers
- 8 - Service interface
- 9 - Programming interface
- 10 - Ethernet
- 11 - Power supply

2.1 Power button

Short press of the power button triggers the FG4 Multibox power-on or power-off sequences. Power-off sequence may also be triggered by [API](#). Power-on sequence may also be triggered automatically by [Mainboard PMIC](#). There exist more types of power sequences and they all may be trigger only by [API](#). The progress of power sequences is indicated by [Power button LED](#).

2.1.1 Power button LED

Power button LED indicates some significant states of FG4 Multibox.

- *off* - box off. Or start of mainboard PMIC power-on or power-cycle sequence, this usually takes a few milliseconds.
- *blue* - box off (CAN triggers are active). Or waiting of mainboard PMIC for Jetson module, this usually takes a few milliseconds.
- *orange* - mainboard PMIC in normal mode, waiting for operating system to be booted up and application service to be started, this usually takes about a half of minute
- *blinking orange* - mainboard PMIC in bootloader mode, waiting for PMIC firmware update, this may take a few minutes
- *pink* - box entered rescue mode, waiting for runtime firmware update, this may take a few minutes
- *dimmed pink* - box exited rescue mode, waiting for graceful reboot or power-off
- *yellow* - checking/updating of mainboard PMIC or FG4 cards firmware started, in case of required update this may take a few minutes and multiple power cycles may occur
- *dimmed yellow* - checking/updating of mainboard PMIC or FG4 cards firmware finished
- *green* - application service started, box ready
- *dimmed green* - application service finished, waiting for graceful reload, reboot, power-cycle or power-off

- *red* - box in error state

2.1.1.1 Power-on sequence (no firmware updates required)

1. *off* - very quick, barely observable by eye
2. *blue* - waiting for Jetson module, very quick, barely observable by eye
3. *orange* - waiting for operating system and application service, about 30s
4. *yellow* - checking of mainboard PMIC firmware started, about 500ms
5. *dimmed yellow* - checking of mainboard PMIC firmware finished, about 500ms
6. *yellow* - checking of FG4 cards firmware started, about 500ms
7. *dimmed yellow* - checking of FG4 cards firmware finished, about 500ms
8. *green* - application service started, box ready

2.1.1.2 Power-off sequence

1. *dimmed green* - application service finished, waiting for graceful power-off
2. *off* or *blue* - box off, LED is *blue* if CAN triggers are active

2.1.1.3 Power-cycle sequence

1. *dimmed green* - application service finished, waiting for graceful power-cycle
2. *off* or *blue* - box off, LED is *blue* if CAN triggers are active, about 1s
3. now the sequence continues from point 1 of *Power-on sequence*

2.1.1.4 Reboot sequence

1. *dimmed green* - application service finished, waiting for graceful reboot
2. after a while the sequence continues from point 4 of *Power-on sequence*

2.1.1.5 Reload sequence

1. *dimmed green* - application service finished
2. *green* - application service started, box ready

2.2 SD card

Full-size SD card interface supporting up to SDR104 card mode (UHS-1). Working with storage devices is described in [Storage](#) chapter.

2.3 USB

USB 2.0, Type-A, Host mode. Multiple device types may be connected via USB interface. See [Storage](#), [Network](#) or [CAN](#) chapters to get detailed information about working with these devices.

2.4 HDMI

HDMI 2.0, Type A (standard) or C (mini), depending on particular FG4 Multibox hardware revision. When external monitor is connected, preferred timing mode (based on EDID, resolution, frame rate, etc.) is selected automatically. Then *home window* is shown. It is a borderless black window with some useful information rendered in the top-left corner. The first line contains actual monitor resolution, the second line contains localized date and time, and the remaining lines contain the state and IP addresses assigned to the connected network devices. The *home window* may be overlapped by another windows, e.g. all video capture and video output devices may have their own *preview windows*.

2.5 CAN termination

DIP switches, that allow to connect internal termination resistors to embedded CAN busses 1 and 2. When the switch is in position *ON* (pulled down), internal resistor 120Ω is connected between CAN high (CANH) and CAN low (CANL) signals.

2.6 CAN

Standard 9-pin CANON male connector, that provides access to embedded CAN busses 1 and 2. The physical layer complies with high-speed CAN (HS-CAN) as defined in ISO 11898-2:2016 and SAE J2284-1 to SAE J2284-5. FG4 Multibox contains two embedded CAN devices, the first one (usually named as *can0* in API) is connected to the bus 1, the second one (usually named as *can1* in API) is connected to the bus 2. Working with CAN devices is described in [CAN](#) chapter.

1	- not connected
2	- CAN low (CAN bus 1)
3	- CAN GND
4	- CAN low (CAN bus 2)
5	- not connected
6	- not connected
7	- CAN high (CAN bus 1)
8	- CAN high (CAN bus 2)
9	- not connected

2.7 External triggers

External triggers TR1 and TR2 are hardware inputs, that can be used to trigger various events within the FG4 Multibox. The inputs are directly connected to [Mainboard PMIC](#), so their properties can also be set via [Mainboard PMIC](#), e.g. connecting pull-up or pull-down resistors, setting the specific triggering edge etc. They are part of [Trigger system](#), so the mapping of events can also be set via [Trigger system](#), e.g. capturing the video frame, rendering the specific trigger mark in video frame etc.

Connector type: DEGSON 15EDGK-3.5-04P-14

2.7.1 Electrical characteristics

Low level input voltage	: <0.8V
High level input voltage	: >2.0V
Maximum input voltage	: $\pm 35.0V$
Internal pull-up/down resistors	: $40-130k\Omega$
Input current (no pull-up/down)	: $3-180nA@3.3V$

2.8 Service interface

USB 2.0, Micro-B, Device mode (FTDI, FT232R USB UART, idVendor=0403, idProduct=6001), 115200 8n1. This serial device provides access to the FG4 Multibox U-boot and Linux console.

2.9 Programming interface

USB 2.0, Micro-B, Device mode (NVIDIA Corp., APX, idVendor=0955, idProduct=7c18). This device is provided by [Nvidia Jetson TX2](#) SOM module booted in recovery mode. The interface is intended only for Digiteq Automotive factory programming of FG4 Multibox.

2.10 Ethernet

Ethernet 10/100/1000 BASE-T, RJ45. Working with network devices is described in [Network](#) chapter. This network device is usually named as *eth0* in API.

2.11 Power supply

Input voltage	: 10-30V DC	
Idle current	: 20mA@12V	Power-off state
Estimated max. power	: $(20 + 15n)$ W	Heavy computing load
Estimated min. power	: $(13 + 10n)$ W	No computing load

where

n - number of inserted FG4 PCIe cards

E.g.

When only one FG4 PCIe card is inserted, power supply 12V/3A should be enough.

When five FG4 PCIe cards are inserted, power supply 12V/8A should be enough.

Connector type: DEGSON 2EDGK-5.0-02P-14

3 Application interface

Next chapters describe the non-gui application interface, intended to be used directly from programming languages, e.g. some automation tools or gui applications. Web application providing the [GUI](#) also uses this API as its backend. Please, read the [Services](#) chapter first, as this describes the API fundamental behavior and also defines the terms, that are used by all following API related chapters.

3.1 Services

Most of the FG4 Multibox functionality is executed by its internal software services, each one with its special purpose. Some of these services expose their API, so they can be controlled by user. The API is exposed in different ways, e.g. each video stream is available on its dedicated TCP server, file sharing is done through Samba server, but the most functionality is available through HTTP server.

The most important services are:

- [Application](#)
- [Logger](#)
- [Filesystem](#)

They all expose their API and also form the core functionality of FG4 Multibox.

HTTP server listens on TCP port 80.

Samba server listens on TCP ports 139 and 445.

Dedicated TCP servers (e.g. video stream servers) have no fixed listening TCP ports, as they are configurable by user.

No username or password is required.

3.1.1 Application service

This is the most important service as this one is responsible for control over the biggest part of the whole system, e.g. setting video, network and CAN interfaces, mounting storage drives etc.

Most of the functionality is available through HTTP server at URL path `/api/app/*`. The service also provides dedicated TCP servers (e.g. video stream servers). Next description refers only to communication through HTTP server.

The service functions may take or return some data. In this case, data are always passed in message body as a single JSON object. For information about JSON object see [RFC8259](#).

The service uses the same status codes for all its functions, `200` (ok) or `202` (accepted) for success, whatever else for a kind of error. The service itself uses only `400` (bad request), `422` (unprocessable entity) and `500` (internal server error), but another error status codes may be returned if transaction fails somewhere on its route, e.g. `502` (bad gateway). In case of error, the service may return detailed error description in output data, JSON schema is available [here](#). Status codes `202` (accepted) and `422` (unprocessable entity) are used only by actions.

The service can be viewed as hierarchy of functional objects, each one responsible for specific part of the system. Each object has its own invokable actions, readable and writable configuration properties and readable status properties. Mainly due to this characteristics the API is divided into separated parts.

3.1.1.1 Actions This part of API allows the object to perform an immediate activity, this is done by invoking its action. Actions are available at URL path `/api/app/actions/*`. The list of currently available (at runtime) actions can be obtained by GET verb at URL path `/api/app/actions`. The list of all existing actions, including JSON schemas of input and output data, is available [here](#). There exist two types of actions, synchronous and asynchronous.

Synchronous action finishes immediately. It is invoked by POST verb on required action name and the result is returned in response. Status code `200` (ok) means, that the action finished with success (output

data are present in response), status code *422* (unprocessable entity) means, that the action finished with error, another status code means another kind of error (action failed in some unexpected way or didn't be even started).

Asynchronous action takes some time to finish, so the result is not available immediately, instead it must be polled later. Action is invoked by POST verb on required action name. Status code *202* (accepted) means, that the action was started (but not finished), another status code means a kind of error. Result is obtained by GET verb on the same action name. Status code *202* (accepted) means, that the action has not finished yet, status code *200* (ok) means, that the action finished with success (output data are present in response), status code *422* (unprocessable entity) means, that the action finished with error, another status code means another kind of error.

3.1.1.1.1 Examples List available actions

```
curl -v -X GET 'http://192.168.1.200/api/app/actions '
```

Get system time

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/time/system_time/get '
```

Echo some JSON data

```
curl -v -X POST -H 'Content-Type: application/json' -d '"hello"' 'http://192.168.1.200/api/app/actions/echo '
```

3.1.1.2 Configuration This part of API allows to set the object into required state, this is done by setting its configuration properties. Configuration is available at URL path `/api/app/config` and corresponding JSON schema is available [here](#). It is possible to address only part of configuration, which is done by specifying the appropriate JSON pointer in URL path (`/api/app/config<json_pointer>`, `/api/app/config/point/to/something`). For information about JSON pointer see [RFC6901](#). There are several HTTP verbs, than can be used on configuration and that are similar to known CRUD operations:

- *GET* - reads existing configuration. Optional JSON pointer in URL path must point to existing object. Output data in message body. No input data.
- *PUT* - updates (by replacing) existing configuration. Optional JSON pointer in URL path must point to existing object. Input data in message body. No output data.
- *PATCH* - updates (by patching) existing configuration. Optional JSON pointer in URL path must point to existing object. Input data (JSON patch) in message body. No output data. For information about JSON patch see [RFC6902](#)
- *POST* - creates new configuration. Required JSON pointer in URL path must meet some criteria to work properly. Let's have a pointer `/x/y/z`. In this case object pointed by `/x/y` must exist and `/x/y/z` will be created (if not exists yet) or replaced (if already exists). Input data in message body. No output data.
- *DELETE* - deletes existing configuration. Required JSON pointer in URL path must meet some criteria to work properly. Let's have a pointer `/x/y/z`. In this case object pointed by `/x/y` must exist and `/x/y/z` will be deleted (if exists) or nothing will be done (if not exists). No input data. No output data.

When any method able to change the existing configuration fails, then the configuration remains in its previous state, no partial changes are made.

The provided configuration must always be valid against the currently supported version of schema. But there is one exception, that is called configuration import. It is allowed to provide configuration of lower version than currently supported. In this case the configuration is imported to the current version. Note that provided configuration of lower version still must be valid against its schema (of matching lower version).

It was mentioned, that provided configuration must always be valid against its schema. This is the first and fundamental check, that is performed with the received configuration. But there may be additional

checks, especially in situations, that cannot be easily detected by schema. Currently there exists only one additional check, which doesn't allow to assign the same TCP port to multiple TCP servers.

3.1.1.2.1 Examples Get configuration of the whole system

```
curl -v -X GET 'http://192.168.1.200/api/app/config'
```

Check if NTP client is enabled

```
curl -v -X GET 'http://192.168.1.200/api/app/config/time/ntp/enabled'
```

Enable NTP client

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/time/ntp/enabled'
```

Enable NTP client and trigger file writer

```
curl -v -X PATCH -H 'Content-Type: application/json' -d '{"time":{"ntp":{"enabled":true}},"trigger":{"file_writer":{"enabled":true}}}' 'http://192.168.1.200/api/app/config'
```

3.1.1.3 Status This part of API allows to observe real state of the object, this is done by getting its status properties. Status is available at URL path `/api/app/status` and corresponding JSON schema is available [here](#). It is possible to address only part of status, which is done by specifying the appropriate JSON pointer in URL path (`/api/app/status<json_pointer>`, `/api/app/status/point/to/something`). Getting status is done by GET verb.

Internally the status properties are updated with period of about 1 second. So it has no sense to get the status more often.

3.1.1.3.1 Examples Get status of the whole system

```
curl -v -X GET 'http://192.168.1.200/api/app/status'
```

Check if NTP client is really running

```
curl -v -X GET 'http://192.168.1.200/api/app/status/time/ntp/running'
```

Get CPU info

```
curl -v -X GET 'http://192.168.1.200/api/app/status/cpu'
```

3.1.1.4 Schemas This part of API allows to get all JSON schemas used by the service. Schemas are available at URL path `/api/app/schemas`. It is possible to address only part of schemas, which is done by specifying the appropriate JSON pointer in URL path (`/api/app/schemas<json_pointer>`, `/api/app/schemas/point/to/something`). Getting schemas is done by GET verb. There are four important parts.

`/api/app/schemas/error` - JSON schema of error (see [here](#))

`/api/app/schemas/actions` - JSON schemas of actions data (see [here](#))

`/api/app/schemas/config` - JSON schema of configuration (see [here](#))

`/api/app/schemas/status` - JSON schema of status (see [here](#))

3.1.1.5 Examples Get all JSON schemas

```
curl -v -X GET 'http://192.168.1.200/api/app/schemas'
```

Get JSON schema of error

```
curl -v -X GET 'http://192.168.1.200/api/app/schemas/error'
```

Get JSON schema of configuration

```
curl -v -X GET 'http://192.168.1.200/api/app/schemas/config'
```

3.1.2 Logger service

This service provides access to system log. These may be useful to create a more detailed look at the whole system and possibly to help with some debugging.

The service is available through HTTP server at URL path `/api/log/*`. The service uses the same status codes for all its functions, `200` (ok) for success, whatever else for a kind of error. The service itself uses only `400` (bad request) and `500` (internal server error), but another error status codes may be returned if transaction fails somewhere on its route, e.g. `502` (bad gateway).

The service uses the same websocket return codes for all its websocket functions, `1000` for success, whatever else for some kind of error. Reason string may be filled with detailed information.

The service uses the same form of passing parameters for all its functions. It uses the query string in pretty standard form, e.g. `/api/log/file?what=app&count=10`.

3.1.2.1 Log file Log file can be downloaded by GET verb at URL path `/api/log/file`. Parameters may be specified to control the content of the log file.

what - identifies the log source. Possible values are *all* (all sources), *kernel* (kernel source) and *app* (application service source). Default value is *all*.

count - determines the number of required historical records to be sent. If equal *-1*, then all records are sent. Default value is *-1*.

since, *until* - sends only records on or newer than the specified date, or on or older than the specified date, respectively. Date specifications should be of the format *YYYY-MM-DD HH:MM:SS*. If the time part is omitted, *00:00:00* is assumed. If only the seconds component is omitted, *:00* is assumed. If the date component is omitted, the current day is assumed. Alternatively the strings *yesterday*, *today*, *tomorrow* are understood, which refer to *00:00:00* of the day before the current day, the current day, or the day after the current day, respectively. *now* refers to the current time. Finally, relative times may be specified, prefixed with *-* or *+*, referring to times before or after the current time, respectively.

3.1.2.1.1 Examples Get all records of the whole system

```
curl -v -X GET 'http://192.168.1.200/api/log/file'
```

Get today's records of the whole system

```
curl -v -X GET 'http://192.168.1.200/api/log/file?since=today'
```

Get last 10 records of application service

```
curl -v -X GET 'http://192.168.1.200/api/log/file?what=app&count=10'
```

3.1.2.2 Log feed Live log can be received by connecting to websocket at URL path `/api/log/feed`. Parameters may be specified to control the content of the log data.

what - identifies the log source. Possible values are *all* (all sources), *kernel* (kernel source) and *app* (application service source). Default value is *all*.

count - determines the number of required historical records to be sent. If equal *-1*, then all records are sent. Default value is *10*.

follow - determines the state of log feed after sending required count of historical records. If equal *0*, then after sending required count of historical records the feed closes immediately. If equal *1*, then after sending required count of historical records the feed remains open to provide future records. Default value is *1*.

3.1.2.2.1 Examples Connect to feed of the whole system (send 10 historical records before waiting for new records)

```
wscat --connect 'http://192.168.1.200/api/log/feed'
```

Connect to feed of the whole system (send no historical records before waiting for new records)

```
wscat --connect 'http://192.168.1.200/api/log/feed?count=0'
```

3.1.2.3 Log clear The whole log can be cleared by POST verb at URL path `/api/log/clear`.

3.1.2.3.1 Examples Clear log

```
curl -v -X POST 'http://192.168.1.200/api/log/clear'
```

3.1.3 Filesystem service

This service provides access to available file systems. This means either mounted devices (e.g. internal hard disk drive, USB drive, SD card) or another specific places (e.g. directory for uploading new firmware).

The service is available through HTTP server at URL path `/api/fs/*`. In this case WebDAV is used to access the file system. When GET verb is used onto existing directory, then list (in JSON format) of files is returned. Both read and write operations may be possible.

The service is also available through HTTP server at URL path `/www/fs/*`. In this case the file system is presented as ordinary static web page, so only GET verb can be used. Only read operations are possible.

The service is also available through Samba server. Both read and write operations may be possible.

3.1.3.1 Mounted devices Currently mounted devices are available at URL paths `/api/fs/mounts/` and `/www/fs/mounts/` in case of using HTTP server, or at URL path `/mounts/` in case of using Samba server. The top level content of these URL paths represents the storage *mount points*. See [Storage](#) chapter for detailed information about storage devices and their mount points.

3.1.3.2 Firmware update There exists a special file system place, that is intended only for control of firmware update process. This place is available at URL paths `/api/fs/fw/` and `/www/fs/fw/` in case of using HTTP server, or at URL path `/fw/` in case of using Samba server. See [Firmware](#) chapter for detailed information about firmware update.

3.1.3.3 Examples Get list of mount points (via HTTP, WebDAV)

```
curl 'http://192.168.1.200/api/fs/mounts/'
```

Get content of firmware upload directory (via HTTP, WebDAV)

```
curl 'http://192.168.1.200/api/fs/fw/'
```

3.2 Power

FG4 Multibox power-on and power-off sequences are triggered by short press of the power button. There exist another power operations, power-cycle, reboot and reload. Power-cycle can be viewed as sequence of power-off and power-on operations, during this process power supply is cut off to the most of box internal circuits. On the other hand, reboot is just hot restart, without power supply cut. Reload is least invasive as it only restarts application service, use of this operation is intended only for debug purposes. The progress of power sequences is indicated by **Power button LED**.

Power-off, power-cycle, reboot and reload operations can be triggered by remote API served by application service, available at URL path `/api/app/actions/power/*`. Just call appropriate nonparametric synchronous action

- `/api/app/actions/power/poweroff`
- `/api/app/actions/power/powercycle`
- `/api/app/actions/power/reboot`
- `/api/app/actions/power/reload`

3.2.1 Examples

Power-off

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/power/poweroff '
```

Reboot

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/power/reboot '
```

3.3 Firmware

There exist two main types of FG4 Multibox firmware packages. The first one is factory package, which is intended to be installed only in Digiteq Automotive company. This package contains all possible firmware components, e.g. boot configuration tables, bootloaders, rescue and application file systems, PMIC and FG4 card firmwares, etc. The second one is runtime package, which is intended to be installed by ordinary users. This package contains subset of factory package. Only runtime firmware update is described in this manual.

