tessie User Manual

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Abstract

This document provides an overview of the tessie software and is intended to provide all information required to install the tessie software and safely operate the coldbox for the CMS phase-2 pixel module testing.
This document is work in progress. Please send all comments, in particular bug reports and complaints, to the email address given above. Many thanks!

Contents

1 Introduction

The `tessie`[1] program controls all aspects of the safe operation of the PSI coldbox developed for the testing of the CMS phase-2 pixel modules. It is hosted in a github respository [1].

`tessie` is a multi-threaded C++ program running on the Raspberry Pi with a custom hardware "hat" inside the coldbox. Originally, it started as a Qt5 GUI (graphical user interface) and it can still be operated in that way. However, in a production setup, it is mostly controlled through a web interface. The threads in `tessie` control, respectively, the graphical display, the underlying hardware (CAN [2] and I2C [3] bus), and the MQTT messaging service [4].

2 Installation

We assume that you have a coldbox where the hardware is completely configured according to the instructions [5]. In this section we describe how to prepare the Raspberry Pi, starting from creating its boot device, installing all required software components, and setting up the automatic `tessie` startup at boot time.

A few important remarks before describing the installation procedure.

- If the Raspberry Pi's screen turns white (at the end of the boot process) very likely the screen flatband connector is not properly inserted. This can happen easily when inserting the microSHDC card.

- After turning off/on the Raspberry Pi with the central power button, it may be necessary to repeat this power-cycling. It has been observed that two power-cycles are required to have the touchscreen work properly (instead of displaying "nothing"). Alternatively, try to connect via ssh and do (in a terminal) `sudo shutdown -r now`. Note that "nothing" is not the same as a white screen.

  It is currently not understand what causes this issue. We have observed it with a fresh microSDHC card, without any system modifications.

Installing `tessie` is straightforward, if the following steps are followed.

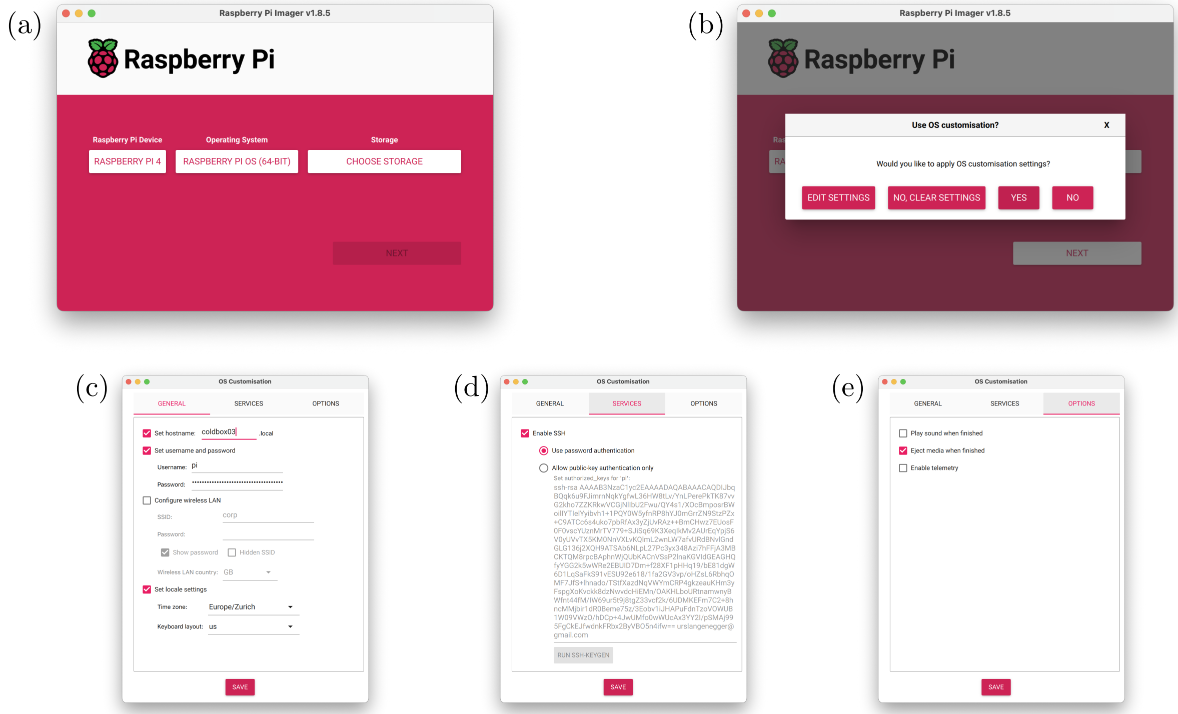
- Using the "Rasberry Pi Imager" [6], available for macOS, Windows, and Linux, burn a microSDHC card with the recommended Raspberry Pi OS (64bit), probably a port of Debian Bookworm with the Raspberry Pi Desktop.

