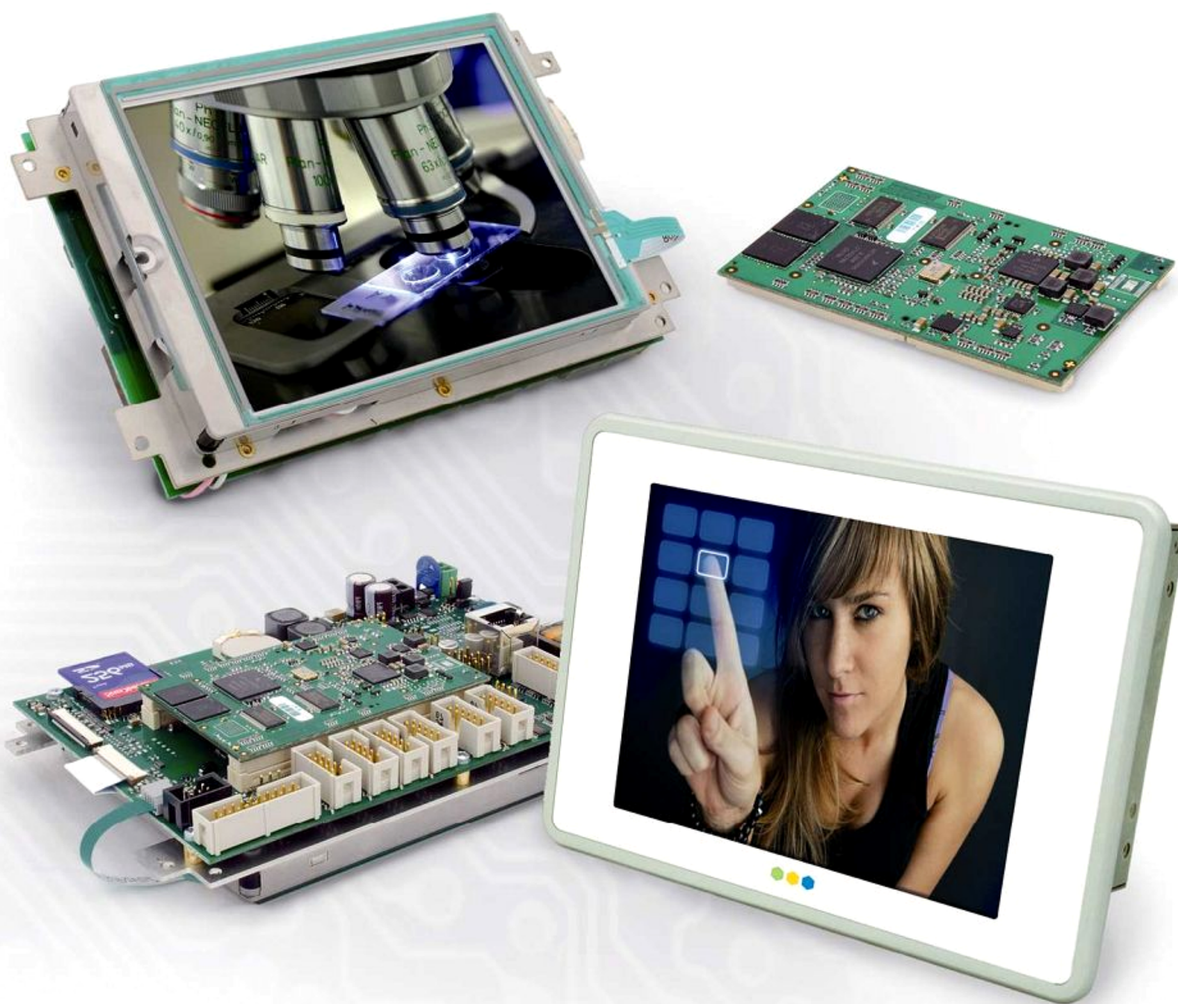
GARZ FRICKE

Embedded Systems

# Garz & Fricke

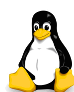
Embedded Computer Systems



# Yocto · User Manual

GUF-Yocto-jethro-4.1-r6741-0 · i.MX6
Built on 13.09.2016

freescale Enabled



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# 1 Introduction

Garz & Fricke systems based on **Freescale i.MX6** can be used with an adapted version of Linux, a royalty-free open-source operating system. The Linux kernel as provided by Garz & Fricke is based on extensions by Freescale that currently have not been contributed back into the mainline kernel. Furthermore, Garz & Fricke has made several modifications and extensions to the kernel which are currently not contributed back to the mainline kernel as well. Nevertheless, the full source code is available as a board support package (BSP) from Garz & Fricke.