3.3.1 FG4 Multibox firmware update

First, the firmware package `mgb4-install.tgz` must be uploaded to FG4 Multibox. This can be done by remote API served by filesystem service, either by using HTTP (WebDAV) server available at URL path `/api/fs/fw/` or by using Samba server at URL path `/fw/`. In fact, both URL paths reference the same directory on the internal eMMC storage. So just upload the firmware package to this directory.

Second, to appropriately execute the update process, some control flags must be given. These control flags are represented by pure empty files, located at the same place as firmware package is uploaded. To start the update process on next boot, create empty file named as `mgb4-flash`. To keep previous configuration, create empty file named as `mgb4-keep`.

Finally, reboot FG4 Multibox. Next boot, if control flag `mgb4-flash` is found, box enters rescue mode (indicated by pink power button LED) and if firmware package is found, update process is started.

When the process is finished (may take several minutes), box reboots into new system. During this boot another reboots may occur as mainboard PMIC and FG4 cards firmware update (indicated by yellow power button LED) may be required. When the power button LED is green, box is ready.

Runtime firmware update may be also accomplished by using SD card. Just copy the firmware package `mgb4-install.tgz` to the first partition (fat, ext2/3/4) and create control flag `mgb4-flash`. Control flag `mgb4-keep` is ignored, keeping previous configuration doesn't work in this case. Then put the card into the box and power-on. From this point the firmware update continues similar to update by API. However, in this case the box shuts down when the process finishes.

3.3.1.1 Examples Get content of firmware upload directory

```
curl 'http://192.168.1.200/api/fs/fw/'
```

Firmware update (upload firmware package, upload control flags and reboot)

```
curl -T 'mgb4-install.tgz' 'http://192.168.1.200/api/fs/fw/'
curl -T 'mgb4-keep' 'http://192.168.1.200/api/fs/fw/'
curl -T 'mgb4-flash' 'http://192.168.1.200/api/fs/fw/'
curl -v -X POST 'http://192.168.1.200/api/app/actions/power/reboot'
```

3.3.2 FG4 card firmware update

Each boot all plugged FG4 cards are checked if they contain valid firmware. Each FG4 card containing invalid firmware is updated automatically. The process of checking and possible updating is indicated by yellow power button LED. FG4 card firmware is considered as valid if it corresponds to the plugged module/interface (FPDL3, GMSL, ...) and if its version matches the one required by the box. Each FG4 Multibox contains its own list of FG4 card firmwares, that are marked as compatible and that are used for automatic FG4 card firmware update. For special use cases, the automatic firmware update may be disabled or even custom list of firmwares may be provided. To disable automatic firmware update create empty directory `mgb4-fg4-firmware` at the same place as FG4 Multibox firmware is uploaded, at URL path `/api/fs/fw/` if using HTTP (WebDAV) server or at URL path `/fw/` if using Samba server. Note that overriding the normal behavior may lead to incompatible FG4 Multibox and FG4 card firmwares. To finish the possible firmware update box must be rebooted, which is also done automatically. It may happen, that something goes wrong during firmware update, in this case the box tries it again several times. If it fails anyway, the box ends up with red power button LED, in this case the automatic firmware update must be disabled or the card must be removed. See [FG4 PCIe cards](#) for detailed information about FG4 card parameters.

3.4 Configuration

The configuration of FG4 Multibox is a very complex topic, that can be described from many different perspectives. The first one involves the common features of [Configuration API](#) of [Application service](#). The second one involves particular thematic components (video, network, storage, time, etc.) and can be seen across multiple chapters. Other perspectives, that involves other specific features are described in this chapter.

3.4.1 Configuration update

FG4 Multibox never adds/removes configurations for newly connected/disconnected physical devices automatically. It is always up to user to check the status, to see all present devices and to decide what to add/remove to/from the configuration. To make the situation with newly connected devices easier, there exists a way how to add configurations for not yet configured devices. Just call nonparametric synchronous action `/api/app/actions/config/update`. Next getting of `/api/app/config` returns the updated configuration. Configuration update involves devices at JSON pointers `/network/devices`, `/can/devices`, `/video/captures` and `/video/outputs`.

3.4.2 Configuration reset

Sometimes it may be desired to return the configuration to its factory state (see [here](#)). To do it via API just call nonparametric synchronous action `/api/app/actions/config/reset`. Next getting of `/api/app/config` returns the factory configuration. To do it via SD card just create empty file `mgb4-reset-config` on the first partition, then insert the card to the box and reboot. Next getting of `/api/app/config` returns the factory configuration. Besides that, a specific custom configuration may be imported via SD card during boot. Just create empty file `mgb4-reset-config` on the first partition (as by factory reset) and also create file `mgb4-config.json` containing the custom configuration.

3.4.3 Devices

Basically there are two types of devices, system-managed and user-managed.

System-managed device is a device (usually physical), whose life cycle is controlled by operating system. Its name is assigned by system and cannot be changed in any way. No special consideration about its form (naming scheme) should be done, it is just a key identifying the device. Never ever parse the name to get any sort of information about the device. Existing system-managed device is always shown in status, regardless of being in configuration. System-managed devices are available at JSON pointers `/network/devices`, `/can/devices`, `/video/captures`, `/fg4/devices`, `/video/outputs`, `/storage/disks` and `/storage/disks/<name>/partitions`.

User-managed device is a device (usually virtual), whose life cycle is controlled by user. Its name is assigned by user, the form of name is also up to user, usually it only must be a string. Usually user can create as many user-managed devices as he wants. User-managed device is shown in status only when it exists in configuration. User-managed devices are available at JSON pointers `/can/captures`, `/timer/devices` and `/storage/mounts`.

3.4.4 Examples

Update configuration (add not yet configured devices)

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/config/update'
```

Reset configuration (to factory state)

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/config/reset'
```

3.5 Logger

The whole system log may be accessed via [Logger service](#). Although the system log has many sources, the most important one is the [Application service](#). This chapter describes how to set the logger of this service. The logger configuration is located at JSON pointer `/logger`.

Snippet of logger configuration (at JSON pointer `/logger`)

```
{
  "filter": {
    "severity": "error",
    "components" : ["mgb4", "netctl"],
    "threads" : ["main", "netctl"]
  }
}
```

Item *severity* is required and is also known as log level. Possible severities (sorted from lowest to highest) are *trace*, *debug*, *info*, *warning*, *error* and *fatal*. Only messages that are equal or higher then configured severity are logged. Be very careful with *trace* severity as it may generate a really huge amount of messages, e.g. each streamed video frame buffer generates multiple messages. For most debug cases, only *debug* or *info* severity should be enough.

Item *components* is optional and contains the names of components, that should be logged. When omitted, then all components are logged. Item *threads* is optional and contains the names of threads, that should be logged. When omitted, then all threads are logged. Both component and thread names are very internal and volatile attributes, not to be listed in this manual.

Item *filter* is optional and when omitted, then severity is defaulted to *error* and all components and threads are logged. Each message from application service has this form: thread |component|severity|message

3.5.1 Examples

Get logger configuration

```
curl -v -X GET 'http://192.168.1.200/api/app/config/logger'
```

Set logger configuration

```
curl -v -X POST -H 'Content-Type: application/json' -d '{"filter":{"severity":"info"}}' 'http://192.168.1.200/api/app/config/logger'
```

3.6 Time

In general there exist multiple sources of time in FG4 Multibox, but only two of them are really important. The first one is system time, that provides information about current date and time. The second one is a special monotonic time, that is primarily used for timestamping of events. Time configuration and status are located at JSON pointer `/time`.

Snippet of time configuration (at JSON pointer `/time`)

```
{
  "ntp": {
    "enabled": true,
    "servers": [
      "0.cz.pool.ntp.org",
      "1.cz.pool.ntp.org",
      "2.cz.pool.ntp.org",
      "3.cz.pool.ntp.org"
    ]
  },
  "timezone": "Europe/Prague"
}
```

Snippet of time status (at JSON pointer `/time`)

```
{
  "ntp": {
    "root_delay": 11200778,
    "root_dispersion": 36780,
    "running": true,
    "source": {
      "name": "82.202.70.139",
      "stratum": 1
    },
    "system_time_error": 6670096,
    "system_time_offset": -1032927,
    "system_time_synchronized": true
  },
  "system_time": "2023-12-07T13:26:08+01:00"
}
```

3.6.1 System time

System time (aka real-time clock or RTC) provides information about current date and time. Basically it can be controlled in two ways, either it can be directly set to specific value or it is controlled by NTP server.

To set the specific time value just call parametric synchronous action `/api/app/actions/time/system_time/set` with parameter containing the time value. To get the current time value just call nonparametric synchronous action `/api/app/actions/time/system_time/get`, the time value is then contained in response. In both cases the time value must comply with full date and time according to ISO 8601, e.g. “2023-12-07T13:26:08+01:00”. Setting the time by mentioned action has no effect when NTP is enabled.

To enable NTP, just fill the *servers* with desired NTP servers and set *enabled* to *true*. The NTP status properties are:

running - If *true*, then NTP is running.

system_time_synchronized - If *true*, then time is being synchronized.

system_time_error - Time error (in nanoseconds). Valid only if NTP is synchronized. Computed by formula: $\text{abs}(\text{system_time_offset}) + \text{root_dispersion} + (\text{root_delay} / 2)$.

system_time_offset - Time offset (in nanoseconds). Valid only if NTP is synchronized.

root_delay - Root delay (in nanoseconds). Valid only if NTP is synchronized.

root_dispersion - Root dispersion (in nanoseconds). Valid only if NTP is synchronized.

source - Time source currently used for synchronization.

source/name - Name (IP address).

source/stratum - Stratum.

As for NTP status, only *running* and *system_time_synchronized* properties are required, the other ones are present only if NTP is running.

It is quite important to have well-adjusted system time. If not, then interaction with FG4 Multibox may be very confusing at some points. Especially Logger service may be affected as it uses system time to timestamp the messages.

3.6.2 Monotonic time

Monotonic time is a special type of time, implemented by monotonically increasing counter, that starts its counting at some point during FG4 Multibox boot sequence. It is primarily used for timestamping of various events, so they can be mutually synchronized. Although the timestamps are usually expressed in micro or nanoseconds, the actual precision is much lesser, typically in ones or even tens of milliseconds. It depends on the actual moment the timestamp is assigned, it also depends on the whole system load. Currently this time is used for timestamping of captured video frames, CAN messages or triggers. There is no configuration or status.

3.6.3 Examples

Set current time

```
curl -v -X POST -H 'Content-Type: application/json' -d '"2023-12-07T15:08:32+01:00"' 'http://192.168.1.200/api/app/actions/time/system_time/set'
```

Get current time (by calling action)

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/time/system_time/get'
```

Get current time (by getting status)

```
curl -v -X GET 'http://192.168.1.200/api/app/status/time/system_time'
```

3.7 Network

Network configuration and status are located at JSON pointer `/network`. Configuration and status of particular network devices are located at JSON pointer `/network/devices`. FG4 Multibox contains one embedded network device, usually named as `eth0`. The name of embedded network device may change if another network device is connected. This usually happens when the device is connected via PCI. On the other hand, this usually doesn't happen when the device is connected via USB. Network devices are **System-managed**, so their names are fully controlled by operating system.

Snippet of network configuration and status (at JSON pointer `/network`)

```
{
  "devices": {
    "eth0": {...},
    "eth1": {...},
    "eth2": {...}
  }
}
```

Snippet of network device configuration (at JSON pointer `/network/devices/eth0`)

```
{
  "addresses": [
    {
      "address": "192.168.1.226/24",
      "scope": "global"
    }
  ],
  "dhcp4_server": {
    "enabled": false,
    "pool_offset": 100,
    "pool_size": 32
  },
  "dhcp_client": {
    "enabled": false,
    "metric": 1024,
    "type": "ipv4"
  },
  "enabled": true,
  "nameservers": [
    "192.168.1.1"
  ],
  "routes": [
    {
      "destination": "0.0.0.0/0",
      "gateway": "192.168.1.1",
      "metric": 0,
      "scope": "global"
    }
  ]
}
```

Snippet of network device status (at JSON pointer `/network/devices/eth0`)

```
{
  "addresses": [
    {
      "address": "192.168.1.226/24",
      "dynamic": false,
      "scope": "global",
      "secondary": false
    },
    {
      "address": "fe80::4ab0:2dff:fe48:d0d7/64",
      "dynamic": false,

```

```

        "scope": "link",
        "secondary": false
    }
],
"mac_address": "48:b0:2d:48:d0:d7",
"operational_state": "up"
}

```

Each network device may have assigned multiple IPv4 and IPv6 addresses, routes and name servers, either statically (by user) or dynamically (by DHCP server). Each network device is able to provide DHCPv4 server. When the network device is enabled and has assigned static IP address (minimum useful configuration), it also has to be connected to real functional network to see both the expected *up* operational state and configured IP address in status.

To enable network device just set *enabled* to *true*. Real device state can be observed in status *operational_state*, which can be one of these values *unknown*, *notpresent*, *down*, *lowerlayerdown*, *testing*, *dormant* and *up*. Typically only *down* and *up* are used most of the time.

To set static IP addresses fill *addresses* array. Each item contains IPv4 or IPv6 *address* (in CIDR notation) and its *scope* (*global*, *link*, *host*). If there are any doubts about address scope, go with *global* value. All assigned addresses can be observed in status *addresses*. Except *address* and *scope* there are some additional items. Item *dynamic* is *true* if address is assigned by DHCP server. Item *secondary* is *true* if address is so called secondary (aliased, not primary). Each network device may have assigned only one primary IPv4 and one primary IPv6 address, so additionally assigned addresses to the same network device are considered as secondary ones.

To set static routes fill *routes* array. Each item contains *destination* prefix (IP address in CIDR notation, use *0.0.0.0/0* (IPv4) or *::/0* (IPv6) to specify all possible addresses), *gateway* IP address, *metric* (unsigned integer, lower value means higher priority) and *scope* (*global*, *link*, *host*). If there are any doubts about route scope, go with *global* value. Optionally *source* prefix (IP address) may be set.

To set static name servers fill *nameservers* array. Each item represents IP address of name server.

To set dynamic IP addresses (also routes and name servers) from DHCP server configure DHCP client at *dhcp_client*. To have working DHCP client set *type* to required IP address protocol version (*ipv4*, *ipv6*, *dual*), also set *metric* (unsigned integer, lower value means higher priority) to dynamically created route and finally set *enabled* to *true*.

Each network device is able to provide DHCPv4 server, configurable at *dhcp4_server*. To have working DHCPv4 server just set *enabled* to *true*. There are also some optional items allowing to configure the pool of IP addresses (to be leased). Item *pool_offset* represents the offset of the pool from the start of subnet. If omitted or zero, then the pool starts at the first address after the subnet address. Item *offset_size* represents number of addresses in the pool. If omitted or zero, then the pool takes up the rest of the subnet.

3.7.1 Examples

Get status of network device *eth0*

```
curl -v -X GET 'http://192.168.1.200/api/app/status/network/devices/eth0'
```

Set static IPv4 address to network device *eth1*

```
curl -v -X POST -H 'Content-Type: application/json' -d '{"address": "192.168.2.200/24", "scope": "global"}' 'http://192.168.1.200/api/app/config/network/devices/eth1/addresses'
```

Enable network device *eth1*

```
curl -v -X POST -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/network/devices/eth1/enabled'
```

3.8 Storage

Storage configuration and status are located at JSON pointer `/storage`. The API is divided into two main parts. The first one (named as Disks) provides information about all connected storage devices. The second one (named as Mounts) allows to mount (attach) specified storage devices to their mount points (directories) and thus allowing access to them.

Snippet of storage configuration (at JSON pointer `/storage`)

```
{
  "mounts": {...}
}
```

Snippet of storage status (at JSON pointer `/storage`)

```
{
  "disks": {...},
  "mounts": {...}
}
```

3.8.1 Disks

Information about all connected storage devices is available in status at JSON pointer `/storage/disks`. There is no configuration available.

Snippet of disks status (at JSON pointer `/storage/disks`)

```
{
  "mmcblk2": {
    "partitions": {
      "mmcblk2p1": {
        "fstype": "vfat",
        "label": "SDCARD",
        "partuuid": "7de4bdea-01",
        "size": 15551430656,
        "uuid": "30D4-034F"
      }
    },
    "size": 15552479232
  },
  "sda": {
    "model": "Samsung SSD 870 ",
    "partitions": {
      "sda1": {
        "fstype": "ext4",
        "label": "SATADISK",
        "partuuid": "0f58d681-01",
        "size": 500106813440,
        "uuid": "a91b29f2-e8d4-4353-bbc9-7777d9f7cdf9"
      }
    },
    "size": 500107862016,
    "vendor": "ATA      "
  },
  "sdb": {
    "model": "VoyagerGT      ",
    "partitions": {
      "sdb1": {
        "fstype": "vfat",
        "label": "FLASH",
        "partuuid": "d353cb65-01",
        "size": 16239296512,
        "uuid": "40EB-8311"
      }
    }
  }
}
```

```

    }
  },
  "size": 16240345088,
  "vendor": "Corsair "
},
"sdc": {
  "fstype": "vfat",
  "label": "FLASH",
  "model": "Cruzer Fit      ",
  "size": 8002732032,
  "uuid": "E8CB-810D",
  "vendor": "SanDisk "
}
}

```

Storage devices are **System-managed**, so their names are fully controlled by operating system. Usually SATA and USB device names are in form of *sdX*, where *X* is an alphabetical character distinguishing the devices and respecting their connection order (the first device has assigned name *sda*, the second one has assigned name *sdb*, etc.). Usually MMC device names are in form of *mmcblkX*, where *X* is a number distinguishing the devices and respecting their connection order (the first device has assigned name *mmcblk0*, the second one has assigned name *mmcblk1*, etc.). FG4 Multibox already contains some private embedded MMC devices, so the first user connected device is named as *mmcblk2* (actually this is also the last one as FG4 Multibox contains only one physical SD card interface).

Each storage device may contain partitions, which are also system-managed devices. Usually partition names of SATA and USB storage device are constructed by appending partition number to storage device name (*sda* device may contain partitions named as *sda1*, *sda2*, etc.). Usually partition names of MMC storage device are constructed by appending character *p* and partition number to storage device name (*mmcblk2* device may contain partitions named as *mmcblk2p1*, *mmcblk2p2*, etc.).

The type of file system is given by item *fstype*. When this item exists, the file system is known and the corresponding storage device or partition is mountable. Note that there may exist storage device, that doesn't contain any partitions (no partition table), but still it may be mountable. In this case the item *fstype* is contained at root level of storage device, see *sdc* device in previous snippet.

All sizes are in bytes.

3.8.2 Mounts

Mounts configuration and status are located at JSON pointer `/storage/mounts`.

Snippet of mounts configuration (at JSON pointer `/storage/mounts`)

```

{
  "ramdisk": {
    "device": "tmpfs",
    "enabled": true,
    "options": "size=128M"
  },
  "satadisk": {
    "device": "sda1",
    "enabled": true
  },
  "sdcard": {
    "device": "mmcblk2p1",
    "enabled": true
  },
  "usbdisk": {
    "device": "sdb1",
    "enabled": false
  },
  "usbdisk_private": {
    "device": "uuid=40EB-8311",

```

```

    "enabled": true
  }
}

```

Snippet of mounts status (at JSON pointer `/storage/mounts`)