  It is recommended to apply a few changes to the default setup, in particular set the user name and password, the hostname, and allow ssh access for remote work, cf. Fig 1.

- Insert the microSDHC card into the foreseen slot beneath the touchscreen flatband cable connector and power up the Raspberry Pi. If the touchscreen goes white, it likely is due to the "big" connector not being plugged in correctly. Try again.

  At the end of the startup/boot sequence you should see a nice background image.

[1] Etymology: tessie sounds better than TC (box), for temperature cycling (box)



Would you like to apply OS customisation settings?

☑ Set hostname: coldbox03 .local

☑ Set username and password

Username: pi

Password: ••••••••••••••••••••••••••••••••••••

□ Configure wireless LAN

SSID: corp

Password:

☑ Show password □ Hidden SSID

Wireless LAN country: GB

☑ Set locale settings

Time zone: Europe/Zurich

Keyboard layout: us

☑ Enable SSH

● Use password authentication

○ Allow public-key authentication only

Set authorized_keys for 'pi':

```
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAACAQDIJbq
BQqk6u9FJimrnNqkYgfwL36HW8tLv/YnLPerePkTK87vv
G2kho7ZZKRkwVCGjNlIbU2Fwu/QY4s1/XOcBmposrBW
oilIYTIelYyibvh1+1PQY0W5yfnRP8hYJ0mGrrZN9StzPZx
+C9ATCc6s4uko7pbRfAx3yZjUvRAz++BmCHwz7EUosF
0F0vscYUznMrTV779+SJiSq69K3XeqIkMv2AUrEqYpjS6
V0yUVvTX5KM0NnVXLvKQlmL2wnLW7afvURdBNvlGnd
GLG136j2XQH9ATSAb6NLpL27Pc3yx348Azi7hFFjA3MB
CKTQM8rpcBAphnWjQUbKACnVSsP2lnaKGVIdGEAGHQ
fyYGG2k5wWRe2EBUID7Dm+f28XF1pHHq19/bE81dgW
6D1LqSaFkS91vESU92e618/1fa2GV3vp/oHZsL6RbhqO
MF7JfS+lhnado/TStfXazdNqVWYmCRP4gkzeauKHm3y
FspgXoKvckk8dzNwvdcHiEMn/OAKHLboURtnamwnyB
Wfnt44fM/IW69ur5t9j8tgZ33vcf2k/6UDMKEFm7C2+8h
ncMMjbir1dR0Beme75z/3Eobv1iJHAPuFdnTzoVOWUB
1W09VWzO/hDCp+4JwUMfo0wWUcAx3YY2I/pSMAj99
5FgCkEJfwdnkFRbx2ByVBO5n4ifw== urslangenegger@
gmail.com
```

□ Play sound when finished

☑ Eject media when finished

□ Enable telemetry

Figure 1: Screen shot of the Raspberry Pi Imager and customization examples. (a) Select the model and OS, (b) choose 'EDIT SETTINGS' to reach the lower panels, (c) enter the hostname and set a password for the default user 'pi' (use this!), (d) enable ssh connections, (e) if you want.

- *Installation of dependencies* Open a terminal (it should be accessible from one of the icons at the top of the display) and do the following:

```
sudo apt install -y nodejs
sudo apt install -y npm

sudo apt-get install -y pigpio

sudo apt-get install -y libmosquitto-dev libmosquittopp-dev
sudo apt install -y mosquitto mosquitto-clients

sudo apt install -y libqt5charts5 libqt5charts5-dev

sudo apt-get install -y nginx

sudo date -s "Mon Apr 8 17:04:00"
```

  Do enter the correct day, date, and time in the line above.

- *Installation of tessie* Get the tessie software and compile it:

  ```
  cd /home/pi
  git clone https://github.com/ursl/tessie.git
  cd tessie/test1
  qmake -o Makefile  test1.pro
  make -j2
  ```

  Note: In case you want to compile tessie on a non-Raspberry Pi host without I2C/CAN bus, invoke `qmake "CONFIG+=NOPI" -o Makefile test1.pro`.

- *Mosquitto setup* Using the nano editor in sudo mode, edit the file /etc/mosquitto/mosquitto.conf to contain the following two lines:

  ```
  listener 1883
  allow_anonymous true
  ```

  In case the above instructions are unclear, the following is what you should type into the terminal: `sudo nano /etc/mosquitto/mosquitto.conf`, jump to the end, insert the two lines, and exit the editor (using in sequence: `CTRL-x  y  RET`).

