User manual for TCSmart+

by

TECHNOLOGY

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1 Overview and Features

This guide describes the features of *TeAx ThermalCapture Smart+* (in the following called *TCSmart+*). It is a powerful computing environment, designed for the full radiometric EOIR (Electro-Optical-Infra-Red) system *ThermalCapture Fusion Zoom (TCFusionZoom)*. Based on the *NVIDIA TK1* this device features high processing power in a small form factor and little weight.

1.1 Scope of Delivery

- TCSmart+
  - Toradex TK1 module (with NVIDIA Tegra K1)
  - TeAx interface board
  - Aluminum case
- Cable Set
  - Power cable
  - Connector cable for TCFusionZoom
  - JST-4-Pin plug with open ends
  - Micro-HDMI to HDMI cable
- User manual

1.2 Hardware Description

The aluminum casing of *TCSmart+* is light weight and provides an exceptionally good heat dissipation for the powerful Toradex TK1 module. Please take care not to isolate the aluminum casing especially in situations when high cpu load is generated permanently. The surface can become hot in such situations (especially the area with the cooling stripes above the TeAx logo)!

Overview of *TCSmart+* (cf. Toradex TK1):

- Quad Core, NVIDIA Tegra K1, Quad-core ARM Cortex-A15
- Up to 2.1GHz
- 2GB RAM
- Full CUDA support (192 NVIDIA CUDA Cores), OpenGL 4.4 and OpenGL ES 3.1

1.3 Software Description

TCSmart+ runs with a pre installed Ubuntu. It is the kernel from a standard Toradex image with the root file system of an L4T (Linux 4 Tegra). Because of the high performance machine and the good

package support it's possible to do native development on the machine itself. No cross compile setup is needed.

For convenience there' s a ready to go setup of a Qt (including Qt Creator) installation with pre configured demo projects that show examples on how to connect *TCFusionZoom*, how to build a qt-based live viewer or how to to process incoming data of *TCFusionZoom* in OpenCV.

2 Operation

Please take some time to read the manual before using *TCSmart+.* A couple of things will become clearer regarding the miscellaneous interfaces of *TCSmart+*. Additionally there will be some hints on howto use the operating system.

2.1 Intended Use

- Please take care not to isolate the aluminum casing as it's needed to dissipate the heat from the TK1.
- *TCSmart+* is designed for use in private and commercial areas.

2.2 Wiring and Connectors

TCSmart+ provides interfaces at the left, front and right side of the aluminum case. Below you see an overview of the IO (figures 1, 2 and 3 with the table below) and a more detailed description in the following text.