```

{
  "ramdisk": {
    "device": "tmpfs",
    "size": {
      "total": 134217728,
      "used": 0
    }
  },
  "satadisk": {
    "device": "sda1",
    "size": {
      "total": 491182030848,
      "used": 75509760
    }
  },
  "sdcard": {
    "device": "mmcblk2p1",
    "size": {
      "total": 15536226304,
      "used": 476225536
    }
  },
  "usbdisk_private": {
    "device": "sdb1",
    "size": {
      "total": 16223436800,
      "used": 16384
    }
  }
}

```

To have access to connected storage device, it must be mounted (attached) to specified mount point (directory). The content of storage device can be then accessed via [Filesystem service](#). To mount the storage device, just create/update appropriate object in configuration at JSON pointer `/storage/mounts`. The key represents mount point and the value contains device to be mounted (item *device*, required), enabled flag (item *enabled*, required), file system type (item *fstype*, optional) and mount options (item *options*, optional). Mount point name is just an user defined string, but it must not be empty and it must not contain the forward slash character “/” (ASCII 0x2F). The only required items specifying the mounted device are device name and enabled flag. In most cases file system is detected automatically and mount options are not required at all. Device name is either the partition name (in case of partitioned disk, can be found in status at JSON pointer `/storage/disks/<disk_name>/partitions/<partition_name>`) or the disk name (in case of not partitioned disk, can be found in status at JSON pointer `/storage/disks/<disk_name>`). When (and only when) the device is really mounted to its mount point, it is also present in status at JSON pointer `/storage/mounts`. The key represents mount point and the value contains name of mounted device (item *name*, required) and size information (item *size*, required).

The device can also be mounted by specifying its uuid, label, partuuid or partlabel, can be found in status at JSON pointers `/storage/disks/<disk_name>/partitions/<partition_name>/uuid|label|partuuid|partlabel` or `/storage/disks/<disk_name>/uuid|label`. In this case specify the device name as *uuid=<value>*, *label=<value>*, *partuuid=<value>* or *partlabel=<value>*. This kind of device specification provides solution for unpredictable disk and partition names.

There exists a very special mountable storage device, that stores data in physical RAM, often simply called as *ramdisk*. It is very fast, but also volatile and very limited in size. The name of this device is *tmpfs*. The contained file system is also *tmpfs*. The size of mounted device can be set by mount option *size=<value><unit>*. The unit can be one of *K*, *M* or *G*, for value in kibi, mebi or gibi bytes. The unit can also be *%*, for value in percentage of physical RAM. When no unit is specified, then value

is considered in bytes. When no size option is specified, then it is defaulted to *size=50%*. Note that the required size is always rounded up to multiple of entire physical RAM page, which is 4096 bytes. The special *tmpfs* device can be mounted multiple times at the same time. Don't set the size to large numbers, the system may then start to behave in a very non-standard way (when the Linux system is out of memory, it may start swapping or OOM killer may be triggered or something worse may happen).

The item *options* contains comma-separated mount options. In most cases they are not required at all. Actually the *options* string is directly given to the Linux 'mount' command, so any supported option may be given here. Be careful when using this parameter. When mounting *tmpfs* device, its size may be specified by *size* option (see the above paragraph). When read-only mounting is required, then add *ro* option. When mounting fat file system, then *utf8* option may be useful.

Supported file systems: vfat (fat16/32), exfat, ntfs, ext2, ext3, ext4, tmpfs.

All sizes are in bytes.

ATTENTION:

Be sure the storage device is unmounted before disconnecting from FG4 Multibox. Otherwise some data may get lost or even the file system may get corrupted. When the storage device is instructed to be unmounted, but it still remains mounted, then in most cases it is actually still used. Maybe some files remain still open, maybe some data are not yet completely flushed to storage.

3.8.3 Examples

Get list of connected storage devices

```
curl -v -X GET 'http://192.168.1.200/api/app/status/storage/disks '
```

Get list of mounted storage devices (mount points)

```
curl -v -X GET 'http://192.168.1.200/api/app/status/storage/mounts '
```

Create configuration for mounting to mount point *mntpt* (device to be mounted is set to *sda1*, but the mounting is still disabled for now)

```
curl -v -X POST -H 'Content-Type: application/json' -d '{"device":"sda1","enabled":false}' 'http://192.168.1.200/api/app/config/storage/mounts/mntpt '
```

Enable mounting to mount point *mntpt* (when the device is connected and contains supported file system, it will be mounted)

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/storage/mounts/mntpt/enabled '
```

Disable mounting to mount point *mntpt* (when the device is mounted, it will be unmounted)

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'false' 'http://192.168.1.200/api/app/config/storage/mounts/mntpt/enabled '
```

Delete configuration for mounting to mount point *mntpt*

```
curl -v -X DELETE 'http://192.168.1.200/api/app/config/storage/mounts/mntpt '
```

Get list of mount points (using Filesystem service, via HTTP, WebDAV)

```
curl 'http://192.168.1.200/api/fs/mounts/ '
```

3.9 Video

Video configuration and status are located at JSON pointer */video*. The API consists of two main parts. The first one (named as video captures) represents the video pipelines, responsible for receiving video frames from physical device (e.g. any video input located on FG4 card's FPD3/GMSL interface), encoding them and transmitting via network or saving to storage. The second one (named as video outputs)

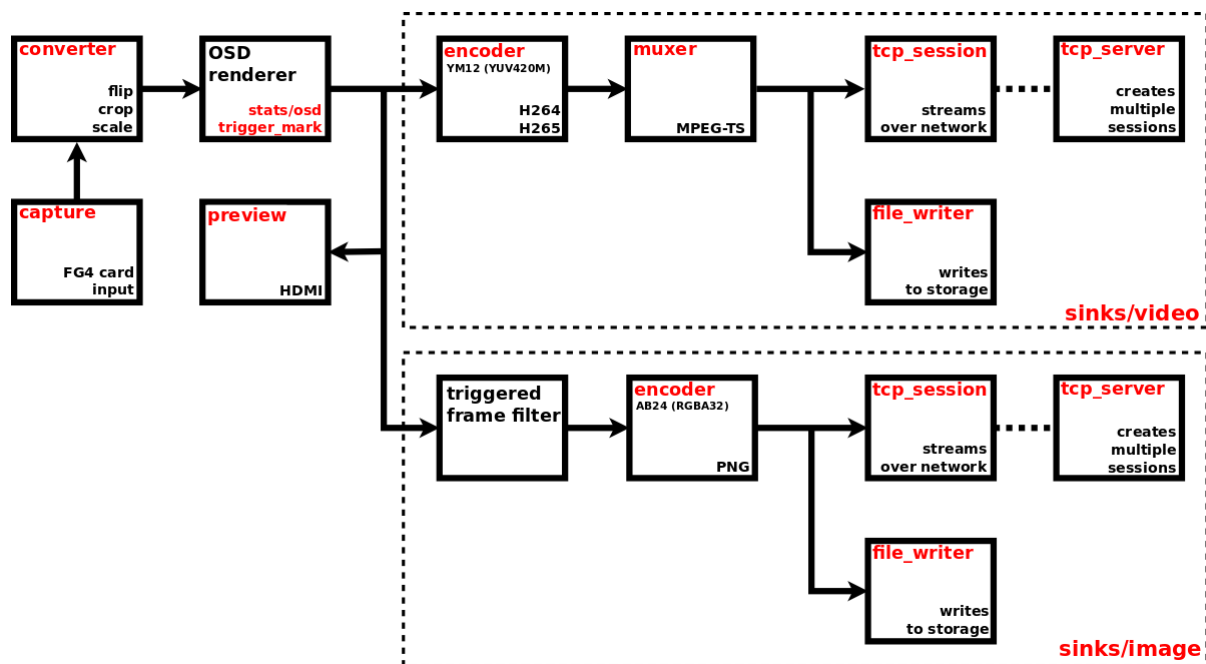
represents the video pipelines, responsible for reading video frames from specified source (e.g. video file, image file or test pattern generator) and transmitting them to physical device (e.g. any video output located on FG4 card's FPD3 interface). Each capture and output pipeline is identified by its unique name (`/video/captures/<name>`, `/video/outputs/<name>`). Actually this name is also the name of physical device, the video frames are received from or transmitted to. It simply means, that each capture and output pipeline has its own associated physical device. Both the capture and output pipelines are **System-managed devices**, so their names (and consequently the names of associated physical devices) are fully controlled by operating system.

Snippet of video configuration and status (at JSON pointer `/video`)

```
{
  "captures": {
    "fg4_001-003-001-018_i0": {...},
    "fg4_001-003-001-018_i1": {...}
  },
  "outputs": {
    "fg4_001-003-001-018_o0": {...},
    "fg4_001-003-001-018_o1": {...}
  }
}
```

3.9.1 Video captures

Next picture shows the component diagram of complete video capture pipeline, with arrows indicating the flow of video frames. Red labels are the names of corresponding objects in configuration and status JSONs, their simplified snippets are shown below the diagram.



Snippet of video capture pipeline configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0`)

```
{
  "enabled": true,
  "capture": {
    "fg4": {...}
  },
}
```

```

"converter": {...},
"preview": {...},
"sinks": {
  "image": {
    "enabled": false,
    "triggered_mode": false,
    "encoder": {...},
    "file_writer": {...},
    "tcp_server": {...},
    "tcp_session": {...}
  },
  "video": {
    "enabled": true,
    "encoder": {...},
    "muxer": {...},
    "file_writer": {...},
    "tcp_server": {...},
    "tcp_session": {...}
  }
},
"stats": {
  "osd": {...}
},
"trigger_mark": {...}
}

```

Snippet of video capture pipeline status (at JSON pointer `/video/captures/fg4_001-003-001-018_i0`)

```

{
  "running": true,
  "capture": {
    "fg4": {...}
  },
  "preview": {...},
  "sinks": {
    "image": {
      "running": false,
      "file_writer": {...}
    },
    "video": {
      "running": true,
      "file_writer": {...}
    }
  }
}

```

To enable the video capture pipeline, just set *enabled* to *true*. See *running* property in status to get the real state of video capture pipeline. If the *running* property is *true*, then at least capture device is running (i.e. video frames are captured from the associated physical device). Preview and individual sinks have their own separate *enable* property. To have the running video capture pipeline, some conditions must be met. Primarily the video capture pipeline must be enabled, the associated physical device must exist and must be ready to provide the video stream (i.e. in case of grabber device, there must be a valid video signal on its input interface).

The following links help to navigate to particular pipeline components (and other stuff).

- [Capture device](#)
- [Converter](#)
- [Preview](#)
- [Video sink](#)
 - [Encoder](#)
 - [Muxer](#)
 - [File writer](#)

- Streaming over network
- Image sink
 - Encoder
 - File writer
 - Streaming over network
- Statistics
- Trigger mark
- Timestamps
- Queuing buffers
- Examples

3.9.1.1 Capture device Currently only one type of physical capture device is supported, namely FG4. So this chapter covers only working with FG4. The configuration and status are located at JSON pointer `/video/captures/<name>/capture/fg4`.

Snippet of video capture device configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/capture/fg4`)

```
{
  "format": {
  },
  "interface": {
    "fpdl3": {
      "color_mapping": "spwg-vesa",
      "fpdl3_input_width": "automatic",
      "frequency_range": "pll_greater_or_equal_50mhz",
      "hsync_gap_length": 1000,
      "oldi_lane_width": "dual",
      "vsync_gap_length": 2
    },
    "gmsl": {
      "color_mapping": "spwg-vesa",
      "frequency_range": "pll_greater_or_equal_50mhz",
      "gmsl_fec": "enabled",
      "gmsl_mode": "br_12000M",
      "gmsl_stream_id": 1,
      "hsync_gap_length": 1000,
      "oldi_lane_width": "dual",
      "vsync_gap_length": 2
    }
  }
}
```

Snippet of video capture device status (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/capture/fg4`)

```
{
  "format": {
    "fourcc": "AR24",
    "rate": [
      150336000,
      2391660
    ],
    "size": [
      1920,
      1080
    ]
  },
  "format_descriptions": [
    {
      "fourcc": "AR24",
      "rates": [

```

```

        150336000,
        2391660,
        125000000,
        4294967295,
        125000000,
        1
    ]
],
"size": [
    1920,
    1080
]
},
{
    "fourcc": "YUYV",
    "rates": [
        [
            150336000,
            2391660,
            125000000,
            4294967295,
            125000000,
            1
        ]
    ],
    "size": [
        1920,
        1080
    ]
}
],
"interface": {
    "fpdl3": {
        "color_mapping": "spwg-vesa",
        "fpdl3_input_width": "automatic",
        "frequency_range": "pll_greater_or_equal_50mhz",
        "hback_porch": 50,
        "hfront_porch": 50,
        "hsync_gap_length": 1000,
        "hsync_status": "active_low",
        "hsync_width": 40,
        "input_id": 0,
        "link_status": "locked",
        "oldi_lane_width": "dual",
        "pclk_frequency": 150338,
        "stream_status": "detected",
        "vback_porch": 31,
        "vfront_porch": 30,
        "video_height": 1080,
        "video_width": 1920,
        "vsync_gap_length": 2,
        "vsync_status": "active_low",
        "vsync_width": 20
    }
},
"parent_device": "001-003-001-018"
}

```

This type of video capture is a part of FG4 card (actually it represents an input of the interface module), so there exists a reference to this card, property *parent_device*. It contains the name of parent FG4 card, whose properties can be found at JSON pointer `/fg4/devices/<name>`. See [FG4 PCIe cards](#) chapter to get detailed information.

3.9.1.1.1 Format In general a capture device acts as essential source of video frames for the whole video capture pipeline. Only when the element *format* is present in status, the capture device is ready to provide the video stream (i.e. in case of FG4 card there is a valid video signal on its input interface). The *format* describes the stream, that is provided by the capture device. When the pipeline is **running**, then *format* describes the actually flowing stream. When the pipeline is **not running**, then *format* describes the stream, that will be flowing when the pipeline is enabled (and consequently running) and no custom format is specified. The format has these properties:

fourcc - Pixel format represented as [FourCC](#).

size - Frame size [width, height], in pixels.

rate - Frame rate represented as rational number [num, den], in frames per second.

It is allowed to specify a custom format. If the element *format* is present in configuration, the capture device tries to provide the stream in specified format. If the specified format cannot be used, then some other is used. Again, when pipeline is running, check *format* in status to get the actually used format. In configuration the element *format* is optional and also its all three sub-elements *fourcc*, *size* and *rate* are optional. Currently only *fourcc* and *rate* are evaluated, *size* is ignored. Possible format values can be determined from status element *format_descriptions*. It is actually an array of allowed formats, where each element has these properties:

fourcc - Pixel format represented as [FourCC](#).

size - Frame size, in pixels. It is represented as [width, height] in case of discrete size, or as [min_width, min_height, max_width, max_height, step_width, step_height] in case of step-wise size.

rates - Array of frame rates, in frames per second. Each one is represented as [num, den] in case of discrete rate, or as [max_num, max_den, min_num, min_den, step_num, step_den] in case of step-wise rate. In calculations step must be used as period (not frame rate), with flipped numerator and denominator, e.g. $custom_rate = 1 / (min_den / min_num + 10 * step_den / step_num)$.

Element *fourcc* may contain only *AR24* or *YUYV*. Pixel format *AR24* is ABGR with four bytes per pixel, pixel format *YUYV* is YUV 4:2:2 with four bytes per two pixels. So the *YUYV* takes only half the bandwidth compared to *AR24*. On the other hand it may lose some information, because e.g. FPD3/GMSL interfaces use the RGB with three bytes per pixel. Omit the *fourcc* to use the default *AR24*.

Element *rate* may be used to set a custom fixed frame rate, which must always be less than the one being captured on hardware interface. It may be useful to reduce the bandwidth. Omit the *rate* to use the value captured on interface.

Element *size* is ignored as it is always used the value captured on interface.

Specifying the custom pixel format may be effectively used only for affecting the bandwidth on PCIe. After capturing into the pipeline the pixel format is always transformed to the format required by the following pipeline components, e.g. video stream (H264, H265) uses *YM12* (YUV 4:2:0 planar).

NOTE:

Firmware version 1.0 doesn't support specifying custom format. It always uses the *AR24* pixel format and the frame size and frame rate captured on interface.

3.9.1.1.2 Interface Each FG4 card may contain an interchangeable part named as interface module (or just interface). Each interface may contain one or more video inputs. Each video input is represented by this capture device. Check the status *interface* element to get the actually used interface type (it contains exactly one sub-element, *fpd3* or *gmsl*). Each interface contains a number of properties, whose actual values are available in status. Some of them can be set to custom value, just put the property into configuration. To use the default (or last set) value, just omit the property from configuration. Currently FPD3 and GMSL interfaces are supported.

FPD3 interface

List of all existing properties (available in status):

input_id - integer. Input number ID, zero based.

oldi_lane_width - string enum (*single*, *dual*). Number of deserializer output lanes.

color_mapping - string enum (*oldi_jeida*, *spwg_vesa*). Mapping of the incoming bits in the signal to the colour bits of the pixels.

link_status - string enum (*unlocked*, *locked*). Video link status. If the link is locked, chips are properly connected and communicating at the same speed and protocol. The link can be locked without an active video stream.

stream_status - string enum (*not_detected*, *detected*). Video stream status. A stream is detected if the link is locked, the input pixel clock is running and the DE signal is moving.

video_width - integer. Video stream width. This is the actual width as detected by the HW.

video_height - integer. Video stream height. This is the actual height as detected by the HW.

vsync_status - string enum (*active_low*, *active_high*, *not_available*). The type of VSYNC pulses as detected by the video format detector.

hsync_status - string enum (*active_low*, *active_high*, *not_available*). The type of HSYNC pulses as detected by the video format detector.

vsync_gap_length - integer. If the incoming video signal does not contain synchronization VSYNC and HSYNC pulses, these must be generated internally in the FPGA to achieve the correct frame ordering. This value indicates, how many *empty* pixels (pixels with deasserted Data Enable signal) are necessary to generate the internal VSYNC pulse.

hsync_gap_length - integer. If the incoming video signal does not contain synchronization VSYNC and HSYNC pulses, these must be generated internally in the FPGA to achieve the correct frame ordering. This value indicates, how many *empty* pixels (pixels with deasserted Data Enable signal) are necessary to generate the internal HSYNC pulse. The value must be greater than 1 and smaller than *vsync_gap_length*.

pclk_frequency - integer. Input pixel clock frequency in kHz.

hsync_width - integer. Width of the HSYNC signal in PCLK pulses.

vsync_width - integer. Width of the VSYNC signal in video lines.

hback_porch - integer. Number of PCLK pulses between deassertion of the HSYNC signal and the first valid pixel in the video line (marked by DE=1).

hfront_porch - integer. Number of PCLK pulses between the end of the last valid pixel in the video line (marked by DE=1) and assertion of the HSYNC signal.

vback_porch - integer. Number of video lines between deassertion of the VSYNC signal and the video line with the first valid pixel (marked by DE=1).

vfront_porch - integer. Number of video lines between the end of the last valid pixel line (marked by DE=1) and assertion of the VSYNC signal.

frequency_range - string enum (*pll_less_than_50mhz*, *pll_greater_or_equal_50mhz*). PLL frequency range of the OLDI input clock generator. The PLL frequency is derived from the Pixel Clock Frequency (PCLK) and is equal to PCLK if *oldi_lane_width* is set to *single* and PCLK/2 if *oldi_lane_width* is set to *dual*.

fpdl3_input_width - string enum (*automatic*, *single*, *dual*). Number of deserializer input lines.

List of configurable properties (may occur in configuration):

oldi_lane_width

color_mapping

vsync_gap_length

hsync_gap_length

frequency_range

fpdl3_input_width

The frame rate may be computed by the formula:

$frame_rate = pclk_frequency * 1000 / (total_width * total_height)$
 $total_width = video_width + hfront_porch + hback_porch + hsync_width$
 $total_height = video_height + vfront_porch + vback_porch + vsync_width$

GMSL interface

List of all existing properties (available in status):

input_id - integer. Input number ID, zero based.

oldi_lane_width - string enum (*single*, *dual*). Number of deserializer output lanes.

color_mapping - string enum (*oldi_jeida*, *spwg_vesa*). Mapping of the incoming bits in the signal to the colour bits of the pixels.

link_status - string enum (*unlocked*, *locked*). Video link status. If the link is locked, chips are properly connected and communicating at the same speed and protocol. The link can be locked without an active video stream.

stream_status - string enum (*not_detected*, *detected*). Video stream status. A stream is detected if the link is locked, the input pixel clock is running and the DE signal is moving.

video_width - integer. Video stream width. This is the actual width as detected by the HW.

video_height - integer. Video stream height. This is the actual height as detected by the HW.

vsync_status - string enum (*active_low*, *active_high*, *not_available*). The type of VSYNC pulses as detected by the video format detector.

hsync_status - string enum (*active_low*, *active_high*, *not_available*). The type of HSYNC pulses as detected by the video format detector.

vsync_gap_length - integer. If the incoming video signal does not contain synchronization VSYNC and HSYNC pulses, these must be generated internally in the FPGA to achieve the correct frame ordering. This value indicates, how many *empty* pixels (pixels with deasserted Data Enable signal) are necessary to generate the internal VSYNC pulse.

hsync_gap_length - integer. If the incoming video signal does not contain synchronization VSYNC and HSYNC pulses, these must be generated internally in the FPGA to achieve the correct frame ordering. This value indicates, how many *empty* pixels (pixels with deasserted Data Enable signal) are necessary to generate the internal HSYNC pulse. The value must be greater than 1 and smaller than *vsync_gap_length*.

pclk_frequency - integer. Input pixel clock frequency in kHz.

hsync_width - integer. Width of the HSYNC signal in PCLK pulses.

vsync_width - integer. Width of the VSYNC signal in video lines.

hback_porch - integer. Number of PCLK pulses between deassertion of the HSYNC signal and the first valid pixel in the video line (marked by DE=1).

hfront_porch - integer. Number of PCLK pulses between the end of the last valid pixel in the video line (marked by DE=1) and assertion of the HSYNC signal.

vback_porch - integer. Number of video lines between deassertion of the VSYNC signal and the video line with the first valid pixel (marked by DE=1).

vfront_porch - integer. Number of video lines between the end of the last valid pixel line (marked by DE=1) and assertion of the VSYNC signal.

frequency_range - string enum (*pll_less_than_50mhz*, *pll_greater_or_equal_50mhz*). PLL frequency range of the OLDI input clock generator. The PLL frequency is derived from the Pixel Clock Frequency (PCLK) and is equal to PCLK if *oldi_lane_width* is set to *single* and PCLK/2 if *oldi_lane_width* is set to *dual*.

gmsl_mode - string enum (*br_12000M*, *br_6000M*, *br_3000M*, *br_1500M*). GMSL speed mode.

gmsl_stream_id - integer. The GMSL multi-stream contains up to four video streams. This parameter selects which stream is captured by the video input. The value is the zero-based index of the stream.

gmsl_fec - string enum (*disabled*, *enabled*). GMSL Forward Error Correction (FEC).

List of configurable properties (may occur in configuration):

oldi_lane_width
color_mapping
vsync_gap_length
hsync_gap_length
frequency_range
gmsl_mode
gmsl_stream_id
gmsl_fec

The frame rate may be computed by the formula:

$$\begin{aligned} \text{frame_rate} &= \text{pclk_frequency} * 1000 / (\text{total_width} * \text{total_height}) \\ \text{total_width} &= \text{video_width} + \text{hfront_porch} + \text{hback_porch} + \text{hsync_width} \\ \text{total_height} &= \text{video_height} + \text{vfront_porch} + \text{vback_porch} + \text{vsync_width} \end{aligned}$$

3.9.1.2 Converter Converter is a component allowing to perform some hardware accelerated transformations (resizing, cropping, rotating, flipping etc.). The configuration is located at JSON pointer `/video/captures/<name>/converter`. There is no status available.

Snippet of converter configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/converter`)