A Garz & Fricke device normally comes with a pre-installed Garz & Fricke Linux operating system. However, since Linux is an open source system, the user is able to build the complete BSP from source, modify it according to his needs and replace the pre-installed Linux system with a custom one.

This manual contains information about the usage of the Garz & Fricke Linux operating system for **i.MX6**, as well as the build process of the Garz & Fricke Linux BSP and the integration of custom software components. The BSP can be downloaded from the Garz & Fricke support server:

- http://support.garz-fricke.com/projects/Santaro/Linux-Yocto/Releases/

It does not include the complete source code to all packages. Instead, several external packages are downloaded from third party online sources and from the Garz & Fricke packages mirror during the build process: If third party souces are not available anymore at the former location there should be a backup available at:

- http://support.garz-fricke.com/mirror

Modifications to these packages are provided as source code patches, which are part of the BSP.

Please note that Linux development at Garz & Fricke is always in progress. Thus, there are new releases of the BSP at irregular intervals. Due to differences between the various Linux BSP platforms and versions, a separate manual is available for every platform/version. To avoid confusion, the version number of the manual exactly matches the BSP version number.

In addition to this manual, please also refer to the dedicated hardware manuals which can be found on the Garz & Fricke website as well.

# 2 Overview

A Garz & Fricke Linux System generally consists of four basic components:

- the bootloader
- the Linux kernel
- the root file system
- the device configuration

These software components are usually installed on separate partitions on the backing storage of the embedded system.

Newer Garz & Fricke devices are shipped with a separate small ramdisk-based Linux system called **Flash-N-Go System** which is installed in parallel to the main operating system. The purpose of Flash-N-Go is to provide the user a comfortable and secure update mechanism for the main operating system components.

## 2.1 The bootloader

There are several bootloaders available for the various Linux platforms in the big Linux world. For desktop PC Linux systems, GRUB or LILO are commonly used. Those bootloaders are started by hardwired PC-BIOS.

Embedded Systems do not have a PC-like BIOS. In most cases they are started from raw flash memory or an eMMC device. For this purpose, there are certain open source boot loaders available, like RedBoot, U-Boot or Barebox. Furthermore, Garz & Fricke provides its own bootloader called **Flash-N-Go Boot** for its newer platforms (e.g. SANTARO).

i.MX6 uses the bootloader **Flash-N-Go Boot**.

## 2.2 The Linux kernel

The Linux OS kernel includes the micro kernel specific parts of the Linux OS and several internal device and subsystem drivers.

## 2.3 The root file system

The root file system is simply a file system. It contains the Linux file system hierarchy folders and files. Depending on the system configuration, the root file system may contain:

- system configuration files
- shared runtime libraries
- dynamic device and subsystem drivers - so called **loadable kernel modules** - in contrast to kernel-included device and subsystem drivers
- executable programs for system handling
- fonts
- etc.

Usually, a certain standard set of runtime libraries can be found in almost every Linux system, including standard C/C++ runtime libraries, math support libraries, threading support libraries, etc.

Embedded Linux systems principally differ in dealing with the graphical user interface (GUI). The following list gives some examples for GUI systems that are commonly used in embedded Linux systems:

- no GUI framework
- Qt Embedded on top of a Linux frame buffer device
- Qt Embedded on top of DirectFB graphics acceleration library
- Qt Embedded on top of an X-Server
- GTK+ on top of DirectFB graphics acceleration library
- GTK+ on top of a X-Server
- Nano-X / Microwindows on top of a Linux frame buffer device

Some system may additionally be equipped with a window manager of small footprint or a desktop system like KDE ore GNOME. However, in practice most embedded Linux Systems are running only one GUI application and a desktop system generates useless overhead.

i.MX6 is equipped with **Qt5 on top of a X-Server**.