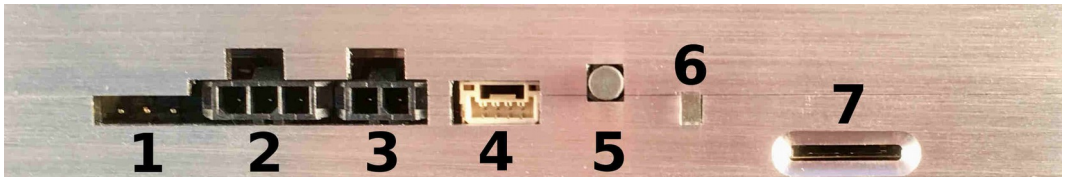


Figure 1: Left side of TCSmart+

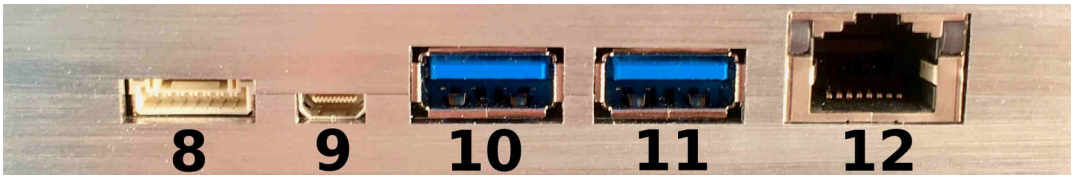


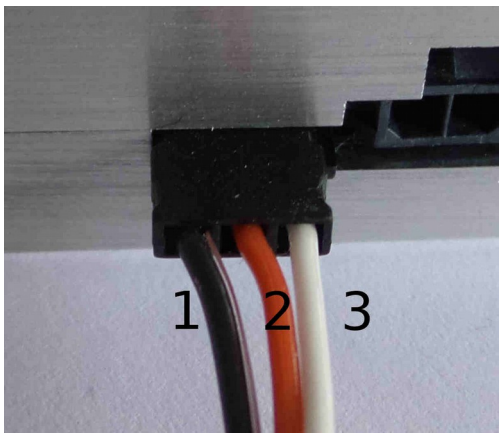
Figure 2: Front side of TCSmart+

Figure 3: Right side of TCSmart+

1	Servo Connector
2	TeAx-GPS input (UART in)
3	Supply
4	UART
5	Push-Button
6	Status LED
7	Micro-SD-Card Slot
8	TCFusionZoom Connector
9	Micro HDMI
10	USB3 Port
11	USB2 Port
12	RJ45 Gigabit Ethernet Port
13	Micro Jack Debug Serial Connector

2.2.1 Servo Connector

The *Servo-Connector* is forwarded to the *JST-7-Pin connector* for *TCFusionZoom*. This makes it possible to feed in an SBUS signal or a Servo PWM for controlling *TCFusionZoom's* behavior (e.g. Trigger, Live-View-Settings etc.).

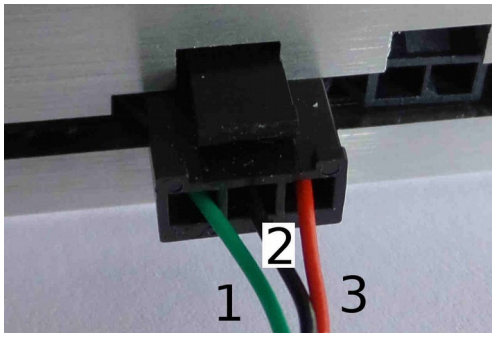


1	GND
2	NC
3	PWM Signal

Keep in mind that there's no 5V supply on the Servo Connector (red cable no. 2).

2.2.2 TeAx GPS Input

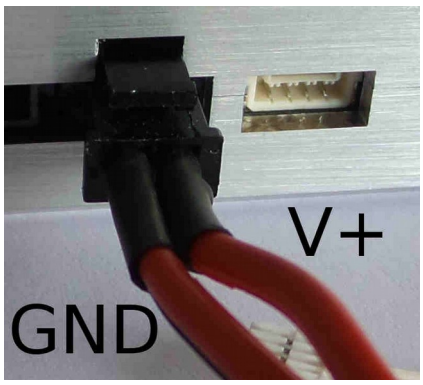
The TeAx-GPS-Input of *TCSmart+* can be used to connect an TeAx-GPS-Module with an also connected *TCFusionZoom*. This way the *TCFusionZoom* still adds GPS information to the recorded or streamed data.



1	GPS Data Input
2	GND
3	5V GPS-Supply provided by TCFusionZoom via JST-7-Pin connector

2.2.3 Supply

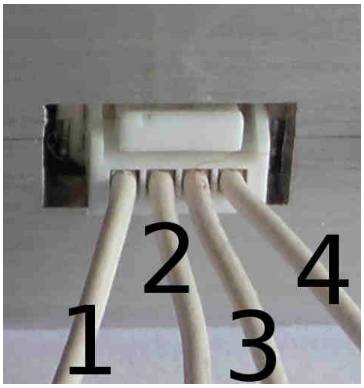
Please take care to provide 12V-32V for the *TCSmart+* power supply. Please keep in mind that an optionally attached *TCFusionZoom* will increase the needed power significantly.



V+	Power supply for the TCSmart+ and additional hardware (e.g. TCFusionZoom)
GND	GND of supply

2.2.4 UART

The UART of TCSmart+ can be used as communication interface (incoming or outgoing control commands for example). Please note the signal voltage level of 3.3V (Never connect regular RS232 signal levels to the UART connection of *TCSmart+*).



1	+3V3
2	GND
3	TX
4	RX

2.2.5 Push Button

The push button has no active function at the moment.

2.2.6 Status LED

The Status LED is a user configurable RGB LED for signaling miscellaneous informations for observation from outside. Please refer to 3.5 Using of Status LED of the user manual for further details.