```
{
  "size": [
    0,
    0
  ],
  "crop_src": [
    0,
    0,
    0,
    0
  ],
  "crop_dst": [
    0,
    0,
    0,
    0
  ],
  "flip": "none",
  "filter": "none"
}
```

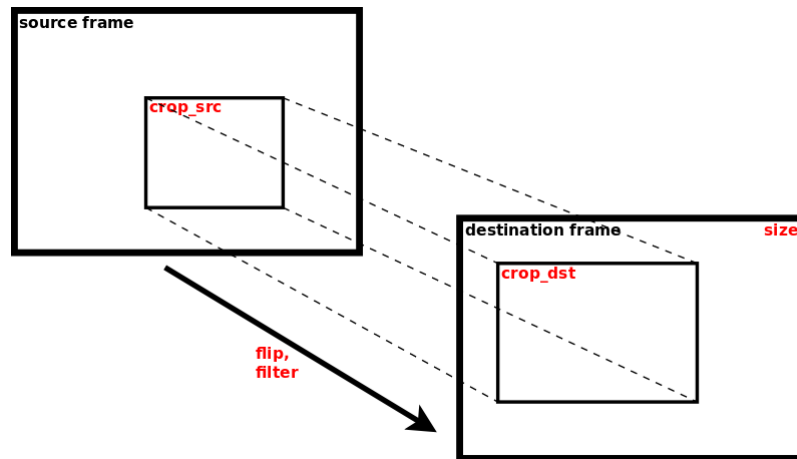
size - Destination frame size [width, height] (in pixels). Must be between [128, 128] and [4096, 4096]. Set to [0, 0] to disable resizing. Any invalid values result in disabled resizing.

crop_src - Source frame cropping parameters [x, y, width, height] (in pixels). Must be between [128, 128] and [4096, 4096]. Set to [0, 0, 0, 0] to disable cropping. Any invalid values result in disabled cropping. When the cropping window exceeds the source frame size, cropping is also disabled.

crop_dst - Destination frame cropping parameters [x, y, width, height] (in pixels). Must be between [128, 128] and [4096, 4096]. Set to [0, 0, 0, 0] to disable cropping. Any invalid values result in disabled cropping. When the cropping window exceeds the destination frame size, cropping is also disabled.

flip - Flipping method (*none*, *rotate_90*, *rotate_180*, *rotate_270*, *flip_x*, *flip_y*, *transpose*, *inverse_transpose*).

filter - Filtering (smoothing) method (*none*, *nearest*, *bilinear*, *tap_5*, *tap_10*, *smart*, *nicest*).



3.9.1.3 Preview Preview is a component allowing to view the video stream on **HDMI**. The configuration and status are located at JSON pointer `/video/captures/<name>/preview`.

Snippet of preview configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/preview`)

```
{
  "enabled": false,
  "window": {
    "position": [
      0,
      0
    ],
    "size": [
      0,
      0
    ],
    "border": {
      "width": 0
    }
  },
}
```

Snippet of preview status (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/preview`)

```
{
  "running": false
}
```

To enable the preview, just set *enabled* property to *true*. See *running* property in status to get the real state of the preview. If the *running* property is *true*, then the video frames are rendered to *window*, whose properties are:

position - Coordinates [x, y] (in pixels) of the top-left corner of rendered window. They are ignored in fullscreen.

size - Size [width, height] (in pixels) of rendered window. It must be greater or equal [128, 128]. Size [0, 0] is translated to fullscreen. Size [1, 1] is translated to the size of original frame. Other combinations (whatever dimension less than 128) are reserved, but currently translated to fullscreen.

border/width - Width (in pixels) of window border.

When no external monitor is detected on **HDMI**, then preview will not be running, although it is enabled.

3.9.1.4 Video sink Video sink is probably the most typical way of processing the captured video stream. In this sink the video stream is being encoded (H264, H265), muxed (MPEG-TS) and then

directly saved to storage or streamed over network. The configuration and status are located at JSON pointer `/video/captures/<name>/sinks/video`.

Snippet of video sink configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/sinks/video`)

```
{
  "enabled": true,
  "encoder": {
    "type": "h264",
    "h264": {
      "profile": "high",
      "bitrate": 33000000,
      "bitrate_peak": 0,
      "idr_interval": 34,
      "iframe_interval": 34
    },
    "h265": {
      "profile": "main",
      "bitrate": 33000000,
      "bitrate_peak": 0,
      "idr_interval": 34,
      "iframe_interval": 34
    }
  },
  "muxer": {
    "type": "mpegts",
    "mpegts": {
      "allocated_capture_buffers": 64
    }
  },
  "file_writer": {
    "enabled": false,
    "path": "mounts:/satadisk/video/captures/fg4_001-003-001-018_i0/sinks/video/",
    "enqueued_output_buffers": 64
  },
  "tcp_server": {
    "port": 50180
  },
  "tcp_session": {
    "enqueued_output_buffers": 32
  }
}
```

Snippet of video sink status (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/sinks/video`)

```
{
  "running": true,
  "file_writer": {
    "running": false
  }
}
```

To enable the sink, just set *enabled* property to *true*. See *running* property in status to get the real state of the sink. If the *running* property is *true*, then at least encoder and muxer are running, also TCP server should be running. When encoder or muxer are not able to run (for whatever reason), then also the sink is not able to run and the *running* property is *false*. When TCP server is not able to run (for whatever reason), then it has no impact on the sink and its *running* property remains unchanged. File writer has its own *enabled* and *running* properties.

After the file writer gets running or the TCP client gets connected, they **immediately** receive frames from already running stream (consisting of encoded and muxed frames). There exists no special file container (mp4, mpv, ...). There exists no additional filtering, e.g. skipping first no-key frames. This is

the pretty suitable solution for having low-latency and high-efficiency video stream for multiple recipients. Any DVB-T/S stream works in the same way.

3.9.1.4.1 Encoder The configuration is located at JSON pointer `/video/captures/<name>/sinks/video/encoder`. Status is not available. There are multiple types of encoder, so set the *type* property to select the required one. The *type* may contain one of these values: *h264*, *h265*. The configuration of each particular encoder is then contained in its own property of the same name.

H264

Encoder H264 (also known as AVC or MPEG-4 Part 10) has these configuration properties:

profile - Profile. It may contain one of these values: *baseline*, *main* and *high*.

bitrate - Bitrate (in bits per second), in range from 8192 (1 kiB/s) to 134217728 (16 MiB/s). It is only a hint, so the real bitrate may vary. Typically, if the configured bitrate is too high to be fully utilized to encode the low complexity frames, then the real bitrate will always be less than the configured one.

bitrate_peak - Peak bitrate (in bits per second), in range from 0 to 134217728 (16 MiB/s). If greater than *bitrate*, then required real bitrate is considered as variable, otherwise it is considered as constant. It is only a hint, so the real bitrate may occur outside the specified range.

idr_interval - Interval between two IDR-frames (in number of frames), in range from 1 to 1024.

iframe_interval - Interval between two I-frames (in number of frames), in range from 1 to 1024.

The encoder is hardware accelerated and always uses the *YM12* (YUV 4:2:0 planar) pixel format, with BT.601 limited range encoding. The frames are converted automatically.

H265

Encoder H265 (also known as HEVC or MPEG-H Part 2) has these configuration properties:

profile - Profile. It may contain one of these values: *main*.

bitrate - Bitrate (in bits per second), in range from 8192 (1 kiB/s) to 134217728 (16 MiB/s). It is only a hint, so the real bitrate may vary. Typically, if the configured bitrate is too high to be fully utilized to encode the low complexity frames, then the real bitrate will always be less than the configured one.

bitrate_peak - Peak bitrate (in bits per second), in range from 0 to 134217728 (16 MiB/s). If greater than *bitrate*, then required real bitrate is considered as variable, otherwise it is considered as constant. It is only a hint, so the real bitrate may occur outside the specified range.

idr_interval - Interval between two IDR-frames (in number of frames), in range from 1 to 1024.

iframe_interval - Interval between two I-frames (in number of frames), in range from 1 to 1024.

The encoder is hardware accelerated and always uses the *YM12* (YUV 4:2:0 planar) pixel format, with BT.601 limited range encoding. The frames are converted automatically.

3.9.1.4.2 Muxer The configuration is located at JSON pointer `/video/captures/<name>/sinks/video/muxer`. Status is not available. There are multiple types of multiplexer, so set the *type* property to select the required one. The *type* may contain one of these values: *mpegts*. The configuration of each particular multiplexer is then contained in its own property of the same name. Currently only one multiplexer (MPEG-TS) is supported.

MPEG-TS

Multiplexer MPEG-TS has these configuration properties:

allocated_capture_buffers - Number of allocated capture buffers, in range from 1 to 128. They are buffers filled with muxed video and going out from the multiplexer. See [Queuing buffers](#) for detailed information.

3.9.1.4.3 File writer The configuration and status are located at JSON pointer `/video/captures/<name>/sinks/video/file_writer`. File writer is responsible for storing the encoded/muxed stream to mounted device (e.g. SATA or USB disk). Destination file is determined by *path*, which is a string complying with definition of URI (Uniform Resource Identifier), see [RFC3986](#). Only scheme and path components are used within the URI.

Scheme component must always be set to *mounts* value. It means that one of the mounted devices will be used for writing the file.

Path component represents the file path. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer `/storage/mounts`. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. The path may contain some special variables, which are replaced by their real values at the time the file is created. These variables must be specified in form `$(variable_name)`. Currently supported variables:

time - system time complying with full date and time according to ISO 8601, with milliseconds

ext - default file extension (including the dot “.”) corresponding with used data format

When the path ends with forward slash character “/”, it is considered as directory and the file name is constructed automatically as `$(time)$(ext)`. When the path contains non-existent directories, they will be created automatically.

Here are examples of possible paths:

```
mounts:/satadisk/video/captures/fg4_001-003-001-018_i0/sinks/video/
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directories *video*, *captures*, *fg4_001-003-001-018_i0*, *sinks* and *video* are created automatically if they don't exist. Because the path ends with “/”, it is considered as directory and the file name is constructed automatically. So the resulting file name on the mounted device may look something like `/video/captures/fg4_001-003-001-018_i0/sinks/video/20240215T105231.517Z.ts`.

```
mounts:/satadisk/captures/fg4_018_$(time)$(ext)
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directory *captures* is created automatically if it doesn't exist. The resulting file name on the mounted device may look something like `/captures/fg4_018_20240215T105231.517Z.ts`.

To enable the file writer, just set *enabled* to *true*. See *running* property in status to get the real state of file writer. To have the running file writer, some conditions must be met. E.g. the whole capture pipeline must be enabled, video sink must be enabled, file writer must be enabled, mount point must exist, mounted device must be writable and must contain enough free space, file name must be correctly specified, valid signal must be present on input of video capture device. When any of these conditions are not met or any errors occur, the file writer stops working and the *running* state is set to *false*. Whenever the file writer changes its *running* state to *true*, it creates new file and opens it for writing. When the file writer changes its *running* state to *false*, it also closes the file.

The last property is *enqueued_output_buffers*. It is the maximum number of enqueued output buffers, with minimum of 1. They are buffers coming directly from multiplexer. See [Queuing buffers](#) for detailed information.

3.9.1.4.4 Streaming over network Encoded/muxed stream may also be transmitted over network as TCP stream. Element *tcp_server* represents the TCP server, that listens on specified *port*. Each time it accepts incoming connection, new TCP session is created. Multiple TCP sessions may exist at the same time. Each created TCP session is configured with parameters found in *tcp_session* element. It has only one single property *enqueued_output_buffers*. It is the maximum number of enqueued output buffers, with minimum of 1. They are buffers coming directly from multiplexer. See [Queuing buffers](#) for detailed information.

3.9.1.5 Image sink Video sink is a little special way of processing the captured video stream. In this sink the video stream is being encoded (PNG) into sequence of separated images, and then directly saved to storage (as separated files) or streamed over network (as sequence of images). The configuration and status are located at JSON pointer `/video/captures/<name>/sinks/image`.

Snippet of image sink configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/sinks/image`)

```
{
  "enabled": true,
  "triggered_mode": false,
  "encoder": {
    "type": "png",
    "png": {
      "filter": "none",
      "compression": 6,
      "threads": 2,
      "allocated_capture_buffers": 64
    }
  },
  "file_writer": {
    "enabled": false,
    "path": "mounts:/satadisk/video/captures/fg4_001-003-001-018_i0/sinks/image/",
    "enqueued_output_buffers": 64,
    "ring_buffer": {
      "enabled": true,
      "size": 100
    }
  },
  "tcp_server": {
    "port": 50184
  },
  "tcp_session": {
    "enqueued_output_buffers": 32
  }
}
```

Snippet of image sink status (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/sinks/image`)

```
{
  "running": true,
  "file_writer": {
    "running": false
  }
}
```

To enable the sink, just set *enabled* property to *true*. See *running* property in status to get the real state of the sink. If the *running* property is *true*, then at least encoder is running, also TCP server should be running. When encoder is not able to run (for whatever reason), then also the sink is not able to run and the *running* property is *false*. When TCP server is not able to run (for whatever reason), then it has no impact on the sink and its *running* property remains unchanged. File writer has its own *enabled* and *running* properties.

After the file writer gets running or the TCP client gets connected, they **immediately** receive frames from already running stream (consisting of encoded frames - images).

Due to its nature the image sink may operate in so called “triggered” mode. To enable this mode, just set *triggered_mode* property to *true*. In this mode the normal streaming of images is blocked and the image is **passed only when** a dedicated nonparametric synchronous action at URL path

- `/api/app/actions/video/captures/<name>/sinks/image/trigger_image`

is called. Every call of this action is buffered. Then, when a frame is captured (by captured device) and the buffer of actions is not empty, the frame is passed and the buffer of actions is cleaned. The buffer is also cleaned whenever the image sink changes its state to running. Of course, the action can be used as

Trigger sink within the **Trigger system**. In this case all participating triggers are stored (if possible) as metadata in the passed image. Actually, when the action is called directly by HTTP API (not as trigger sink), the action is also stored, the same way as the trigger, but with empty trigger identifier. See the particular encoder chapters how the triggers are stored in the image.

Although the captured video frames and generated triggers have their own timestamps, there exists no their explicit timestamp-based synchronization when working in triggered mode. Typically, the triggers are generated (and timestamped) in their own threads, the video frames are captured (and timestamped) in their own threads and also the trigger-based video frame filter works in its own thread. The filter processes the triggers and frames as they are coming, as fast as possible and without any specific timestamp-based synchronization. So the time-based closeness depends primarily on CPU power. This behaviour results from the fact, that the precision of assigning the timestamps to the triggers and video frames also depends primarily on CPU power and within the current Linux system it can't be solved in a better way. So the timestamps difference between the passed video frame and its trigger is absolutely as small as possible (dependent on CPU power), but it may have both positive and negative sign. See the **Examples** how the timestamps may look like.

3.9.1.5.1 Encoder The configuration is located at JSON pointer `/video/captures/<name>/sinks/image/encoder`. Status is not available. There are multiple types of encoder, so set the *type* property to select the required one. The *type* may contain one of these values: *png*. The configuration of each particular encoder is then contained in its own property of the same name. Currently only one encoder (PNG) is supported.

PNG

Encoder PNG has these configuration properties:

filter - Filter type, may contain one of these values: *none*, *sub*, *up*, *avg*, *paeth*. The purpose of the filter is to prepare the image data for optimum compression.

compression - Compression level, in range from 0 to 9. Zero level means no compression.

threads - Number of threads performing the compression, in range from 1 to 6.

allocated_capture_buffers - Number of allocated capture buffers, in range from 1 to 128. They are buffers filled with encoded images and going out from encoder. See **Queuing buffers** for detailed information.

The encoder is lossless and always uses RGBA pixel format, with 32-bit per pixel. The frames are converted automatically. The encoder is not hardware accelerated, but it provides the possibility to set the number of threads performing the compression. Increasing the *threads* property increases the frame rate, of course, the latency remains unchanged. Note that increasing the *threads* property causes more consumed CPU power, so it may have significant impact on the rest of the system. Interesting possibility to increase the frame rate, decrease latency and save CPU power is to decrease the *compression* property, of course at the cost of increased bandwidth. Also the *filter* property has significant impact on CPU power, e.g. setting to *none* totally disables the filtering, so it saves CPU power, of course, at the cost of worse compression. Setting *filter* to *none* and *compression* to 0 results in streaming totally unencoded (raw) image data, so it usually saves maximum CPU power but consumes maximum bandwidth.

PNG format allows to store additional textual metadata. This is used for storing the timestamp and trigger, both in key-value tEXt chunks.

Timestamp is identified by the key *ts*, the value contains the timestamp, as integer number in nanoseconds. See the **Timestamps** for detailed information.

Trigger is identified by the key *tr*, the value contains the trigger, as JSON object. See the **Trigger** for detailed information. Multiple triggers are stored as multiple key-value chunks.

3.9.1.5.2 File writer The configuration and status are located at JSON pointer `/video/captures/<name>/sinks/image/file_writer`. File writer is responsible for storing the encoded frames to mounted device (e.g. SATA or USB disk). Each frame is stored to **its own separate** file. The file is determined by *path*, which is a string complying with definition of URI (Uniform Resource Identifier), see **RFC3986**. Only scheme and path components are used within the URI.

Scheme component must always be set to *mounts* value. It means that one of the mounted devices will be used for writing the file.

Path component represents the file path. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer */storage/mounts*. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. The path may contain some special variables, which are replaced by their real values at the time the file is created. These variables must be specified in form *\$(variable_name)*. Currently supported variables:

time - system time complying with full date and time according to ISO 8601, with milliseconds

ext - default file extension (including the dot “.”) corresponding with used data format

When the path ends with forward slash character “/”, it is considered as directory and the file name is constructed automatically as *\$(time)\$(ext)*. When the path contains non-existent directories, they will be created automatically.

Here are examples of possible paths:

```
mounts:/satadisk/video/captures/fg4_001-003-001-018_i0/sinks/image/
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directories *video*, *captures*, *fg4_001-003-001-018_i0*, *sinks* and *image* are created automatically if they don't exist. Because the path ends with “/”, it is considered as directory and the file name is constructed automatically. So the resulting file name on the mounted device may look something like */video/captures/fg4_001-003-001-018_i0/sinks/image/20240215T105231.517Z.png*.

```
mounts:/satadisk/captures/fg4_018_$(time)$(ext)
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directory *captures* is created automatically if it doesn't exist. The resulting file name on the mounted device may look something like */captures/fg4_018_20240215T105231.517Z.png*.

To enable the file writer, just set *enabled* to *true*. See *running* property in status to get the real state of file writer. To have the running file writer, some conditions must be met. E.g. the whole capture pipeline must be enabled, image sink must be enabled, file writer must be enabled, mount point must exist, mounted device must be writable and must contain enough free space, file name must be correctly specified, valid signal must be present on input of video capture device. When any of these conditions are not met or any errors occur, the file writer stops working and the *running* state is set to *false*.

Because each frame is stored to its own separate file, the number of created files may grow very quickly and the filesystem may get overloaded very easily. Therefore the file writer is equipped with ring buffer, that allows to keep only specified number of latest files. The buffer remembers created files (full paths) and when their number exceeds specified size, the oldest ones are deleted. When ring buffer is disabled, whole remembered history of created files is lost, but created files still remain on storage. The configuration is contained in property *ring_buffer*. The property *enabled* enables/disables ring buffer (by default it is always enabled), the property *size* determines the size of ring buffer, it means the number of latest files being kept on storage.

The last property is *enqueued_output_buffers*. It is the maximum number of enqueued output buffers, with minimum of 1. They are buffers coming directly from encoder. See [Queuing buffers](#) for detailed information.

3.9.1.5.3 Streaming over network Encoded frames may also be transmitted over network as TCP stream. Element *tcp_server* represents the TCP server, that listens on specified *port*. Each time it accepts incoming connection, new TCP session is created. Multiple TCP sessions may exist at the same time. Each created TCP session is configured with parameters found in *tcp_session* element. It has only one single property *enqueued_output_buffers*. It is the maximum number of enqueued output buffers, with minimum of 1. They are buffers coming directly from encoder. See [Queuing buffers](#) for detailed information.

3.9.1.6 Statistics When the video pipeline is running, some useful statistics are being computed. The configuration is located at JSON pointer `/video/captures/<name>/stats`. Status is not available.

Snippet of statistics configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/stats`)

```
{
  "osd": {
    "enabled": true,
    "position": [
      16,
      16
    ],
    "size": 10
  }
}
```

The statistics are quite rough numbers, rather intended for quick insight or debug purposes. They may be rendered into the running video stream as OSD window. Currently this is the only way how to view them. The configuration properties are:

osd/enabled - If *true*, then OSD window is enabled.

osd/position - Coordinates [x, y] (in pixels) of the top-left corner of rendered OSD window.

osd/size - Font size.

The example of statistics OSD window:

```
capt > size:1920x1080 rate:63/497 delay:0 pass:9151 drop:0
conv > size:1920x1080 rate:63/502 delay:4 pass:9151
venc > rate:63/0 delay:23 pass:9150 drop:0
ienc > rate:27/2 delay:109 pass:3859 drop:5289
vfwr > drop: 0
ifwr > drop: 0
vtcp 192.168.1.114:56460 > delay:23 drop:0
itcp 192.168.1.114:34272 > delay:109 drop:0
```

Each line begins with shortened name of the video pipeline component followed by its statistics. Possible components:

capt - **Capture device**. Always present.

conv - **Converter**. Always present.

venc - **Video sink encoder**. Present only if video sink is enabled.

ienc - **Image sink encoder**. Present only if image sink is enabled.

vfwr - **Video sink file writer**. Present only if video sink file writer is enabled.

ifwr - **File sink file writer**. Present only if image sink file writer is enabled.

vtcp <ip>:<port> - **Video sink TCP session**. IP address and port identify the connected client. Present only if the client is connected.

itcp <ip>:<port> - **Image sink TCP session**. IP address and port identify the connected client. Present only if the client is connected.

The following statistics are:

size - Size (width x height) of the video frame.

rate - The first number indicates the frame rate (in frames per second, fps). The second number indicates the bitrate (in megabytes per second, MiB/s). Both numbers are shown as integers (truncated floats).

delay - Delay (in milliseconds) of the frame at time of leaving the corresponding component. It is measured relatively to the time at which the frame was received by driver of the underlying linux video device. As shown in the OSD window example, it took 23 milliseconds from capturing the frame till passing it into the video sink TCP socket.

pass - Number of frames, that were passed through the corresponding component. It is counted from the time at which the component was created/enabled.

drop - Number of frames, that couldn't be passed through the corresponding component (e.g. it was busy) and thus were dropped. It is counted from the time at which the component was created/enabled. It is very typical for PNG image sink encoder (*ienc*) to have many dropped frames, because it is not hardware accelerated. In case of slow network or TCP client the number of dropped frames may grow by TCP session (*vtcp*, *itcp*). In case of slow storage device the number of dropped frames may grow by file writer (*vfwr*, *ifwr*). To get the number of frames dropped alongside multiple pipeline components, just sum the dropped frames from all participating components. E.g. to get the total number of dropped frames on the path the between capture device and video sink TCP client, sum dropped frames from *capt*, *vinc* and *vtcp*. Converter and muxer never drop the frames, because they are tightly coupled with preceding component. E.g. if converter is too slow, then number of dropped frames by capture device is growing, if muxer is too slow, then number of dropped frames by encoder is growing.

3.9.1.7 Trigger mark Trigger mark configuration is located at JSON pointer `/video/captures/<name>/trigger_mark`. Status is not available.

Snippet of trigger mark configuration (at JSON pointer `/video/captures/fg4_001-003-001-018_i0/trigger_mark`)

```
{
  "position": [
    0,
    0
  ],
  "size": 10
}
```

Trigger mark is a custom text rendered into the running video stream for a specified time. The configuration properties are:

position - Coordinates [x, y] (in pixels) of the top-left corner of the first (oldest) rendered trigger mark. When multiple trigger marks have to be rendered at the same time, they are serialized by their creation time into one single column, with the oldest one at the top and with the latest one at the bottom.

size - Font size.

To create a trigger mark, just call this parametric synchronous action at URL path

- `/api/app/actions/video/captures/<name>/trigger_mark`

with parameter being a JSON object like this:

```
{
  "text" : "My custom trigger mark",
  "timeout" : 1000
}
```

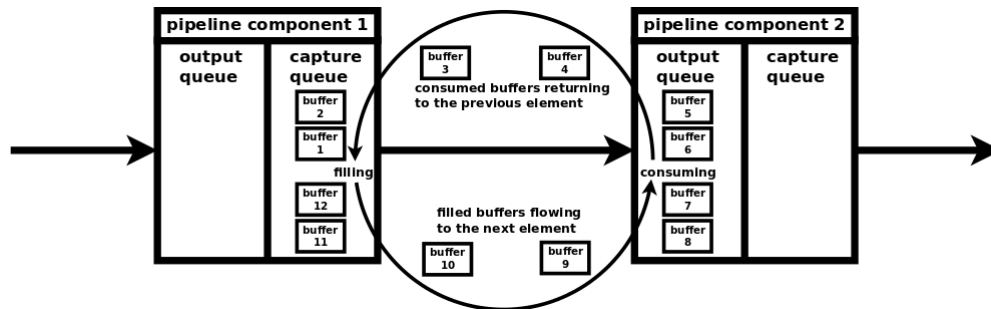
text - Text to be rendered as trigger mark.

timeout - Duration (in milliseconds) for which the trigger mark is being rendered.

Although the trigger mark has the word *trigger* in its name (for historical reasons), actually it has nothing much to do with **Trigger system**. Except one simple fact, creating trigger mark is done by calling the action, so it can be used as **Trigger sink**.

3.9.1.8 Timestamps Each frame going from **Capture device** contains the timestamp. In case of FG4 capture device the timestamp is assigned in linux driver, immediately after the frame is received from PCIe bus. **Monotonic time** is used as time base. The way how the timestamp is attached to the frame depends on actually used format. E.g. frame muxed in MPEG-TS contains the timestamp in PTS (presentation timestamp) field, frame encoded in PNG contains the timestamp in tEXt chunk.

3.9.1.9 Queueing buffers This chapter describes a little bit internal topic, but it should help to understand some special parameters occurring by some video pipeline components. The chapter explains how the data are transferred between the video pipeline components.



Each pipeline component capable of consuming data has at least one special queue, called *output queue*, that is designated to receive data from the previous component. Each pipeline component capable of producing data has at least one special queue, called *capture queue*, that is designated to transmit data to the next component. The naming of the queues may seem confusing, but it is not when you realize, that they are named from the outer point (rest of the pipeline), not from the inner point (the affected pipeline component). This naming convention just mirrors the convention used by video subsystem used by Linux (*Video4Linux* aka. V4L).

Each pair of neighbouring queues (capture queue of the producing component and output queue of the consuming component) has a fixed number of allocated buffers, that continuously transfer the video data of specific format from the producing component (producer) to the consuming component (consumer). Usually one buffer contains one frame. At the beginning, when the pipeline is initialized, all buffers are enqueued in capture queue of the producer. The producer starts to fill the enqueued buffers (writes data) and once the buffers are filled they are dequeued from the capture queue. Then the filled buffers are enqueued to output queue of the consumer. The consumer starts to consume the enqueued buffers (reads data) and once the buffers are consumed they are dequeued from the output queue. Then the consumed buffers are enqueued to capture buffer of the producer and the process repeats.

There may exist multiple consumers connected to one producer. In this case the filled buffers are enqueued to all connected producers at the same time (the buffers are just pointers). After and only after the buffers are dequeued from all consumers, they are again enqueued back to the producer. Although this kind of zero-copy implementation is very effective, it has a potential drawback. When one of the consumer is not able to consume the enqueued buffers at sufficient speed, then remaining consumers are affected as well. In the worst case the slow consumer may exhaust all allocated buffers (they are kept in its output queue) and so there is no free buffer, that can be used to transfer data between the producer and the remaining consumers. To prevent this situation, some components contain the configurable limit for number of simultaneously enqueued buffers in their output queues. This limit can be set by property *enqueued_output_buffers* and currently it is present in *video sink file writer*, *video sink TCP session*, *image sink file writer* and *image sink TCP session* components. The number of all allocated buffers can be set by property *allocated_capture_buffers* and currently it is present in *video sink muxer MPEG-TS* and *image sink encoder PNG*.

When the buffer can't be enqueued to the output queue of the consumer (e.g. due to limit of simultaneously enqueued buffers), it is considered as dropped and when no other consumer exists, it is enqueued back to the producer's capture queue. Number of dropped buffers/frames may be observed in *Statistics*. On the other hand, when all allocated buffers are enqueued in the output queue of the consumer (e.g. there exists no limit of simultaneously enqueued buffers and the consumer is too slow), then the lack of free buffers is transferred to the previous component. Its capture queue is empty, so it is not able to consume buffers in its output queue and the situation repeats.

3.9.1.10 Examples Check if video pipeline (at its top level) is running.

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/captures/fg4_001-003-001-018_i0/running'
```

Enable video pipeline (at its top level).

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/video/captures/fg4_001-003-001-018_i0/enabled'
```

Enable video pipeline, preview, video sink and video sink file writer with one command.

```
curl -v -X PATCH -H 'Content-Type: application/json' -d '{"enabled":true,"preview":{"enabled":true},"sinks":{"video":{"enabled":true,"file_writer":{"enabled":true}}}}' 'http://192.168.1.200/api/app/config/video/captures/fg4_001-003-001-018_i0'
```

Get properties of FPD3 interface of FG4 card.

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/captures/fg4_001-003-001-018_i0/capture/fg4/interface/fpd3'
```

Get format of video signal, that is (or ‘will be’ if currently not enabled) sourced into the video pipeline by FG4 capture device. Note, that JSON element *format* exists only when valid video signal is present on input of FG4 capture device. If there is no valid video signal, then the JSON element doesn’t exist and the server doesn’t respond with 200 (ok).

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/captures/fg4_001-003-001-018_i0/capture/fg4/format'
```

Create trigger mark

```
curl -v -X POST -H 'Content-Type: application/json' -d '{"text":"My custom trigger mark","timeout":1000}' 'http://192.168.1.200/api/app/actions/video/captures/fg4_001-003-001-018_i0/trigger_mark'
```

Trigger image (image sink must be in triggered mode)

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/video/captures/fg4_001-003-001-018_i0/sinks/image/trigger_image'
```

Print tEXt chunks contained in PNG file

```
pngcheck -t -q image.png
```

Possible output of command `pngcheck -t -q image.png`. Key *ts* contains image timestamp. Key *tr* contains trigger, that created the image. It is obvious (because of existing *tr* key), that the image was created in triggered mode by action `/video/captures/<name>/sinks/image/trigger_image`. In this case the action was called as trigger sink, whose trigger source was the expiration of timer *t0*. Timestamps difference is -1.9ms.

```
File: image.png (72237 bytes)
```

```
ts:
```

```
514842528000
```

```
tr:
```

```
{"id":"/timer/devices/t0/shot","ts":514844439596}
```

Possible output of command `pngcheck -t -q image.png`. Key *ts* contains image timestamp. Key *tr* contains trigger, that created the image. It is obvious (because of existing *tr* key), that the image was created in triggered mode by action `/video/captures/<name>/sinks/image/trigger_image`. In this case the action was called as trigger sink, whose trigger source was the call of parametric synchronous action at URL path `/api/app/actions/trigger/send` with parameter *tr0*. Timestamps difference is -2.8ms.

```
File: image.png (72909 bytes)
```

```
ts:
```

```
423846699000
```

```
tr:
```

```
{"id":"/control/tcp_session/tr0","ts":423849467195}
```

Possible output of command `pngcheck -t -q image.png`. Key *ts* contains image timestamp. Key *tr* contains trigger, that created the image. It is obvious (because of existing *tr* key), that the image was created in triggered mode by action `/video/captures/<name>/sinks/image/trigger_image`. In this case (because of empty *id*) the nonparametric synchronous action at URL path `/api/app/actions/video/captures/<name>/sinks/image/trigger_image` was called via HTTP API. Timestamps difference is 10.8ms.

File: image.png (75873 bytes)

```
ts:
    193064627000
tr:
    {"id":"","ts":193053840419}
```

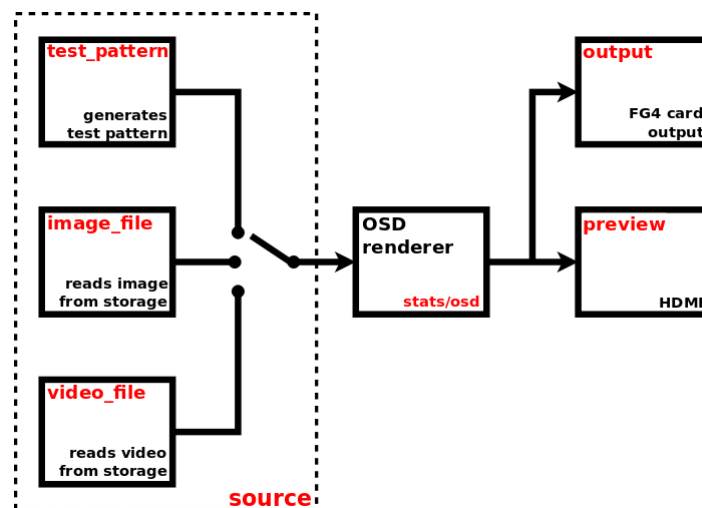
Possible output of command `pngcheck -t -q image.png`. Key *ts* contains image timestamp. It is obvious (because of missing *tr* key), that the image was created in normal (non-triggered) mode.

File: image.png (261858 bytes)

```
ts:
    65092348053000
```

3.9.2 Video outputs

Next picture shows the component diagram of complete video output pipeline, with arrows indicating the flow of video frames. Red labels are the names of corresponding objects in configuration and status JSONs, their simplified snippets are shown below the diagram.



Snippet of video output pipeline configuration (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0`)

```
{
  "enabled": true,
  "source": {
    "type": "test_pattern",
    "test_pattern": {...},
    "image_file": {...},
    "video_file": {...}
  },
  "preview": {...},
  "output": {
    "fg4": {...}
  },
  "stats": {
```

```

    "osd": {...}
  }
}

```

Snippet of video output pipeline status (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0`)

```

{
  "running": true,
  "preview": {...},
  "output": {
    "fg4": {...}
  }
}

```

To enable the video output pipeline, just set *enabled* to *true*. See *running* property in status to get the real state of video output pipeline. If the *running* property is *true*, then at least the *source* component is running (i.e. video frames are captured from the selected source). Preview and output device have their own separate *enable* property. To have the running video output pipeline, some conditions must be met. Primarily the video output pipeline must be enabled and the selected video source must be ready to provide the video stream (i.e. in case of image/video file source, there must exist a valid image/video file on storage).

In contrast to the video capture pipeline, in video output pipeline the associated physical device acts as video stream consumer, so it is not required to be ready to consume the video stream in order to have the running pipeline.

The following links help to navigate to particular pipeline components.

- [Source](#)
 - [Test pattern](#)
 - [Image file](#)
 - [Video file](#)
- [Preview](#)
- [Output device](#)
- [Statistics](#)
- [Examples](#)

3.9.2.1 Source The source component acts as essential source of video frames for the whole video output pipeline. The configuration is located at JSON pointer `/video/outputs/<name>/source`. Status is not available.

Snippet of video source configuration (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/source`)

```

{
  "type": "test_pattern",
  "test_pattern": {
    "pattern": "colorbars_v_100",
    "format": {
      "rate": [
        60,
        1
      ],
      "size": [
        1920,
        1080
      ]
    }
  },
  "image_file": {
    "path": "mounts:/satadisk/image.png",
    "format": {
      "rate": [
        60,

```

```

        1
      ]
    }
  },
  "video_file": {
    "path": "mounts:/satadisk/video.ts"
  }
}

```

There are multiple types of video source, so set the *type* property to select the required one. The *type* may contain one of these values: *test_pattern*, *image_file*, *video_file*. The configuration of each particular type is then contained in its own property of the same name.

3.9.2.1.1 Test pattern Test pattern source generates the stream by repeating the predefined pattern. The configuration is located at JSON pointer `/video/outputs/<name>/source/test_pattern`. It contains these properties:

pattern - Test pattern. It must contain one of these values:

- *solid_black*
- *solid_white_100*
- *solid_red_100*
- *solid_green_100*
- *solid_blue_100*
- *colorbars_v_75*
- *colorbars_v_100*
- *colorbars_h_75*
- *colorbars_h_100*
- *colorsquares_75*
- *colorsquares_100*
- *clock_analog_white_100*
- *clock_analog_red_100*
- *clock_analog_green_100*
- *clock_analog_blue_100*

The generated patterns (frames) are natively represented in RGB, each color component in range from 0x00 (0) to 0xFF (255). The postfix *100* implies the color components of value 0xFF (100), the postfix *75* implies the color components of value 0xBF (191).

format/rate - Frame rate represented as rational number [num, den], in frames per second.

format/size - Frame size [width, height], in pixels.

3.9.2.1.2 Image file Image file source generates the stream by repeating the image loaded from specified file. It is expected, that the file contains one single image, encoded in any supported format (PNG, JPG, ...). The configuration is located at JSON pointer `/video/outputs/<name>/source/image_file`. It contains these properties:

path - Location of the image file. It is a string complying with definition of URI (Uniform Resource Identifier), see [RFC3986](#). Two URI schemes are supported, *mounts* and *tcp*.

When the URI component scheme is *mounts*, then one of the mounted devices is used for loading the file. In this case URI component path is used. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer `/storage/mounts`. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. E.g. when the *path* is `mounts:/satadisk/images/image.png`, then the image is loaded from path `/images/image.png` located on storage mounted to mount point `satadisk`.

When the URI component scheme is *tcp*, then the TCP socket is used for loading the file. In this case URI components host and port are used. E.g. when the *path* is `tcp://192.168.1.1:8888`, then the image is loaded from TCP server listening on address 192.168.1.1 and port 8888. Note, that more than one connection may be required before the image file source begins to feed the stream into the video pipeline. Typically the first connection loads the image only to determine its parameters (required for creating pipeline) and the second connection loads the image for immediate streaming (within the already created pipeline).

format/rate - Frame rate represented as rational number [num, den], in frames per second.

3.9.2.1.3 Video file Video file source provides the stream loaded from specified file. It is expected, that the file contains at least one video stream, encoded/muxed in any supported container (TS, MP4, MKV, AVI, ...). The first found stream is always used. The configuration is located at JSON pointer `/video/outputs/<name>/source/video_file`. It contains these properties:

path - Location of the video file. It is a string complying with definition of URI (Uniform Resource Identifier), see [RFC3986](#). Two URI schemes are supported, *mounts* and *tcp*.