- *Hardware (I2C and CAN) bus configuration* Using the nano editor in sudo mode, edit the file
  /boot/firmware/config.txt to contain the following two lines:

  ```
  dtparam=spi=on
  dtoverlay=mcp2515-can0,oscillator=12000000,interrupt=25
  dtoverlay=spi-bcm2835-overlay
  dtparam=i2c_vc=on
  ```

- *Hardware power buttton configuration* Download the auxiliary software package and install it:

  ```
  cd /home/pi
  git clone https://github.com/Howchoo/pi-power-button.git
  ./pi-power-button/script/install
  ```

- *Splash screen configuration* (Note: This is not compulsory. There is no real need to change the splash screen.) Using the nano editor in sudo mode, edit the file /boot/firmware/cmdline.txt to contain *on one line* the following two lines (they are provided here on two lines such that they can be copied in their entirety):

  ```
  console=serial0,115200 console=tty1 root=PARTUUID=7a0cea11-02  rootfstype=ext4
  fsck.repair=yes rootwait quiet splash plymouth.ignore-serial-consoles
  ```

  Using the nano editor in sudo mode, edit the file
  /boot/firmware/config.txt to contain

```
disable_splash=1
```

Enter the following in a terminal:

```
cd /usr/share/plymouth/themes/pix/
sudo mv splash.png splash.png.bac
sudo cp /home/pi/tessie/splash.png ./
```

- *tessie webserver* Setup the tessie web server by installing all required node packages

  ```
  cd /home/pi/tessie/node/test1
  npm install --save express socket.io mqtt
  ```

- *tessie startup at boot time* With `sudo nano` create the file `/lib/systemd/system/tessie.service` with the following content (i.e. do `sudo nano /lib/systemd/system/tessie.service` and copy-paste the following):

  ```
  [Unit]
  Description=tessie
  After=network.target

  [Service]
  Type=idle
  Environment="XAUTHORITY=/home/pi/.Xauthority"
  Environment="DISPLAY=:0"
  WorkingDirectory=/home/pi/tessie/test1
  ExecStartPre=/home/pi/tessie/resetCAN.sh
  ExecStart=/home/pi/tessie/test1/tessie
  StandardOutput=inherit
  StandardError=inherit

  [Install]
  WantedBy=graphical.target
  ```

  For the tessie webserver do `sudo nano /lib/systemd/system/tessieWeb.service` with the following contents

  ```
  [Unit]
  Description=tessie
  After=multi-user.target

  [Service]
  Type=idle
  WorkingDirectory=/home/pi/tessie/node/test1
  ExecStart=/usr/bin/node /home/pi/tessie/node/test1/server3.js
  ```

```
[Install]
WantedBy=multi-user.target
```

- *Configure nginx* This optional section allows connecting to `http://coldbox03` instead of `http://coldbox03:3000`. Create the `nginx` configuration file with the command `sudo nano /etc/nginx/sites-available/default` and replace the contents of the file with the following contents

  ```
  server {
      listen 80;
      server_name coldbox03.psi.ch;

      location / {
          proxy_pass http://localhost:3000;
          proxy_http_version 1.1;
          proxy_set_header Upgrade $http_upgrade;
          proxy_set_header Connection 'upgrade';
          proxy_set_header Host $host;
          proxy_cache_bypass $http_upgrade;
      }
  }
  ```

  Do change `coldbox03.psi.ch` to your coldbox hostname and domain! Be careful when copy-pasting the inverted commas! Start the service with

  ```
  sudo service nginx start
  ```