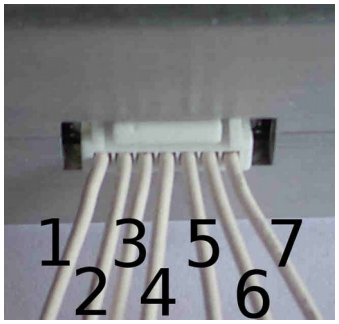
2.2.7 Micro-SD-Card Slot

This is a slot for a Micro SD card. You can use it in *TCSmart+* to store log files or processed data on an SD card. Please take care that the SD card's class is fast enough for your needs (we recommend an SDHC Class 10 card at least).

2.2.8 TeAx TCFusionZoom Connector

The *JST-7-Pin plug* can be used to connect a *TCFusionZoom*. Besides the power supply for *TCFusionZoom* (V+ and GND) this interface connects the *TeAx GPS Input* of *TCSmart+* to the *TCFusionZoom*. Please refer to the JST-7-Pin connector image and the table below for a

description of pins.:



1	5V supply for GPS
2	NC
3	NC
4	V+
5	GND
6	Trigger_Out Connects the Servo Connector signal to the Trigger_In of *TCFusionZoom*
7	GPS_Out forwards GPS data to TCFusionZoom

The *Trigger_Out* pin forwards a PWM signal from the *Servo Connector* of *TCSmart+* to the *Trigger_In* pin of *TCFusionZoom*. On Pin1 is the supply for an optionally TeAx-GPS-Module connected to the TeAx-GPS-Connector (supply of GPS by *TCFusionZoom*). Via Pin7 GPS_Out the GPS data from an optionally available TeAx-GPS-Module are forwarded to the GPS_In of *TCFusionZoom*.

2.2.9 Micro HDMI

This Micro HDMI port provides a standard HDMI output. You can connect every standard HDMI monitor or TV. It's intended for developing directly on the target system. The system should be able to detect the correct resolution of the monitor via EDID information. To be on the safe side connect the monitor before starting the system. Please remember that you can always access the system via ssh if something went wrong and the monitor is not detected correctly. Tools like *xrandr* and derivatives can be useful to explore the available monitor devices.

2.2.10 USB3-Port

TCSmart+ provides a USB 3.0 connection for devices with high bandwidth needs (Bus 03 Port 1 in listing below). It's fully downward compatible to USB 2.0 and USB 1.0. Ideally connect *TCFusionZoom* to this USB port.

```
ubuntu@ubuntu:$ sudo lsusb -t
/:  Bus 03.Port 1: Dev 1, Class=root_hub, Driver=tegra-xhci/2p, 5000M
/:  Bus 02.Port 1: Dev 1, Class=root_hub, Driver=tegra-xhci/6p, 480M
    |__ Port 2: Dev 3, If 0, Class=Vendor Specific Class, Driver=, 480M
    |__ Port 2: Dev 3, If 1, Class=Vendor Specific Class, Driver=, 480M
/:  Bus 01.Port 1: Dev 1, Class=root_hub, Driver=tegra-ehci/1p, 480M
```

2.2.11 USB2-Port

TCSmart+ provides a USB 2.0 port that is ideal to attach a usb hub (e.g. for mouse and keyboard; Bus 02 Port 1 on listing below). It's fully downward compatible to USB 1.0.

```
ubuntu@ubuntu:$ sudo lsusb -t
/:  Bus 03.Port 1: Dev 1, Class=root_hub, Driver=tegra-xhci/2p, 5000M
/:  Bus 02.Port 1: Dev 1, Class=root_hub, Driver=tegra-xhci/6p, 480M
    |__ Port 2: Dev 3, If 0, Class=Vendor Specific Class, Driver=, 480M
    |__ Port 2: Dev 3, If 1, Class=Vendor Specific Class, Driver=, 480M
/:  Bus 01.Port 1: Dev 1, Class=root_hub, Driver=tegra-ehci/1p, 480M
```

2.2.12 RJ45 Gigabit Ethernet Port

You can use a standard RJ45 ethernet plug for connecting *TCSmart+* to a network. Please take care to use the appropriate category of ethernet cable for gigabit networks. This 1Gbit/s network port is fully downward compatible to 100MBit/s and 10MBit/s network connections.