When the URI component scheme is *mounts*, then one of the mounted devices is used for loading the file. In this case URI component path is used. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer `/storage/mounts`. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. E.g. when the *path* is `mounts:/satadisk/videos/video.ts`, then the stream is loaded from path `/videos/video.ts` located on storage mounted to mount point `satadisk`.

When the URI component scheme is *tcp*, then the TCP socket is used for loading the file. In this case URI components host and port are used. E.g. when the *path* is `tcp://192.168.1.1:8888`, then the stream is loaded from TCP server listening on address 192.168.1.1 and port 8888. Note, that more than one connection may be required before the video file source begins to feed the stream into the video pipeline. Typically the first connection loads a few frames only to determine their parameters (required for creating pipeline) and the second connection begins to continuously load the whole stream for immediate streaming (within the already created pipeline).

NOTE:

Currently no hardware accelerated decoding is possible.

3.9.2.2 Preview Preview is a component allowing to view the video stream on [HDMI](#). The configuration and status are located at JSON pointer `/video/outputs/<name>/preview`.

Snippet of preview configuration (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/preview`)

```
{
  "enabled": false,
  "window": {
    "position": [
      0,
      0
    ],
    "size": [
      0,
      0
    ],
    "border": {
      "width": 0
    }
  }
}
```


Snippet of preview status (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/preview`)

```
{
  "running": false
}
```

To enable the preview, just set *enabled* property to *true*. See *running* property in status to get the real state of the preview. If the *running* property is *true*, then the video frames are rendered to *window*, whose properties are:

position - Coordinates [x, y] (in pixels) of the top-left corner of rendered window. They are ignored in fullscreen.

size - Size [width, height] (in pixels) of rendered window. It must be greater or equal [128, 128]. Size [0, 0] is translated to fullscreen. Size [1, 1] is translated to the size of original frame. Other combinations (whatever dimension less than 128) are reserved, but currently translated to fullscreen.

border/width - Width (in pixels) of window border.

When no external monitor is detected on **HDMI**, then preview will not be running, although it is enabled.

3.9.2.3 Output device Currently only one type of physical output device is supported, namely FG4. So this chapter covers only working with FG4. The configuration and status are located at JSON pointer `/video/outputs/<name>/output/fg4`.

NOTE:

Firmware version 1.0 doesn't support **GMSL** outputs. Although they may be present both in status and configuration, they do not actually work.

Snippet of video output device configuration (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/output/fg4`)

```
{
  "enabled": true,
  "format": {
  },
  "interface": {
    "fpdl3": {
      "display_height": 1080,
      "display_width": 1920,
      "fpdl3_output_width": "dual",
      "frame_rate": 200,
      "pclk_frequency": 150000,
      "video_source": "v4l2_output_0"
    },
    "gmsl": {
      "display_height": 1080,
      "display_width": 1920,
      "frame_rate": 200,
      "pclk_frequency": 150000
    }
  }
}
```

Snippet of video output device status (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/output/fg4`)

```
{
  "running": true,
  "format": {
    "fourcc": "AR24",
    "rate": [
      150000000,
      2391660
    ],
  },
}
```

```

        "size": [
            1920,
            1080
        ]
    },
    "format_descriptions": [
        {
            "fourcc": "AR24",
            "rates": [
                [
                    150000000,
                    2391660,
                    125000000,
                    4294967295,
                    125000000,
                    1
                ]
            ],
            "size": [
                1920,
                1080
            ]
        },
        {
            "fourcc": "YUYV",
            "rates": [
                [
                    150000000,
                    2391660,
                    125000000,
                    4294967295,
                    125000000,
                    1
                ]
            ],
            "size": [
                1920,
                1080
            ]
        }
    ],
    "interface": {
        "fpdl3": {
            "de_polarity": "active_high",
            "display_height": 1080,
            "display_width": 1920,
            "fpdl3_output_width": "dual",
            "frame_rate": 200,
            "hback_porch": 50,
            "hfront_porch": 50,
            "hsync_polarity": "active_low",
            "hsync_width": 40,
            "output_id": 0,
            "pclk_frequency": 150000,
            "vback_porch": 31,
            "vfront_porch": 30,
            "video_source": "v4l2_output_0",
            "vsync_polarity": "active_low",
            "vsync_width": 20
        }
    },
    "parent_device": "001-003-001-018"
}

```

This type of video output is a part of FG4 card (actually it represents an output of the interface module), so there exists a reference to this card, property *parent_device*. It contains the name of parent FG4 card, whose properties can be found at JSON pointer `/fg4/devices/<name>`. See [FG4 PCIe cards](#) chapter to get detailed information.

To enable the output device, just set the *enabled* property to *true*. See *running* property in status to get the real state of output device. If the *running* property is *true*, then the video frames are consumed from the pipeline and should occur at the corresponding output of FG4 card's interface.

3.9.2.3.1 Format In general an output device acts as consumer of video frames from video output pipeline. Only when the element *format* is present in status, the output device is ready to consume the video stream. The *format* describes the stream, that must be provided to the output device. When the device is **running**, then *format* describes the actually flowing stream. When the device is **not running**, then *format* describes the stream, that will be flowing when the device is enabled (and consequently running) and no custom format is specified. The format has these properties:

fourcc - Pixel format represented as [FourCC](#).

size - Frame size [width, height], in pixels.

rate - Frame rate represented as rational number [num, den], in frames per second.

It is allowed to specify a custom format. If the element *format* is present in configuration, the output device tries to consume the stream in specified format. If the specified format cannot be used, then some other is used. Again, when device is running, check *format* in status to get the actually used format. In configuration the element *format* is optional and also its all three sub-elements *fourcc*, *size* and *rate* are optional. Currently only *fourcc* and *rate* are evaluated, *size* is ignored. Possible format values can be determined from status element *format_descriptions*. It is actually an array of allowed formats, where each element has these properties:

fourcc - Pixel format represented as [FourCC](#).

size - Frame size, in pixels. It is represented as [width, height] in case of discrete size, or as [min_width, min_height, max_width, max_height, step_width, step_height] in case of step-wise size.

rates - Array of frame rates, in frames per second. Each one is represented as [num, den] in case of discrete rate, or as [max_num, max_den, min_num, min_den, step_num, step_den] in case of step-wise rate. In calculations step must be used as period (not frame rate), with flipped numerator and denominator, e.g. $custom_rate = 1 / (min_den / min_num + 10 * step_den / step_num)$.

Element *fourcc* may contain only *AR24* or *YUYV*. Pixel format *AR24* is ABGR with four bytes per pixel, pixel format *YUYV* is YUV 4:2:2 with four bytes per two pixels. So the *YUYV* takes only half the bandwidth compared to *AR24*. On the other hand it may lose some information, because e.g. FPD3/GMLS interfaces use the RGB with three bytes per pixel. Omit the *fourcc* to use the default *AR24*.

Element *rate* may be used to set a custom fixed frame rate, which must always be less than the one being configured on interface. It may be useful to reduce the bandwidth. Omit the *rate* to use the value from interface configuration.

Element *size* is ignored as it is always used the value from interface configuration.

Possible *format* and *format_descriptions* values **are always derived** from interface configuration. So set the interface configuration properly to have the required format on interface output. On the contrary, the setting of *format* property to custom value is not necessary in most cases. It may be effectively used only for affecting the bandwidth on PCIe.

It doesn't matter, which format is used by the video source. It is always transformed to the *format* required by the output device. Of course, when the video source has the same resolution and RGB pixel format with three bytes per pixel (used by FPD3/GMLS interfaces), then no image information is lost. As for the frame rates, when they don't match exactly, the frames are dropped or duplicated to maintain the rate in interface configuration.

NOTE:

Firmware version 1.0 doesn't support specifying custom format. It always uses the *AR24* pixel format and the frame size and frame rate from interface configuration.

3.9.2.3.2 Interface Each FG4 card may contain an interchangeable part named as interface module (or just interface). Each interface may contain one or more video outputs. Each video output is represented by this output device. Check the status *interface* element to get the actually used interface type (it contains exactly one sub-element, *fpdl3* or *gmsl*). Each interface contains a number of properties, whose actual values are available in status. Some of them can be set to custom value, just put the property into configuration. To use the default (or last set) value, just omit the property from configuration. Currently FPD3 and GMSL interfaces are supported.

FPDL3

List of all existing properties (available in status):

output_id - integer. Output number ID, zero based.

video_source - string enum (*input_0*, *input_1*, *v4l2_output_0*, *v4l2_output_1*). Output video source. If set to *input_0* or *input_1*, the source is the corresponding hardware input (of interface module) and the pipeline output device (*/output/fg4*, here also called as v4l2 device) is internally disabled (can't be in *running* state). In this mode the stream flows from the specified hardware input to the output in a direct way (kind of hardware loopback), the pipeline is not used as the source and so it may be disabled completely (or at least the pipeline output device should be disabled, */output/fg4/enabled* set to *false*). If set to *v4l2_output_0* or *v4l2_output_1*, the source is the corresponding pipeline output device (*/output/fg4*, here also called as v4l2 device). In this mode both the corresponding pipeline and its output device should be enabled to have a video stream at the output.

Let's have FG4 card (*/fg4/devices/001-003-001-018*) equipped with FPD3 interface module containing two inputs (*/video/captures/fg4_001-003-001-018_i0*, */video/captures/fg4_001-003-001-018_i1*) and two outputs (*/video/outputs/fg4_001-003-001-018_o0*, */video/outputs/fg4_001-003-001-018_o1*). Now let's talk about output */video/outputs/fg4_001-003-001-018_o0* and its video source */video/outputs/fg4_001-003-001-018_o0/output/fg4/interface/fpdl3/video_source*.

- When the source is set to *v4l2_output_0*, then the output pipeline device */video/outputs/fg4_001-003-001-018_o0/output/fg4* is used as the video source (**normal** mode).
- When the source is set to *v4l2_output_1*, then the output pipeline device */video/outputs/fg4_001-003-001-018_o1/output/fg4* is used as the video source (**cross pipeline** mode).
- When the source is set to *input_0*, then the hardware input of */video/captures/fg4_001-003-001-018_i0/capture/fg4* is used as the video source (**hardware loopback** mode).
- When the source is set to *input_1*, then the hardware input of */video/captures/fg4_001-003-001-018_i1/capture/fg4* is used as the video source (**hardware loopback** mode).

The number *X* from enum *input_X*, *input_X*, *v4l2_output_X*, *v4l2_output_X* must be matched with the number contained in corresponding interface property (*/output/fg4/interface/fpdl3/output_id* or */capture/fg4/interface/fpdl3/input_id*), not with the number contained in device name (*/video/captures/fg4_001-003-001-018_iX* or */video/captures/fg4_001-003-001-018_oX*).

display_width - integer. Display width. There is no autodetection of the connected display, so the proper value must be set before the start of streaming.

display_height - integer. Display height. There is no autodetection of the connected display, so the proper value must be set before the start of streaming.

frame_rate - integer. Output video signal frame rate limit (in frames per second). Due to the limited output pixel clock steps, the card can not always generate a frame rate perfectly matching the value required by the connected display. Using this parameter one can limit the frame rate by *crippling* the signal so that the lines are not equal but the signal appears like having the exact frame rate to the connected display.

hsync_polarity - string enum (*active_low*, *active_high*). HSYNC signal polarity.

vsync_polarity - string enum (*active_low*, *active_high*). VSYNC signal polarity.

de_polarity - string enum (*active_low*, *active_high*). DE signal polarity.

pclk_frequency - integer. Output pixel clock frequency (in kHz). Allowed values are between 25000-190000 and there is a non-linear stepping between two consecutive allowed frequencies. The nearest allowed frequency to the given value is found and set.

hsync_width - integer. Width of the HSYNC signal in PCLK pulses.

vsync_width - integer. Width of the VSYNC signal in video lines.

hback_porch - integer. Number of PCLK pulses between deassertion of the HSYNC signal and the first valid pixel in the video line (marked by DE=1).

hfront_porch - integer. Number of PCLK pulses between the end of the last valid pixel in the video line (marked by DE=1) and assertion of the HSYNC signal.

vback_porch - integer. Number of video lines between deassertion of the VSYNC signal and the video line with the first valid pixel (marked by DE=1).

vfront_porch - integer. Number of video lines between the end of the last valid pixel line (marked by DE=1) and assertion of the VSYNC signal.

fpdl3_output_width - string enum (*automatic*, *single*, *dual*). Number of serializer output lines.

List of configurable properties (may occur in configuration):

video_source
display_width
display_height
frame_rate
hsync_polarity
vsync_polarity
de_polarity
pclk_frequency
hsync_width
vsync_width
hback_porch
hfront_porch
vback_porch
vfront_porch
fpdl3_output_width

GMSL

List of all existing properties (available in status):

_output_id - integer. Output number ID, zero based.

video_source - string enum (*input_0*, *input_1*, *v4l2_output_0*, *v4l2_output_1*). Output video source. If set to *input_0* or *input_1*, the source is the corresponding hardware input (of interface module) and the pipeline output device (*/output/fg4*, here also called as v4l2 device) is internally disabled (can't be in *running* state). In this mode the stream flows from the specified hardware input to the output in a direct way (kind of hardware loopback), the pipeline is not used as the source and so it may be disabled completely (or at least the pipeline output device should be disabled, */output/fg4/enabled* set to *false*). If set to *v4l2_output_0* or *v4l2_output_1*, the source is the corresponding pipeline output device (*/output/fg4*, here also called as v4l2 device). In this mode both the corresponding pipeline and its output device should be enabled to have a video stream at the output. See description of **FPDL3** *video_source* to get the example of how it's working.

display_width - integer. Display width. There is no autodetection of the connected display, so the proper value must be set before the start of streaming.

display_height - integer. Display height. There is no autodetection of the connected display, so the proper value must be set before the start of streaming.

frame_rate - integer. Output video signal frame rate limit (in frames per second). Due to the limited output pixel clock steps, the card can not always generate a frame rate perfectly matching the value required by the connected display. Using this parameter one can limit the frame rate by *crippling* the signal so that the lines are not equal but the signal appears like having the exact frame rate to the connected display.

hsync_polarity - string enum (*active_low*, *active_high*). HSYNC signal polarity.

vsync_polarity - string enum (*active_low*, *active_high*). VSYNC signal polarity.

de_polarity - string enum (*active_low*, *active_high*). DE signal polarity.

pclk_frequency - integer. Output pixel clock frequency (in kHz). Allowed values are between 25000-190000 and there is a non-linear stepping between two consecutive allowed frequencies. The nearest allowed frequency to the given value is found and set.

hsync_width - integer. Width of the HSYNC signal in PCLK pulses.

vsync_width - integer. Width of the VSYNC signal in video lines.

hback_porch - integer. Number of PCLK pulses between deassertion of the HSYNC signal and the first valid pixel in the video line (marked by DE=1).

hfront_porch - integer. Number of PCLK pulses between the end of the last valid pixel in the video line (marked by DE=1) and assertion of the HSYNC signal.

vback_porch - integer. Number of video lines between deassertion of the VSYNC signal and the video line with the first valid pixel (marked by DE=1).

vfront_porch - integer. Number of video lines between the end of the last valid pixel line (marked by DE=1) and assertion of the VSYNC signal.

List of configurable properties (may occur in configuration):

video_source
display_width
display_height
frame_rate
hsync_polarity
vsync_polarity
de_polarity
pclk_frequency
hsync_width
vsync_width
hback_porch
hfront_porch
vback_porch
vfront_porch

3.9.2.4 Statistics When the video pipeline is running, some useful statistics are being computed. The configuration is located at JSON pointer `/video/outputs/<name>/stats`. Status is not available.

Snippet of statistics configuration (at JSON pointer `/video/outputs/fg4_001-003-001-018_o0/stats`)

```
{
  "osd": {
    "enabled": true,
    "position": [
      16,
      16
    ],
    "size": 10
  }
}
```

}

The statistics are quite rough numbers, rather intended for quick insight or debug purposes. They may be rendered into the running video stream as OSD window. Currently this is the only way how to view them. The configuration properties are:

osd/enabled - If *true*, then OSD window is enabled.

osd/position - Coordinates [x, y] (in pixels) of the top-left corner of rendered OSD window.

osd/size - Font size.

The example of statistics OSD window:

```
src > size:1920x1080 rate:60/479 delay:0 pass:3968 drop:0
out > rate:60/480 delay:26 pass:3966 drop:0
```

Each line begins with shortened name of the video pipeline component followed by its statistics. Possible components:

src - **Source**. Always present.

out - **Output device**. Present only if output device is enabled.

The following statistics are:

size - Size (width x height) of the video frame.

rate - The first number indicates the frame rate (in frames per second, fps). The second number indicates the bitrate (in mebibytes per second, MiB/s). Both numbers are shown as integers (truncated floats).

delay - Delay (in milliseconds) of the frame at time of leaving the corresponding component. It is measured relatively to the time at which the frame was created the source device. As shown in the OSD window example, it took 26 milliseconds from creating the frame till passing it into the output device.

pass - Number of frames, that were passed through the corresponding component. It is counted from the time at which the component was created/enabled.

drop - Number of frames, that couldn't be passed through the corresponding component (e.g. it was busy) and thus were dropped. It is counted from the time at which the component was created/enabled. It is typical for output device (*out*) to have growing dropped frames if its configured frame rate is less then the frame rate of the source. To get the number of frames dropped alongside multiple pipeline components, just sum the dropped frames from all participating components. E.g. to get the total number of dropped frames on the path between the source and output device, sum dropped frames from *src* and *out*.

3.9.2.5 Examples Check if video pipeline (at its top level) is running.

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/outputs/fg4_001-003-001-018_o0/running'
```

Enable video pipeline (at its top level).

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/video/outputs/fg4_001-003-001-018_o0/enabled'
```

Check if FG4 card output is running (consumes video frames from pipeline and sends them to the card output).

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/outputs/fg4_001-003-001-018_o0/output/fg4/running'
```

Enable video pipeline and FG4 card output with one command.

```
curl -v -X PATCH -H 'Content-Type: application/json' -d '{"enabled":true,"output":{"fg4":{"enabled":true}}}' 'http://192.168.1.200/api/app/config/video/outputs/fg4_001-003-001-018_o0'
```

Get properties (real values) of FPD13 interface of FG4 card.

```
curl -v -X GET 'http://192.168.1.200/api/app/status/video/outputs/fg4_001-003-001-018_o0/output/fg4/interface/fpd13'
```

Get properties (required values) of FPD13 interface of FG4 card.