## 2.4 The partition layout

As already stated in chapter [▶ 2 Overview], the different components of the embedded Linux system are stored in different partitons of the backing-storage. The backing-storage type of i.MX6 is eMMC. In addition to the partitions for the basic Linux components there may be some more partitions depending on the system configuration.

The partition layout for the i.MX6 platform is:

| Partition | File System | Contents |
|---|---|---|
| mmcblk0boot0 | none | bootloader image |
| mmcblk0boot1 | FAT32 | XML configuration parametes (config.xml) and touchscreen configuration (ts.conf) |
| mmcblk0p1 | FAT32 | Linux kernel image file (linuximage), bootloader command file (boot-alt.cfg) and Flash-N-Go ramdisk file (root.cpio.gz) |
| mmcblk0p2 | FAT32 | Linux kernel image file (linuximage), the devicetree file (*.dtb) and the bootloader command file (boot.cfg) for the Garz & Fricke Linux system |
| mmcblk0p3 | ext3 | root file system |

Flash-N-Go Boot can start the following Linux kernel image types:

- **zImage** compressed image
- **uImage** compressed image with u-boot header
- **Image** uncompressed image

## 2.5 Further information

For readers who are not familar with Linux in general, the following link may be helpful:

▶ http://tldp.org/LDP/intro-linux/html

Information regarding embedded Linux systems can be found in the following book:

- "Building Embedded Linux systems 2nd Edition", Karim Yaghmour, John Masters, Gilad Ben-Yossef, Philippe Gerum, O'Reilly, 2008, ISBN: 978-0-596-52968-0

Information regarding Linux infrastructure issues in general can be found at:

▶ http://tldp.org/LDP/Pocket-Linux-Guide/html
▶ http://www.linuxfromscratch.org

Information about Qt/Embedded can be found at:

▶ http://directfb.org

Information about the X window system can be found at:

▶ http://www.freedesktop.org

Information about Qt/Embedded can be found at:

▶ http://qt-project.org

Information about Nano-X / Microwindows can be found at:

▶ http://www.microwindows.org

Information about GTK+ can be found at:

▶ http://www.gtk.org

Information about U-Boot can be found at:

▶ http://www.denx.de/wiki/U-Boot

Information about the RedBoot can be found at:

- http://ecos.sourceware.org/docs-latest/redboot/redboot-guide.html

Information about the Yocto Project can be found at:

- https://www.yoctoproject.org

Documentation of the Yocto Project can be found at:

- https://www.yoctoproject.org/documentation/current

# 3 Accessing the target system

A Garz & Fricke hardware platform can be accessed from a host system using the following technologies:

- **Serial console** console access over RS-232
- **Telnet** console access over Ethernet
- **SSH** encrypted console access and file transfer over Ethernet
- **TFTP** file downoad over Ethernet
- **SFTP** file upload and download over Ethernet

Each of the following chapters describes one of these possibilities and, where applicable, gives a short example of how to use it. For all examples, the Garz & Fricke target system is assumed to have the IP address 192.168.1.1.

## 3.1 Serial console

The easiest way to access the target is via the serial console. There are two way to connect the serial console:

- RS232 on Molex Micro-Fit connector
- Virtual console over USB

To use the RS232 connection, connect the first RS232 port of your target system using to a COM port of your PC or a USB-to-RS232 converter using a null modem cable.

For a working connection, the signals TXD and RXD have to be connected **cross-over** in the same way like a null modem cable does. The location of the RS232 connector and the necessary pins can be found in [▶ Figure 1], [▶ Figure 2] below. If you received your system as part of a starter kit, this kit should also contain a cable to be used for this connection.