2.2.13 Micro Jack Debug Serial Port

This interface provides access to a serial console of the system. Normally the usage of this interface won't be needed. The usage of a terminal login via SSH is much more convenient and should be preferred.

3 ThermalCapture Smart+ Usage

TCSmart+ was designed to provide a powerful computing device that is light and small enough to be placed under a UAV. This way it's possible to do real time processing of daylight and infrared data from *TCFusionZoom*. There's a pre installed Ubuntu linux for easy development.

3.1 Power On

As soon as the device is powered up it starts to boot the Ubuntu Linux. If there is a connected HDMI monitor you can see the boot prompt and kernel messages. After a couple of seconds you see a login prompt. Without HDMI monitor you should be able to login to *TCSmart+* via SSH session. Please take care to always correctly shutdown the device after usage.

3.2 Login

As a development machine the focus is on easy usage. This means that the device is not

configured for security. There's a standard user ubuntu with password ubuntu. On a graphical user session you can just login (with HDMI monitor, keyboard and mouse):

- User: ubuntu
- Pwd: ubuntu

If you want to connect the machine via network theres an SSH service running on *TCSmart+*. You need the IP address of the *TCSmart+* for the SSH session. The IP address depends on the configuration of *TCSmart+* and the network (e.g. router) the *TCSmart+* is connected to. To find out the IP address of *TCSmart+* you can use a linux machine in the same network (*user* on the machine *host* in the following example). First find out the IP of your host:

```
user@host:$ ifconfig
```

If you know the IP of your machine (eg. 192.168.0.42) you can search the network for other machines in your network:

```
user@host:$ nmap -sP 192.168.0.42/24
```

After a couple of seconds you should see a list of all found machines found in the same network including the *TCSmart+* (it's name is Apalis-TK1). Assuming *TCSmart+*'s IP is 192.168.0.8 you can now log in via:

```
user@host:$ ssh ubuntu@192.168.0.8
```

3.3 Power Off

To shutdown the machine please use the graphical tools provided by the operating system or a shutdown command from the command line (e.g. via ssh):

```
ubuntu@ubuntu:$ sudo shutdown -h now
```

3.4 Connecting TCFusionZoom

In order to get access to live data from *TCFusionZoom,* please check the hardware setup:

- Connect *TCFusionZoom* with 7-Pin JST-Connector of *TCSmart+*
- Connect the USB3 Port of *TCSmart+* with the USB port of *TCFusionZoom*

You can check the presence of the device in the terminal by using the command *lsusb*.

```
ubuntu@ubuntu:$ lsusb -t
```

3.4.1 Using libtcfusionzoom

To connect *TCFusionZoom* there is an already installed library *libtcfusionzoom* in folder */usr/local/lib/*. The appropriate header can be found in */usr/local/include/*. This library detaches the standard kernel driver and communicates directly via *libusb* with *TCFusionZoom*. Normally this would require the lib using program to run with root privileges. To circumvent this and to make *TCFusionZoom* accessible by normal users there is an udev rule installed to */etc/udev/rules.d/99-teax.rules*. This way the device is attached with the appropriate permissions.

```
ubuntu@ubuntu:$ cat /etc/udev/rules.d/99-teax.rules
SUBSYSTEM=="usb", ATTRS{idVendor}=="0483", MODE="0666"
SUBSYSTEM=="usb_device", ATTRS{idVendor}=="0483", MODE="0666"
```

Using *libtcfusionzoom* requires you to provide a callback function for receiving TFC data from *TCFusionZoom*. Every time a TFC frame is received via USB the callback gets called with the new frame. Please refer to the doxygen documentation of *libtcfusionzoom*. Besides the API description of *libtcfusionzoom* there is a code example that shows how to access the lib. Please also refer to the demo projects to see how you can access the lib.

3.4.2 Using libtmc

The delivered TFC frames consist of a TMC frame and a corresponding daylight jpeg. The data of the daylight jpeg can be directly processed but the TMC is a compressed binary in a proprietary format. In order to access the raw pixel data of the infrared image you have to use *libtmc* that is also installed on the system in */usr/local/lib/* with the appropriate header file in */usr/local/include/*. This *libtmc* also provides functions for conversion from raw data to miscellaneous formats like:

- TauBitmapRaw
- TauBitmapGrayScale
- TauBitmapRGB
- TauBitmapRGBFusion
- TauBitmapARGBFusion
- TauBitmapRGBRainbow
- TauBitmapARGBRainbow

Please refer to the doxygen information of libtmc for further details about general usage and API description.