```
curl -v -X GET 'http://192.168.1.200/api/app/config/video/outputs/fg4_001-003-001-018_o0/output/fg4/interface/fpd13'
```

3.10 CAN

CAN configuration and status are located at JSON pointer `/can`. The API consists of two main parts. The first one (named as CAN devices) represents the physical devices, CAN controllers and transceivers. The second one (named as CAN captures) represents the streams, responsible for capturing CAN messages from specified CAN device, encoding them and transmitting via network or saving to storage.

Snippet of CAN configuration and status (at JSON pointer `/can`)

```
{
  "captures": {
    "capt0" : {...},
    "capt1" : {...},
    "capt2" : {...},
    "capt3" : {...}
  },
  "devices": {
    "can0" : {...},
    "can1" : {...}
  }
}
```

3.10.1 CAN devices

CAN devices configuration and status are located at JSON pointer `/can/devices`. They are physical devices, CAN controllers and transceivers, directly connected to link layer. They are also **System-managed devices**, so their names are fully controlled by operating system. FG4 Multibox contains two embedded CAN devices, usually named as `can0` and `can1`.

Snippet of CAN device configuration (at JSON pointer `/can/devices/can0`)

```
{
  "bittiming": {
    "bitrate": 500000,
    "sample_point": 0.75
  },
  "ctrlmode": {
    "fd": false,
    "fd_non_iso": false
  },
  "data_bittiming": {
    "bitrate": 2000000,
    "sample_point": 0.75
  },
  "enabled": false
}
```

Snippet of CAN device status (at JSON pointer `/can/devices/can0`)

```
{
  "berr_counter": {
    "rx": 0,

```



```

    "tx": 0
  },
  "bittiming": {
    "bitrate": 500000,
    "phase_seg1": 30,
    "phase_seg2": 20,
    "prop_seg": 29,
    "sample_point": 0.75,
    "sjw": 1,
    "tq": 25
  },
  "bittiming_const": {
    "brp": {
      "max": 511,
      "min": 1
    },
    "brp_inc": 1,
    "sjw": {
      "max": 127,
      "min": 1
    },
    "tseg1": {
      "max": 255,
      "min": 2
    },
    "tseg2": {
      "max": 127,
      "min": 0
    }
  },
  "clock": 40000000,
  "ctrlmode": {
    "berr_reporting": false,
    "fd": false,
    "fd_non_iso": false,
    "listen_only": false,
    "one_shot": false,
    "presume_ack": false,
    "triple_sampling": false
  },
  "data_bittiming_const": {
    "brp": {
      "max": 15,
      "min": 1
    },
    "brp_inc": 1,
    "sjw": {
      "max": 15,
      "min": 1
    },
    "tseg1": {
      "max": 31,
      "min": 1
    },
    "tseg2": {
      "max": 15,
      "min": 0
    }
  },
  "restart_delay": 0,
  "state": "stopped",
  "stats": {
    "flow": {

```

```

    "rx": {
        "bytes": 0,
        "dropped": 0,
        "errors": 0,
        "packets": 0
    },
    "tx": {
        "bytes": 0,
        "dropped": 0,
        "errors": 0,
        "packets": 0
    }
},
"link": {
    "arbitration_lost": 0,
    "bus_error": 0,
    "bus_off": 0,
    "error_passive": 0,
    "error_warning": 0,
    "restarts": 0
}
}
}

```

Bit timing is configured by *bittiming* (and also by *data_bittiming* if FD is used). Bit timing can be configured in two ways. The first way is to set only *bitrate* (in bits per second) and *sample_point* (from interval 0.0 to 0.999). The second way is to set time quanta *tq* (in nanoseconds), propagation segment *prop_seg* (in units of time quanta), phase buffer segments *phase_seg1* and *phase_seg2* (in units of time quanta) and synchronization jump width *sjw* (in units of time quanta). In case of the first method, at least *bitrate* must be specified, *sample_point* is optional. In case of the second method, at least *tq*, *prop_seg*, *phase_seg1* and *phase_seg2* must be specified, *sjw* is optional. If bit timing configuration contains *bitrate*, then the first method is used, otherwise the second method is used. Remember, that bit rate and sample point are only alternative parameters, intended for setting bit timing in simple way. The parameters used by CAN controllers are time quanta (realized by bit rate prescaler connected to clock, see *brp* and *clock* in status), propagation segment, phase buffer segments and synchronization jump width. These are derived from bit rate and sample point automatically. To view the actually used bit timing parameters, see *bittiming* (and also *data_bittiming* if FD is used) in status. Note that these status parameters are not present until the CAN device is started for the first time and subsequently they are updated only whenever the CAN device is restarted. The limits for bit timing parameters can be found in *bittiming_const* and *data_bittiming_const* in status.

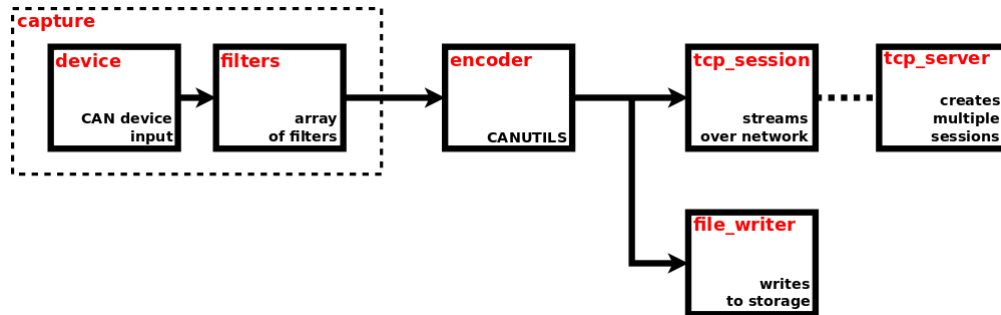
Control modes are configured by *ctrlmode*. Bus error reporting can be enabled by *berr_reporting*. Using of FD (flexible data rate) can be enabled by *fd*. Using of non-ISO FD can be enabled by *fd_non_iso*. Using of listen only mode (no ACKs) can be enabled by *listen_only*. Using of one-shot mode (no retransmits due to arbitration loss or error frame) can be enabled by *one_shot*. Presuming ACKs (behave like there exist ACKs on the bus, although there may be none in reality) can be enabled by *presume_ack*. Using of triple sampling (sample for 3 time quanta per bit instead of 1) can be enabled by *triple_sampling*. All these parameters are optional and to use them they must also be supported by connected CAN device and/or its corresponding operating system driver. See status to view actually used control modes. Note that they are updated only whenever CAN device is restarted. Also note that status always shows all control modes, even if they are not supported by connected CAN device/driver. It is up to user to know, which modes are supported. FG4 Multibox embedded CAN devices support theses modes: *berr_reporting*, *fd*, *fd_non_iso*, *listen_only* and *one_shot*.

To enable CAN device just set *enabled* to *true*. Real device state can be observed in status *state*, which can be one of these values *error_active*, *error_warning*, *error_passive*, *bus_off* and *stopped*. To get from bus-off state, device must be disabled (wait for *stopped* in *state*) and enabled again. Or, when *restart_delay* is set to non-zero value (in milliseconds), device is restarted after specified delay automatically. Currently FG4 Multibox only receives, so no bus-off state should occur.

There exist more items in status, especially statistics *stats* may be useful. They are all fairly self-explanatory.

3.10.2 CAN captures

CAN captures (aka CAN capture devices) configuration and status are located at JSON pointer `/can/captures`. Each CAN capture device represents the stream, responsible for capturing CAN messages from physical CAN device, encoding to specific format and then transmitting via network or saving to storage. They are also **User-managed devices**, so their count, naming and life cycle are fully controlled by user. Multiple CAN capture devices may use the same physical CAN device. Following image shows the structure of CAN capture device. The red strings are object names, the same names are used in JSON configuration and status.



Snippet of CAN capture configuration (at JSON pointer `/can/captures/capt0`)

```
{
  "capture": {
    "device": "can0",
    "filters": [
      {
        "data": [0, 1, 0, 1],
        "data_mask": [255, 255, 255, 255],
        "ext": false,
        "fd": false,
        "id": 2046,
        "id_mask": 2047,
        "rtr": false,
        "trigger_source": false
      },
      {
        "data": [0, 0, 0, 0, 0, 0, 0, 0, 2],
        "data_mask": [0, 0, 0, 0, 0, 0, 0, 0, 255],
        "ext": true,
        "fd": false,
        "id": 536870910,
        "id_mask": 536870911,
        "rtr": false,
        "trigger_source": false
      }
    ],
    "filters_enabled": true
  },
  "enabled": false,
  "encoder": {
    "canutils": {},
    "type": "canutils"
  },
  "file_writer": {
    "enabled": false,
    "path": "mounts:/satadisk/can/captures/capt0/"
  },
  "tcp_server": {
```

```

    "port": 51001
  },
  "tcp_session": {}
}

```

Snippet of CAN capture status (at JSON pointer `/can/captures/capt0`)

```

{
  "file_writer": {
    "running": false
  },
  "running": false
}

```

To enable the CAN capture device, just set *enabled* to *true*. See *running* property in status to get the real state of CAN capture device. If the *running* property is set to *true*, then *capture*, *encoder* and *tcp_server* are also running. Element *file_writer* has its own separate *enable* property. To have the running CAN capture device, some conditions must be met. Primarily the used physical CAN device must be enabled and must be in *error_active* state. CAN messages are timestamped by **Monotonic time**.

3.10.2.1 Capture and filters The *capture* element is the first one in the pipeline. It is the element, where all CAN messages are coming from. The actual physical CAN device used for capturing the messages is specified by *device*. It may be one of the CAN devices found at JSON pointer `/can/devices`. Then, if *filters_enabled* is set to *true*, the captured CAN message is going to *filters*, otherwise it is directly going to *encoder*.

The *filters* array contains filters, each one successively applied on captured CAN message. If any of filters match, then the message passes. If *filters* array is empty, then no message passes. Each filter may contain multiple criteria and if all of them match, then the filter matches. The only required criterion is *id* (CAN message identifier).

id - CAN message identifier. Should be between 0 and 2047 (0x7FF) for standard 11-bit identifier (CAN 2.0A), or between 0 and 536870911 (0x1FFFFFFF) for extended 29-bit identifier (CAN 2.0B).

id_mask - CAN message identifier mask. If omitted, then defaults to 536870911 (0x1FFFFFFF).

data - CAN message data. Array of bytes, each between 0 and 255 (0xFF). Should be of the same size as the message expected on the bus, between 0 and 8 for non-FD, or between 0 and 8, 12, 16, 20, 24, 32, 48 or 64 for FD messages. If omitted, then filtering by this criterion is disabled.

data_mask - CAN message data mask. Array of bytes. Must be of the same size as CAN message data. If omitted, then defaults to array of 255 (0xFF).

ext - CAN message 'Extended' flag. If omitted, then filtering by this criterion is disabled.

fd - CAN message 'FD' flag. If omitted, then filtering by this criterion is disabled.

rtr - CAN message 'Remote Transmission Request' flag. If omitted, then filtering by this criterion is disabled.

The following pseudocode shows the process of filter criteria matching:

```

match = ((message.id BITWISE_AND filter.id_mask) EQUALS (filter.id BITWISE_AND
  filter.id_mask))
  AND (NOT EXISTS filter.data OR ((message.data BITWISE_AND filter.data_mask)
    EQUALS (filter.data BITWISE_AND filter.data_mask)))
  AND (NOT EXISTS filter.ext OR message.ext EQUALS filter.ext)
  AND (NOT EXISTS filter.fd OR message.fd EQUALS filter.fd)
  AND (NOT EXISTS filter.rtr OR message.rtr EQUALS filter.rtr)

```

Each filter is able to act as trigger source within the **Trigger system**. To enable this feature just set *trigger_source* of appropriate filter to *true*. To avoid the unintentional overload of trigger system enable the trigger source only if really required. Identifier of generated trigger is `/can/captures/<name>/capture/filters/<index>`.

3.10.2.2 Encoder The *encoder* element is responsible for encoding the proprietary stream of CAN messages into any well known format. The common attribute of all supported encoders is the fact, that encoded stream has no special header or footer. It basically means, that CAN messages can be decoded from any point of running stream, of course usually from boundary of individual messages. Each supported encoder has its own configuration element and the actually selected encoder is determined by *type*. Currently there is only one supported encoder type: *canutils*.

canutils

This format is used by *can-utils*, a well known linux project providing various SocketCAN userspace utilities and tools (see [here](#) for detailed description). Basically there are two types of format used by *can-utils*, *compact* and *long*. Currently only *compact* type is supported. The configuration element is empty object as there is nothing to be configured for now.

Snippet of encoded stream containing these 5 CAN messages (transmitted with 1 second period)

1. id=0x100 (sff), dlc=8, data=[0x00,0x11,0x22,0x33,0x44,0x55,0x66,0x77]
2. id=0x100 (eff), dlc=8, data=[0x00,0x11,0x22,0x33,0x44,0x55,0x66,0x77]
3. id=0x100 (sff), dlc=8, data=[0x00,0x11,0x22,0x33,0x44,0x55,0x66,0x77], fd
4. id=0x100 (sff), dlc=8, data=[0x00,0x11,0x22,0x33,0x44,0x55,0x66,0x77], fd, brs
5. id=0x100 (sff), dlc=8, rtr

```
(0000012300.000000) can0 100#0011223344556677
(0000012301.000000) can0 00000100#0011223344556677
(0000012302.000000) can0 100##40011223344556677
(0000012303.000000) can0 100##50011223344556677
(0000012304.000000) can0 100#R8
```

3.10.2.3 File writer The *file_writer* element is responsible for storing the encoded stream to mounted device (e.g. SATA or USB disk). Destination file is determined by *path*, which is a string complying with definition of URI (Uniform Resource Identifier), see [RFC3986](#). Only scheme and path components are used within the URI.

Scheme component must always be set to *mounts* value. It means that one of the mounted devices will be used for writing the file.

Path component represents the file path. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer */storage/mounts*. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. The path may contain some special variables, which are replaced by their real values at the time the file is created. These variables must be specified in form *\$(variable_name)*. Currently supported variables:

time - system time complying with full date and time according to ISO 8601, with milliseconds

ext - default file extension (including the dot “.”) corresponding with used data format

When the path ends with forward slash character “/”, it is considered as directory and the file name is constructed automatically as *\$(time)\$(ext)*. When the path contains non-existent directories, they will be created automatically.

Here are examples of possible paths:

```
mounts:/satadisk/can/captures/capt0/
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directories *can*, *captures* and *capt0* are created automatically if they don't exist. Because the path ends with “/”, it is considered as directory and the file name is constructed automatically. So the resulting file name on the mounted device may look something like */can/captures/capt0/20240215T105231.517Z.log*.

```
mounts:/satadisk/captures/capt0_$(time)$(ext)
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directory *captures* is created automatically if it doesn't exist. The resulting file name on the mounted device may look something like */captures/capt0_20240215T105231.517Z.log*.

To enable the file writer, just set *enabled* to *true*. See *running* property in status to get the real state of file writer. To have the running file writer, some conditions must be met. E.g. the whole CAN capture device must be enabled, file writer must be enabled, mount point must exist, mounted device must be writable and must contain enough free space, file name must be correctly specified, used physical CAN device must be enabled. When any of these conditions are not met or any errors occur, the file writer stops working and the *running* state is set to *false*. Whenever the file writer changes its *running* state to *true*, it creates new file and opens it for writing. When the file writer changes its *running* state to *false*, it also closes the file.

3.10.2.4 Streaming over network Encoded stream may also be transmitted over network as TCP stream. Element *tcp_server* represents the TCP server, that listens on specified *port*. Each time it accepts incoming connection, new TCP session is created. Multiple TCP sessions may exist at the same time. Each created TCP session is configured with parameters found in *tcp_session* element. Actually this element is empty object as there is nothing to be configured for now.

3.10.2.5 Examples Get status of CAN capture device *capt0*

```
curl -v -X GET 'http://192.168.1.200/api/app/status/can/captures/capt0'
```

Enable the CAN capture device *capt0*

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/can/captures/capt0/enabled'
```

Read the encoded stream of CAN messages from port *51001* (assume that there is listening CAN capture TCP server)

```
nc 192.168.1.200 51001
```

Get list of files contained in specified directory and then read the content of selected file

```
curl http://192.168.1.200/api/fs/mounts/satadisk/can/captures/capt0/
curl http://192.168.1.200/api/fs/mounts/satadisk/can/captures/capt0/20240216T110003.165Z.log
```

3.11 Timers

Timers are simple devices, that allow to perform any predefined operation (via **Trigger system**) after the specified period expires. They are also **User-managed devices**, so their count, naming and life cycle are fully controlled by user. Configuration and status are located at JSON pointer */timer*.

Snippet of timers configuration (at JSON pointer */timer*)

```
{
  "devices": {
    "t0": {
      "arm_on_enable": false,
      "enabled": false,
      "periods": [
        500,
        1000,
        2000
      ],
      "shots_count_max": 0,
      "trigger_sources": {
        "shot": false,
        "shot_number": false,
        "shot_period": false
      }
    },
    "t1": {
```

```

    "arm_on_enable": false,
    "enabled": false,
    "periods": [
        0,
        1000
    ],
    "shots_count_max": 0,
    "trigger_sources": {
        "shot": false,
        "shot_number": false,
        "shot_period": false
    }
}
}
}

```

Snippet of timers status (at JSON pointer `/timer`)

```

{
  "devices": {
    "t0": {
      "armed": false,
      "arms_count": 0,
      "shots_count": 0
    },
    "t1": {
      "armed": false,
      "arms_count": 0,
      "shots_count": 0
    }
  }
}

```

To work with timer it must be enabled first, just set the *enabled* property to *true*. When the timer is enabled, it can be switched between armed and disarmed state. The current state is indicated by *armed* status property. When property *arm_on_enable* is *true*, the timer is armed automatically by transition to enabled state (changing *enabled* property to *true*). To manually switch the armed state, just call one of these synchronous nonparametric actions at URL paths

- `/api/app/actions/timer/devices/<name>/arm`
- `/api/app/actions/timer/devices/<name>/disarm`

When the timer gets armed, it starts counting with milliseconds resolution. Now the property *periods* comes into the game. It contains the array of periods, in milliseconds, the timer successively counts and after each period is reached, the timer shots (expires). When the last period is reached, the counting continues from the **second** element of *periods* array (*periods[1]*). The **first** element (*periods[0]*) is skipped when returning, so it may be used as initial delay.

Let's have *periods* containing `[500,1000,2000]`. When the timer gets armed, it shots as follows:

```

500ms | shot | 1000ms | shot | 2000ms | shot | 1000ms | shot | 2000ms | shot | 1000
ms | ...

```

Let's have *periods* containing `[0,1000]`. When the timer gets armed, it shots as follows:

```

shot | 1000ms | shot | 1000ms | shot | 1000ms | ...

```

When the number of shots reaches the value set in *shots_count_max* property, the timer is disarmed automatically. Set the *shots_count_max* property to zero to allow infinite counting. The number of shots is indicated by *shots_count* status property, which is zeroed by transition to armed state. The number of transitions to armed state is indicated by *arms_count* status property, which is zeroed by transition to enabled state.

The timer gets armed (counting starts) on either of following conditions:

- property *enabled* changes to *true* while property *arm_on_enable* is *true*
- action at URL path `/api/app/actions/timer/devices/<name>/arm` is called while property *enabled* is *true*

The timer gets disarmed (counting stops) on either of following conditions:

- property *periods* contains only one element, so return to the second element is not possible
- number of shots reaches the value set in *shots_count_max* property
- action at URL path `/api/app/actions/timer/devices/<name>/disarm` is called
- property *enabled* changes to *false*

Each timer is able to act as trigger source within the **Trigger system**. To enable this feature just set the required trigger source type within the *trigger_sources* property. To avoid the unintentional overload of trigger system enable only those trigger sources, that are really required. There exist three types of trigger sources, each one generates exactly one trigger per one timer shot.

The *shot* type generates triggers, whose identifier is `/timer/devices/<name>/shot`.

The *shot_number* type generates triggers, whose identifier is `/timer/devices/<name>/shot/number/<value>`. The `<value>` identifies the shot number, it equals the *shots_count* status property.

The *shot_period* category generates triggers, whose identifier is `/timer/devices/<name>/shot/period/<value>`. The `<value>` identifies the shot period, it equals the index of period in *periods* array property.

The configuration properties *periods*, *shots_count_max* and *trigger_sources* are sampled (taken into effect) only by transition from disarmed to armed state. The configuration property *arm_on_enable* is sampled (taken into effect) only by transition from disabled to enabled state.

3.11.1 Examples

Get status of timer device *t0*

```
curl -v -X GET 'http://192.168.1.200/api/app/status/timer/devices/t0'
```

Enable timer device *t0*

```
curl -v -X PUT -H 'Content-Type: application/json' -d 'true' 'http://192.168.1.200/api/app/config/timer/devices/t0/enabled'
```

Arm timer device *t0*

```
curl -v -X POST 'http://192.168.1.200/api/app/actions/timer/devices/t0/arm'
```

3.12 FG4 PCIe cards

This part of API describes the parameters of Digiteq Automotive FG4 PCIe cards. Common FG4 status is available at JSON pointer `/fg4`. Status of particular devices is available at JSON pointer `/fg4/devices`. FG4 devices are **System-managed**, so their names are fully controlled by operating system. There is no configuration available.

Snippet of FG4 status (at JSON pointer `/fg4`)

```
{
  "devices": {
    "001-003-001-018": {...},
    "001-031-002-072": {...},
    "001-031-002-099": {...}
  }
}
```

Snippet of FG4 device status (at JSON pointer `/fg4/devices/001-003-001-018`)


```
{
  "address": "0000:06:00.0",
  "vendor_id": 7896,
  "device_id": 257,
  "product_id": 1,
  "fw_type": "fpdl3",
  "fw_version": 814,
  "module_type": "fpdl3",
  "module_version": 1,
  "serial_number": "001-003-001-018",
  "temperature": 52,
  "video": {
    "captures": [
      "fg4_001-003-001-018_i1",
      "fg4_001-003-001-018_i0"
    ],
    "outputs": [
      "fg4_001-003-001-018_o0",
      "fg4_001-003-001-018_o1"
    ]
  }
}
```

address - PCI address.

vendor_id - Vendor ID, 7896 (0x1ed8) - Digiteq Automotive.

device_id - Device ID, 257 (0x0101) - T100, 513 (0x0201) - T200.

product_id - Product ID, 1 - T100, 2 - T200.

fw_type - Firmware type (*fpdl3*, *gmsl*, *recovery*).

fw_version - Firmware version.

module_type - Module type (*fpdl3*, *gmsl*, *no_module_present*).

module_version - Module version.

serial_number - Serial number.

temperature - Temperature, in degree Celsius.

video/captures - List of video captures. These are the names of video capture devices available on module..

video/outputs - List of video outputs. These are the names of video output devices available on module.