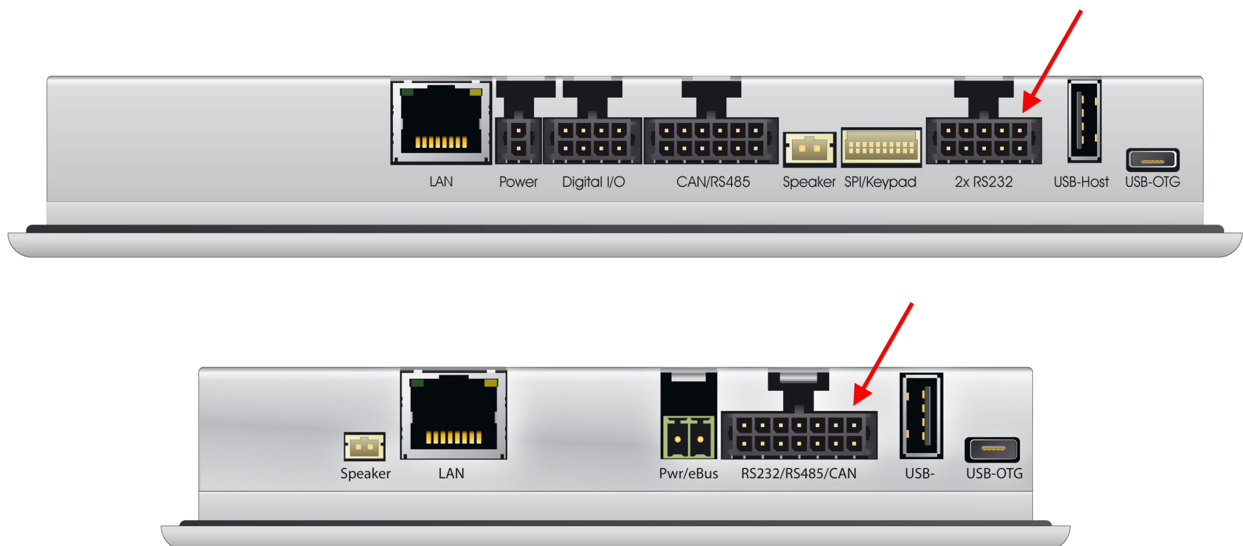


Figure 1: Location of the RS232 connector on a 7" device (upper) and on a 5" device (lower)

| Pin | Name | Description |
|---|---|---|
| 1 | GND | Ground |
| 2 | RS232_TXD1 | Port#1: Transmit data (Output) |
| 3 | RS232_RXD1 | Port#1: Receive data (Input) |
| 4 | RS232_RTS1 | Port#1: Request-to-send (Output) |
| 5 | RS232_CTS1 | Port#1: Clear-to-send (Input) |

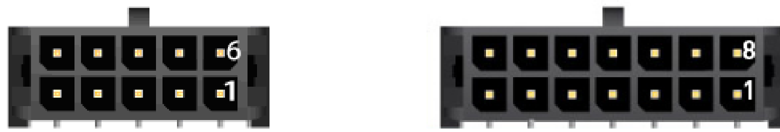


Figure 2: Pinning of the RS232 connector on a 7" device (left) and on a 5" device (right)

To use the serial console provided over USB, connect a Micro-USB cable to the USB-OTG connector of the target. When this USB cable is connected to a Windows PC, a driver is installed and a new COM port is created. Its name can be seen in the device manager.

**Note:** Although the serial connection over USB is easy to setup, there are some disadvantages over the RS232 connection: The output of the bootloader and the boot messages are not shown. The first thing you see is the login shell. This way it is not ideal for system updates.

With the serial connection set up start your favourite terminal program (e.g. minicom) with the following settings:

- 115200 baud
- 8 data bits
- no parity
- 1 stop bit
- no hardware flow control
- no software flow control

If you are using the RS232 connection, you should see debug messages in the terminal from the very first moment when the target is powered. After the boot process has finished, you will see the Linux login shell:

```
Garz & Fricke Yocto BSP (based on Poky) @VERSION@ santaro /dev/ttymxc0

santaro login:
```

You can log in as user **root** without any password by default.