3.5 Using of Status LED

The status LED can be freely configured. It's an RGB LED. Each of the 3 channels can be switched independently by using the appropriate GPIO-Pin of the *TCSmart+* (the RGB channels can be combined, e.g. red + green = yellow). The setup of the GPIO can be done via sysfs. First export the appropriate GPIO number and then set the direction to *out*. Now you are able to control the pin by writing a character *1* (enable) or *0* (disable) to the appropriate path of each GPIO. These settings are volatile and have do be repeated after each system start (this can also be automated with a bash script that is executed on startup). Please have a look at the examples below.

The red LED can be switched with GPIO-237 (you can check the setting with the cat command in the last row):

```
ubuntu@ubuntu:$ echo 237 > /sys/class/gpio/export
ubuntu@ubuntu:$ echo "out" > /sys/class/gpio/gpio237/direction
ubuntu@ubuntu:$ echo 1 > /sys/class/gpio/gpio237/value
ubuntu@ubuntu:$ cat /sys/class/gpio/gpio237/value
```

The green LED can be switched with GPIO-234 (you can check the setting with the cat command in the last row):

```
ubuntu@ubuntu:$ echo 234 > /sys/class/gpio/export
ubuntu@ubuntu:$ echo "out" > /sys/class/gpio/gpio234/direction
ubuntu@ubuntu:$ echo 1 > /sys/class/gpio/gpio234/value
ubuntu@ubuntu:$ cat /sys/class/gpio/gpio234/value
```

The blue LED can be switched with GPIO-248 (you can check the setting with the cat command in the last row):

```
ubuntu@ubuntu:$ echo 248 > /sys/class/gpio/export
ubuntu@ubuntu:$ echo "out" > /sys/class/gpio/gpio248/direction
ubuntu@ubuntu:$ echo 1 > /sys/class/gpio/gpio248/value
ubuntu@ubuntu:$ cat /sys/class/gpio/gpio248/value
```

3.6 Temperature Information

If there is a need to be informed about the systems temperature values (CPU, memory, etc.) you can request the temperatures from the system for each of the 4 zones (just adapt 0-4 after thermal_zone*). The call for *type* shows the measured location. The call for *temp* shows the temperature in fix point (e.g. a printed value of 42000 means 42.0 degree celsius).

```
ubuntu@ubuntu:$ cat /sys/class/thermal/thermal_zone0/type
ubuntu@ubuntu:$ cat /sys/class/thermal/thermal_zone0/temp
```

4 Post Processing with ThermoViewer Software

ThermoViewer is the post-processing software provided by *TeAx Technology* to process RAW data captured by *TeAx* products like *TCFusionZoom*. It allows the user to quickly browse through recorded data and tune every single frame into the perfect result. For further usage of the data it can be exported into images like JPG and PNG, videos and CSV data. CSV is especially useful, if further automatic data processing follows. There is also the option to export data into radiometric JPGs. Those files can be opened with powerful FLIR tools for deeper analysis, or automatic report generation. Please take a look at the *ThermoViewer* user manual for further information.

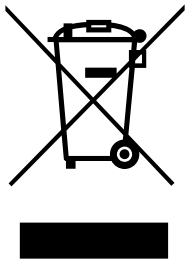
5 Technical Data

Digital TV-formats	Full-HD via HDMI (1080p, 60Hz)
Input voltage	12-32 V DC
power consumption	TBD.
Storage temperature	-4°F to 131°F -20°C to 55°C
Operating temperature	23°F to 113°F -5°C to 45°C
weight	210g

6 Disposal and recycling information

You must dispose this device properly according to local laws and regulations. Because this device contains electronic components, the device must be disposed separately from household waste. When this device reaches its end of life, contact local authorities to learn about disposal and recycling options.

6.1 European Union — Disposal Information



The symbol above means that according to local laws and regulations your product and/or its battery shall be disposed separately from household waste. When this product reaches its end of life, take it to a collection point designated by local authorities. The separate collection and recycling of your product and/or its battery at the time of disposal will help conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

7 Contact

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WEEE: DE 47 94 44 05

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