All these parameters are specific for alone FG4 PCIe card, no matter which (if ever) module is inserted. The configuration and status parameters of particular video capture/output devices (dependent on inserted module) are part of video capture/output streaming subsystem. It is available at JSON pointers `/video/captures/<name>/capture/fg4` and `/video/outputs/<name>/output/fg4`, where the `<name>` corresponds to the name available in list at JSON pointer `/fg4/devices/*/video/captures` and `/fg4/devices/*/video/outputs`. See [Video captures](#) and [Video outputs](#) for detailed information about video capture/output streaming subsystem.

Each FG4 PCIe card must contain firmware, which is compatible with used FG4 Multibox and also with the type of inserted module. FG4 Multibox tries to satisfy this requirement automatically, see [FG4 card firmware update](#) for detailed information.

3.13 Mainboard PMIC

Mainboard PMIC (Power Management IC) is an integrated circuit located on [Mainboard](#). It controls the onboard power supply, power on/off sequences and also external triggers. It also provides the ability to automatically power-on the FG4 Multibox, either when it gets connected to power supply or when configured event occurs on external trigger. The configuration and status are located at JSON pointer `/mbpmic`.

Snippet of maiboard PMIC configuration (at JSON pointer `/mbpmic`)

```
{
  "poweron": false,
  "triggers": {
    "tr1": {
      "edge": "none",
      "pull": "none",
      "wake": false
    },
    "tr2": {
      "edge": "none",
      "pull": "none",
      "wake": false
    }
  }
}
```

Snippet of maiboard PMIC status (at JSON pointer `/mbpmic`)

```
{
  "monitor": {
    "fanrpm": 1234,
    "tmb": 35,
    "tmcu": 36,
    "vin": 18837,
    "vinb": 18946
  },
  "version": "1.1.6",
  "waker": "pwrbtn"
}
```

The boolean property *poweron* controls the behavior of FG4 Multibox after the power supply is connected. If *false*, then it remains in power-off state. If *true*, then the power-on sequence is started automatically. For example this may be useful for automatic restoration of function after accidental power cut.

The object *triggers* controls the **External triggers** TR1 and TR2. The property *edge* (*none*, *rising*, *falling* or *both*) configures the type of edge causing the trigger event. Set to *none* to disable the trigger. The property *pull* (*none*, *up* or *down*) configures the connection of internal pull-up or pull-down resistor. Set to *none* to have no pull resistor connected. The boolean property *wake* allows to power-on the FG4 Multibox when configured trigger event occurs. Set to *false* to disable this feature. Triggers TR1 and TR2 also act as trigger sources within the **Trigger system**. Identifiers of generated triggers are `/mbpmic/tr1` and `/mbpmic/tr1`.

There are also some status properties. The object *monitor* shows values from some internal sensors.

fanrpm - cooling fan speed, in rotations per second

tmb - mainboard temperature, in degree Celsius

tmcu - PMIC temperature, in degree Celsius

vin - input voltage, in millivolts

vinb - input backup voltage, in millivolts

The property *waker* shows the source causing the power-on of FG4 Multibox, it may be one of

n/a - not available (should not occur)

pwron - power supply was connected (should occur only if *poweron* is *true*)

pwrbtn - power button was pressed

pwrc - power-cycle was requested

tr1 - configured event occurred on external trigger TR1

tr2 - configured event occurred on external trigger TR2

can1 - not implemented yet (should not occur)

can2 - not implemented yet (should not occur)

bootldr - requested by mainboard PMIC bootloader (may occur after PMIC firmware is updated)

Property *version* shows the version of mainboard PMIC firmware.

3.14 Trigger system

Trigger system allows to perform a specific operation as a reaction to a specific event. Now some terms must be introduced to avoid possible ambiguous understanding. Object that generates the *trigger* is called *trigger source*. Object that consumes the *trigger* is called *trigger sink*. Object that is generated by *trigger source* and is consumed by *trigger sink* is called *trigger*. Trigger source represents a place, where an event may be generated. This event is called trigger. Through a configurable connection matrix the event may arrive to any trigger sink. Trigger sink represents a place, where any event may be consumed by performing a specified operation/reaction. Trigger system configuration and status are located at JSON pointer `/trigger`.

Snippet of trigger system configuration (at JSON pointer `/trigger`)

```
{
  "connections": {},
  "file_writer": {
    "enabled": false,
    "path": "mounts:/satadisk/triggers/"
  },
  "tcp_server": {
    "port": 51000
  }
}
```

Snippet of trigger system status (at JSON pointer `/trigger`)

```
{
  "file_writer": {
    "running": false
  }
}
```

3.14.1 Trigger

Trigger (event) is an object generated by trigger source. Each trigger has two attributes, identifier and timestamp. Identifier determines the trigger source, that generated the trigger. Timestamp determines the moment in time the trigger was generated, **Monotonic time** is used as time base. Triggers may be written to storage or streamed over network. In both cases they are transferred as a stream of newline delimited JSON objects, known as NDJSON. Each JSON object is described by this schema:

```
{
  "$schema" : "http://json-schema.org/draft-07/schema#",
  "type" : "object",
  "properties" : {
    "id" : {
      "title" : "Trigger identifier",
      "description" : "Trigger identifier determines the trigger source, that generated the trigger.",
      "type" : "string"
    },
    "ts" : {
      "title" : "Trigger timestamp",
      "description" : "Trigger timestamp determines the moment in time the trigger was generated, in nanoseconds.",
      "type" : "integer"
    }
  },
  "required" : ["id", "ts"]
}
```

The stream of triggers, either written to storage or received via network, may look something like:

```
{
  "id": "/mbpmic/tr1",
  "ts": 3961704067701
}
{
  "id": "/control/tcp_session/tr0",
  "ts": 3962698000787
}
{
  "id": "/can/captures/capt0/capture/filters/0",
  "ts": 3963809236439
}
{
  "id": "/timer/devices/t0/shot",
  "ts": 3964894626995
}
```

3.14.2 Trigger source

Trigger source represents a place, where triggers (events) are generated. Each trigger source has its own unique identifier. Identifiers of existing trigger sources:

- `/can/captures/<name>/capture/filters/<index>`
- `/trigger/tcp_session/<arg>`
- `/control/tcp_session/<arg>`
- `/mbpmic/{tr1|tr2}`
- `/timer/devices/<name>/shot`
- `/timer/devices/<name>/shot/number/<value>`
- `/timer/devices/<name>/shot/period/<value>`

`/can/captures/<name>/capture/filters/<index>`

This trigger source generates its trigger whenever a CAN message received on capture `<name>` matches filter `<index>`. See [Capture and filters](#) for detailed description.

`/trigger/tcp_session/<arg>`

This trigger source generates its trigger whenever a specific message is received via trigger TCP session. It is the same session as the one created for streaming triggers over network, see [Streaming over network](#). The message must be a newline delimited JSON (NDJSON) of type string, whose value determines the `arg` component of the trigger source name. So if `"tr"` message is received, then trigger source `/trigger/tcp_session/tr` generates its trigger.

`/control/tcp_session/<arg>`

This trigger source generates its trigger whenever a dedicated action is called via remote API served by application service. Just call the parametric synchronous action at URL path `/api/app/actions/trigger/send` to generate the trigger. The parameter contains a custom text (expressed as JSON of type string), that determines the `arg` component of the trigger source name. So if action `/api/app/actions/trigger/send` with parameter `"tr"` is called, then trigger source `/control/tcp_session/tr` generates its trigger.

`/mbpmic/{tr1|tr2}`

This trigger source generates its trigger whenever an specified event occurs on external trigger TR1 or TR2. See [Mainboard PMIC](#) for detailed description.

`/timer/devices/<name>/shot`

`/timer/devices/<name>/shot/number/<value>`

`/timer/devices/<name>/shot/period/<value>`

These trigger sources generate their triggers whenever a timer `<name>` expires. See [Timers](#) for detailed description.

3.14.3 Trigger sink

Trigger sink represents a place, where triggers (events) are consumed, where specified reactions are performed. There are two types of sinks, configuration and action. Both sinks allow to perform any operation, that can also be performed via remote API served by [Application service](#). Configuration sink allows to manipulate the configuration available at URL path `/api/app/config`, see [Application service configuration](#). Action sink allows to call any action at URL path `/api/app/actions/*`, see [Application service actions](#). It just invokes the specified action, without waiting for results, so it can be used for all types of actions (parametric/nonparametric, synchronous/asynchronous). See [Connections](#) to see how to use trigger sinks.

3.14.4 File writer

The *file_writer* element is responsible for storing the generated triggers to mounted device (e.g. SATA or USB disk). Destination file is determined by *path*, which is a string complying with definition of URI (Uniform Resource Identifier), see [RFC3986](#). Only scheme and path components are used within the URI.

Scheme component must always be set to *mounts* value. It means that one of the mounted devices will be used for writing the file.

Path component represents the file path. It must always start with forward slash character “/”. The first segment of the path must always be the name of specific mount point, in general it can be any of mount points located in status at JSON pointer */storage/mounts*. See [Mounts](#) chapter for detailed description. The following segments represent the rest of the file path within the mount point. The path may contain some special variables, which are replaced by their real values at the time the file is created. These variables must be specified in form *\$(variable_name)*. Currently supported variables:

time - system time complying with full date and time according to ISO 8601, with milliseconds

ext - default file extension (including the dot “.”), currently it is always *.ndjson*

When the path ends with forward slash character “/”, it is considered as directory and the file name is constructed automatically as *\$(time)\$(ext)*. When the path contains non-existent directories, they will be created automatically.

Here are examples of possible paths:

```
mounts:/satadisk/triggers/
```

The file is created on storage device, that is mounted to mount point *satadisk*. Directory *triggers* is created automatically if it doesn't exist. Because the path ends with “/”, it is considered as directory and the file name is constructed automatically. So the resulting file name on the mounted device may look something like */triggers/20240215T105231.517Z.ndjson*.

```
mounts:/satadisk/triggers_$(time)$(ext)
```

The file is created on storage device, that is mounted to mount point *satadisk*. The resulting file name on the mounted device may look something like */triggers_20240215T105231.517Z.ndjson*.

To enable the file writer, just set *enabled* to *true*. See *running* property in status to get the real state of file writer. To have the running file writer, some conditions must be met. E.g. the file writer must be enabled, mount point must exist, mounted device must be writable and must contain enough free space, file name must be correctly specified. When any of these conditions are not met or any errors occur, the file writer stops working and the *running* state is set to *false*. Whenever the file writer changes its *running* state to *true*, it creates new file and opens it for writing. When the file writer changes its *running* state to *false*, it also closes the file.

3.14.5 Streaming over network

Generated triggers may also be transmitted over network as TCP stream. Element *tcp_server* represents the TCP server, that listens on specified *port*. Each time it accepts incoming connection, new TCP session is created. Multiple TCP sessions may exist at the same time.

3.14.6 Connections

The *connections* object contains connections between trigger sources and trigger sinks. Multiple trigger sinks may be connected to single trigger source. When trigger source generates a trigger (an event occurs), all connected trigger sinks consume it (an reaction happens). Each object in *connections* represents connection between single trigger source and multiple trigger sinks. The object name specifies trigger source identifier, the object value specifies an array of connected trigger sinks. Each trigger sink contain one single child object, whose name determines the type of trigger sink. Currently there are two possible types, configuration (named as *config*) and action (named as *action*).

Snippet of trigger connections configuration (at JSON pointer `/trigger/connections`)

```
{
  "/control/tcp_session/tr0": [
    {
      "config": {
        "operation": {
          "arg": false,
          "name": "replace"
        },
        "path": "/video/captures/fg4_001-003-001-018_i0/enabled"
      }
    }
  ],
  "/control/tcp_session/tr1": [
    {
      "config": {
        "operation": {
          "arg": {
            "enabled": true,
            "sinks": {
              "video": {
                "enabled": true,
                "file_writer": {
                  "enabled": true
                }
              }
            }
          },
          "name": "modify"
        },
        "path": "/video/captures/fg4_001-003-001-018_i0"
      }
    }
  ],
  "/control/tcp_session/tr2": [
    {
      "config": {
        "operation": {
          "name": "negate"
        },
        "path": "/video/captures/fg4_001-003-001-018_i0/enabled"
      }
    }
  ],
  "/control/tcp_session/tr3": [
    {
      "action": {
        "arg": {
          "text": "tr3",
          "timeout": 1000
        },
        "name": "/video/captures/fg4_001-003-001-018_i0/trigger_mark"
      }
    }
  ],
  "/timer/devices/t0/shot": [
    {
      "action": {
        "arg": {
          "text": "t0",
          "timeout": 250
        },
        "name": "/video/captures/fg4_001-003-001-018_i0/trigger_mark"
      }
    }
  ]
}
```

```

    }
  }
]
}

```

3.14.6.1 Configuration trigger sink Configuration trigger sink allows to manipulate the configuration available at URL path `/api/app/config`, see [Application service configuration](#). It behaves the similar way as via HTTP API, any JSON nodes may be changed, created, deleted, etc. Configuration trigger sink is contained in object named as *config*. It contains two required items, *path* and *operation*. The *path* is of type string and contains JSON pointer to the configuration node, that should be manipulated. The *operation* is of type object and contains one required item *name* and one optional item *arg*. The presence and content of *arg* depends on operation *name*. This is the way how the configuration trigger sink works, an operation (specified by *name*) is performed on configuration JSON node (specified by *path*). Supported operation names:

- *replace* - replaces content of existing node (at JSON pointer *path*) by content of *arg*. It works the same way as PUT verb in HTTP API.
- *modify* - modifies/patches content of existing node (at JSON pointer *path*) by using content of *arg*. The content of *arg* is considered as JSON patch, see [RFC6902](#). It works the same way as PATCH verb in HTTP API.
- *create* - creates new node (if doesn't exist) at JSON pointer *path*. The last segment of *path* is used as name of node to be created. The previous segments must point to existing nodes. The content of *arg* is used as content of the new node. It works the same way as CREATE verb in HTTP API.
- *delete* - deletes existing node (if exists) at JSON pointer *path*. The last segment of *path* is used as name of node to be deleted. The previous segments must point to existing nodes. The *arg* is not used. It works the same way as DELETE verb in HTTP API.
- *negate* - negates value at JSON pointer *path*. The value must be of boolean type. The *arg* is not used. There is no counterpart verb in HTTP API.

Basically there are two methods how to set multiple properties as a reaction to single trigger. First, each property is set (by *replace*) in separate sink and these sinks are the separate members of trigger sink array. Second, all properties are part of single JSON patch, which is then used (by *modify*) in one single trigger sink. Always prefer the second method as it is much more efficient.

For better understanding let's go through the above snippet of trigger connections. There are three configuration trigger sinks, each connected to different trigger source.

First trigger sink is connected to trigger source `/control/tcp_session/tr0`. The trigger source generates its trigger whenever action `/trigger/send` is called with argument `"tr0"`. As a reaction, trigger sink sets the configuration property `/video/captures/fg4_001-003-001-018_i0/enabled` to *false*. It means, that the video capture device `fg4_001-003-001-018_i0` will be disabled.

Second trigger sink is connected to trigger source `/control/tcp_session/tr1`. The trigger source generates its trigger whenever action `/trigger/send` is called with argument `"tr1"`. As a reaction, multiple configuration properties are set at the same time. Properties `/video/captures/fg4_001-003-001-018_i0/enabled`, `/video/captures/fg4_001-003-001-018_i0/sinks/video/enabled` and `/video/captures/fg4_001-003-001-018_i0/sinks/video/file_writer/enabled` are set to *true*. It means, that the video capture device `fg4_001-003-001-018_i0` will be enabled, its video sink will be enabled and the file writer of this video sink will also be enabled.

Third trigger sink is connected to trigger source `/control/tcp_session/tr2`. The trigger source generates its trigger whenever action `/trigger/send` is called with argument `"tr2"`. As a reaction, trigger sink negates (switches) the configuration property `/video/captures/fg4_001-003-001-018_i0/enabled`.

3.14.6.2 Action trigger sink Action trigger sink allows to call any action at URL path `/api/app/actions/*`, see [Application service actions](#). It behaves the similar way as via HTTP API, any action with any argument may be called. It just invokes the specified action, without waiting for results, so it can be used for all types of actions (parametric/nonparametric, synchronous/asynchronous). Action

trigger sink is contained in object named as *action*. It contains one required item *name* and one optional item *arg*. The presence and content of *arg* depends on *name*. This is the way how the action trigger sink works, it calls the action (specified by *name*) with argument (specified by *arg*).

For better understanding let's go through the above snippet of trigger connections. There are two action trigger sinks, each connected to different trigger source.

First trigger sink is connected to trigger source */control/tcp_session/tr3*. The trigger source generates its trigger whenever action */trigger/send* is called with argument *"tr3"*. As a reaction, trigger sink calls the action */video/captures/fg4_001-003-001-018_i0/trigger_mark* with argument *{ "text": "tr3", "timeout": 1000 }*. It means, that a trigger mark *tr3* will be rendered in video capture stream for 1000 milliseconds.

Second trigger sink is connected to trigger source */timer/devices/t0/shot*. The trigger source generates its trigger whenever timer device *t0* expires. As a reaction, trigger sink calls the action */video/captures/fg4_001-003-001-018_i0/trigger_mark* with argument *{ "text": "t0", "timeout": 250 }*. It means, that a trigger mark *t0* will be rendered in video capture stream for 250 milliseconds.

3.14.7 Examples

Get status of trigger system

```
curl -v -X GET 'http://192.168.1.200/api/app/status/trigger'
```

Get configuration of trigger connections

```
curl -v -X GET 'http://192.168.1.200/api/app/config/trigger/connections'
```

Read the stream of triggers from dedicated trigger TCP session on port *51000*

```
nc 192.168.1.200 51000
```

Generate trigger */trigger/tcp_session/tr* by dedicated trigger TCP session on port *51000*

```
echo '"tr"' | nc -N 192.168.1.200 51000
```

Generate trigger */control/tcp_session/tr* by calling of dedicated action via HTTP API

```
curl -v -X POST -H 'Content-Type: application/json' -d '"tr"' 'http://192.168.1.200/api/app/actions/trigger/send'
```

Get list of files contained in specified directory and then read the content of selected file

```
curl http://192.168.1.200/api/fs/mounts/satadisk/triggers/
curl http://192.168.1.200/api/fs/mounts/satadisk/triggers/20240314T111001.479Z.ndjson
```

3.15 CPU

CPU related stuff is located at JSON pointer */cpu*. Only status is available.

Snippet of CPU status (at JSON pointer */cpu*)

```
{
  "usage": 12,
  "temperature": 44
}
```

usage - Usage, in percentage, in range from 0 to 100. The usage is computed over all six (2x Denver 2, 4x Cortex-A57) cores. Typical usage of idle state is below 5%.

temperature - Temperature, in degree Celsius.

3.16 RAM

RAM related stuff is located at JSON pointer `/ram`. Only status is available.

Snippet of RAM status (at JSON pointer `/ram`)

```
{
  "size": {
    "total": 8241074176,
    "used": 1721339904
  }
}
```

/size/total - Total RAM size, in bytes.

/size/used - Used RAM size, in bytes.

3.17 About

Some general information about FG4 Multibox is located at JSON pointer `/about`. Only status is available. The information is static, so it never changes when the FG4 Multibox is running.

Snippet of about status (at JSON pointer `/about`)

```
{
  "factory_installer_version": "32.5.0.5",
  "factory_package_version": "1.0-build236",
  "runtime_package_version": "1.0-build236",
  "serial_number": "010-001-001-001"
}
```

factory_installer_version - Version of used factory installer. It is the tool, that is used for installation of factory package. See [Firmware](#) to get detailed information.

factory_package_version - Version of installed factory package.

runtime_package_version - Version of installed runtime package.

serial_number - Serial number of FG4 Multibox.

4 Graphical interface

Graphical interface is implemented by web application, hosted on FG4 Multibox HTTP server, TCP port 80, URL path `/www/web/index.html`. Actually URL path `/` may be also used as there exists redirection *301* (move permanently) to real location. So when using default IP address, just write *http://192.168.1.200/* to your favourite web browser. Web application uses the FG4 Multibox **API** as its backend.