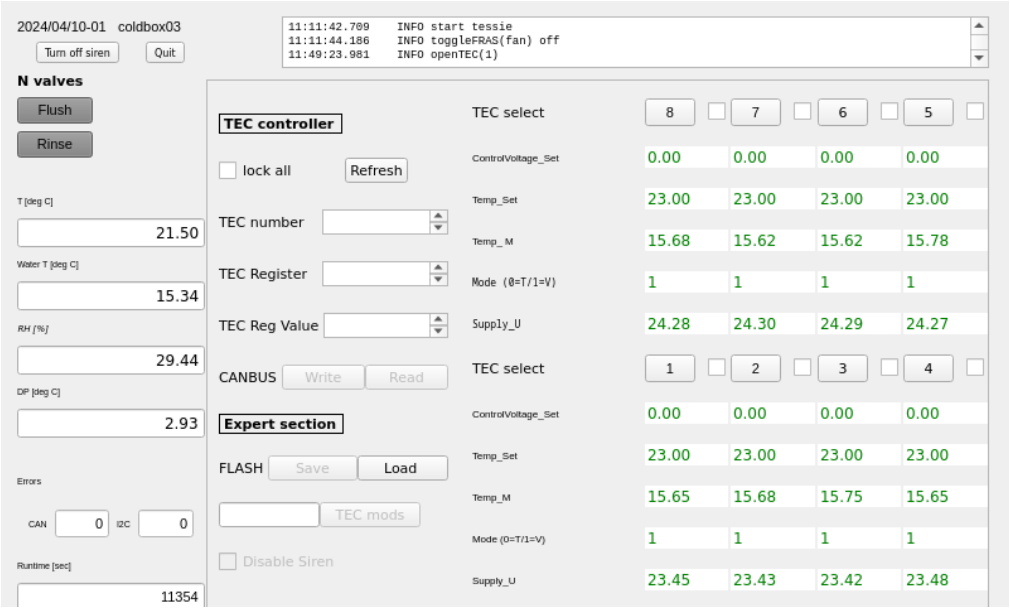
- *Startup services* Now enable the startup of the two low-level components at boot time plus tessie and its webserver

  ```
  sudo systemctl enable pigpiod
  sudo systemctl enable mosquitto.service

  sudo systemctl enable tessie.service
  sudo systemctl enable tessieWeb.service
  ```

  You can always monitor the status of these ”services” with

  ```
  systemctl status tessie
  systemctl status tessieWeb
  ```

Now reboot the system, e.g., with `sudo shutdown -r now`. If the shutdown process gets stuck, hit the central power button. If all goes well, the touchscreen of the Raspberry Pi will show the GUI featured in Fig. 2. You can connect from any PC.
The normal manual way to interact with `tessie` is through a webbrowser. Point your favorite browser to `http://coldbox03`, cf. Fig 3.



2024/04/10-01 coldbox03

```
11:11:42.709    INFO start tessie
11:11:44.186    INFO toggleFRAS(fan) off
11:49:23.981    INFO openTEC(1)
```

T [deg C]: 21.50

Water T [deg C]: 15.34

RH [%]: 29.44

DP [deg C]: 2.93

Errors: CAN 0, I2C 0

Runtime [sec]: 11354

TEC select	8 □	7 □	6 □	5 □
ControlVoltage_Set	0.00	0.00	0.00	0.00
Temp_Set	23.00	23.00	23.00	23.00
Temp_M	15.68	15.62	15.62	15.78
Mode (0=T/1=V)	1	1	1	1
Supply_U	24.28	24.30	24.29	24.27

TEC select	1 □	2 □	3 □	4 □
ControlVoltage_Set	0.00	0.00	0.00	0.00
Temp_Set	23.00	23.00	23.00	23.00
Temp_M	15.65	15.68	15.75	15.65
Mode (0=T/1=V)	1	1	1	1
Supply_U	23.45	23.43	23.42	23.48

Figure 2: The GUI appearing on the Raspberry Pi touch screen.

3 Upgrades

3.1 `tessie` Upgrades

Upgrading `tessie` is straightforward in a terminal:

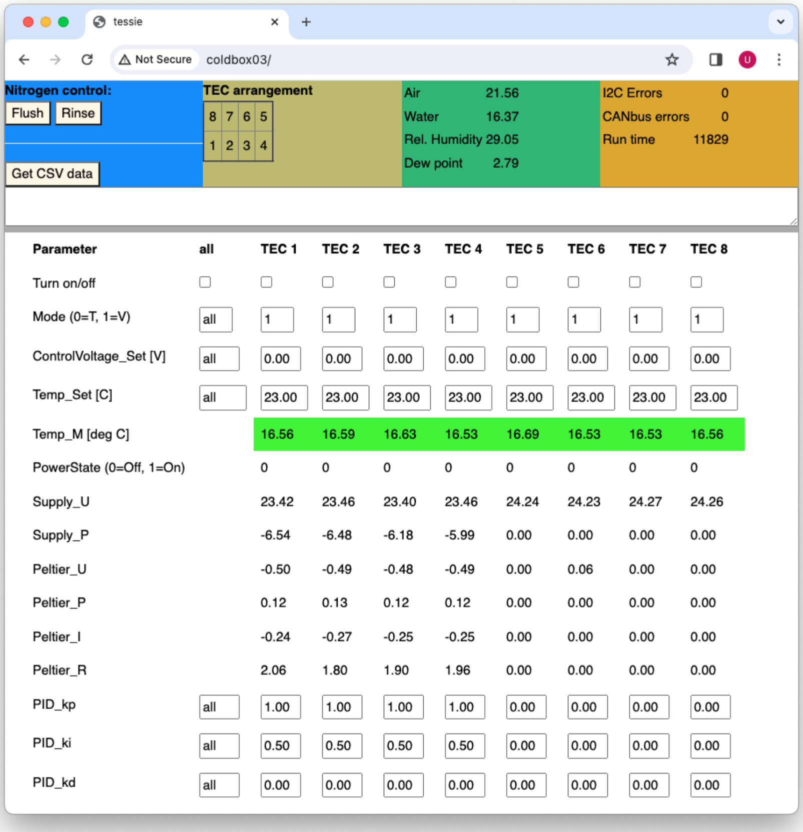
```
cd /home/pi/tessie
git pull
git checkout "tags/2024/04/10-01"
cd test1

qmake -o Makefile  test1.pro
make -j2
```

The command git checkout "tags/2024/04/10-01" is not compulsory, and you can work with the HEAD of the master branch (which is what you get when simplying cloning the repository). However, for production systems, it is better to work with a specific tag (in this example '2024/04/10-01'). Note the git message about being in 'detached HEAD' state. Unless you intend to do code development, you can safely ignore it. If you want to do code development and commit your changes, read the rest of the warning message and do as told.
To make the changes take effect, it is sufficient to restart the `tessie` service:

```
sudo systemctl restart tessie
```

There is no need to restart the web service `tessieWeb`.
Alternatively, you can reboot the coldbox, either by turning it off/on (pressing the central power button) or in a terminal:

```
sudo shutdown -r now
```



Nitrogen control:

TEC arrangement

8	7	6	5
1	2	3	4

Air	21.56
Water	16.37
Rel. Humidity	29.05
Dew point	2.79

I2C Errors	0
CANbus errors	0
Run time	11829

Parameter	all	TEC 1	TEC 2	TEC 3	TEC 4	TEC 5	TEC 6	TEC 7	TEC 8
Turn on/off	□	□	□	□	□	□	□	□	□
Mode (0=T, 1=V)	all	1	1	1	1	1	1	1	1
ControlVoltage_Set [V]	all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Temp_Set [C]	all	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Temp_M [deg C]		16.56	16.59	16.63	16.53	16.69	16.53	16.53	16.56
PowerState (0=Off, 1=On)		0	0	0	0	0	0	0	0
Supply_U		23.42	23.46	23.40	23.46	24.24	24.23	24.27	24.26
Supply_P		-6.54	-6.48	-6.18	-5.99	0.00	0.00	0.00	0.00
Peltier_U		-0.50	-0.49	-0.48	-0.49	0.00	0.06	0.00	0.00
Peltier_P		0.12	0.13	0.12	0.12	0.00	0.00	0.00	0.00
Peltier_I		-0.24	-0.27	-0.25	-0.25	0.00	0.00	0.00	0.00
Peltier_R		2.06	1.80	1.90	1.96	0.00	0.00	0.00	0.00
PID_kp	all	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
PID_ki	all	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
PID_kd	all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 3: Web graphical interface to `tessie`. The top right brown-yellow box will turn red in case the connection to `tessieWeb` is interrupted.

In both cases, you can verify the update by comparing the version string of the GUI displayed on the Raspberry Pi's touch screen.

3.2 TEC firmware upgrades

FIXME

4 Operations

4.1 Traffic Lights

Three lights are used for a visual display of the operations status of the coldbox, cf. Table 1.

4.2 Safe operations limits

Table 1: Traffic light display of the `tessie` status.

Color	**Meaning**
Green	Safe to open the box, all environmental parameters in safe range.
Yellow static	At least one `TEC` turned on (e.g., during a test)
Yellow blinking	No `TEC` turned on, but not safe to open the box.
Red	Alarm raised.

References

[1] Urs Langenegger, “tessie”. https://github.com/ursl/tessie.

[2] Steve Corrigan, “Introduction to the Controller Area Network (CAN)”. https://www.ti.com/lit/an/sloa101b/sloa101b.pdf.

[3] Jonathan Valdez, Jared Becker, “Understanding the I2C Bus”. https://www.ti.com/lit/an/slva704/slva704.pdf.

[4] MQTT.org, “MQTT: The Standard for IoT Messaging”. https://mqtt.org/.

[5] Noah Piqué, “Coldbox assembly manual”. https://psi-lab.docs.cern.ch/coldbox/assembly/.

[6] Raspberry Pi OS, “Raspberry Pi Imager”. https://www.raspberrypi.com/software/.