## 3.2 SSH console

Using SSH, you can access the console of the device and copy files to or from the target. Please note that SSH must be installed on the host system in order to gain access.

To login via SSH, type on the host system:

```
$ ssh root@192.168.1.1
```

The first time you access the target system from the host system, the target is added to the list of known hosts. You have to confirm this step in order to establish the connection.

```
The authenticity of host '192.168.1.1 (192.168.1.1)' can't be established.
RSA key fingerprint is e5:86:89:19:50:a5:46:52:15:35:e5:0e:d2:d1:f9:62.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.1.1' (RSA) to the list of known hosts.
root@santaro:~#
```

To return to your host system's console, type:

```
root@santaro:~# exit
```

You can use **secure copy (scp)** on the device or the host system to copy files from or to the device.

**Example**: To copy the file **myapp** from the host's current working directory to the target's **/usr/bin** directory, type on the host's console:

```
$ scp ./myapp root@192.168.1.1:/usr/bin/myapp
```

To copy the target's **/usr/bin/myapp** file back to the host's current working directory, type:

```
$ scp root@192.168.1.1:/usr/bin/myapp ./myapp
```

## 3.3 Telnet console

Telnet can be used to access the console. Please note that Telnet must be installed on the host system in order to gain access.

To login via Telnet, type on the host system:

```
$ telnet 192.168.1.1
```

The login prompt appears and you can login with username and password:

```
Trying 192.168.1.1...
Connected to 192.168.1.1.
Escape character is '^]'.
santaro login: root
Password: [Enter password]
root@santaro:~#
```

## 3.4 Uploading files with TFTP

You can copy files from the host system to the target system using the target's TFTP client. Please note that a TFTP server has to be installed on the host system. Usually, a TFTP server can be installed on every Linux distribution. To install the TFTP server under Debian based systems with apt, the following command must be executed on the host system:

```
$ sudo apt-get install xinetd tftpd tftp
```

The TFTP server must be configured as follows in the **/etc/xinetd.d/tftpd** file on the host system in order to provide the directory **/srv/tftp** as TFTP directory:

```
service tftp
{
    protocol        = udp
    port            = 69
    socket_type     = dgram
    wait            = yes
    user            = nobody
    server          = /usr/sbin/in.tftpd
    server_args     = /srv/tftp
    disable         = no
}
```

The **/srv/tftp** directory must be created on the host system with the following commands:

```
$ sudo mkdir /srv/tftp
$ sudo chmod -R 777 /srv/tftp
$ sudo chown -R nobody /srv/tftp
```

After the above modification the xinetd must be restarted on the host system with the new TFTP service with the following command:

```
$ sudo service xinetd restart
```

From now on, you can access files in this directory from the target.

**Example:** Copying the file **myapp** from the host system to the target's **/usr/bin** directory. To achieve this, first copy the file **myapp** to your TFTP directory on the host system:

```
$ cp ./myapp /srv/tftp/
```

The host system is assumed to have the ip address **192.168.1.100**. On the target system, type:

```
root@santaro:~# tftp -g 192.168.1.100 -r myapp -l /usr/bin/myapp
```

## 3.5 Uploading files with SFTP

You can exchange files between the host system and the target system using an SFTP (Secure FTP) client on the host system. Simply choose your favourite SFTP client (e.g. FileZilla) and connect to **sftp://192.168.1.1** with user root and no password.

# 4 Services and utilities

The Garz & Fricke Linux BSP includes several useful services for flexible application handling. Some of them are just run-once services directly after the OS has been started, others are available permanently.

## 4.1 Services

The services on Garz & Fricke Yocto Linux systems are usually started with start scripts. This is a very common technique on Linux systems. Yocto uses the **/etc/init.d/rc** script for this purpose. This script is run by the **init** process after parsing the **/etc/inittab** file:

```
[...]
# The default runlevel.
id:5:initdefault:

# Boot-time system configuration/initialization script.
# This is run first except when booting in emergency (-b) mode.
si::sysinit:/etc/init.d/rcS

# What to do in single-user mode.
~~:S:wait:/sbin/sulogin

# /etc/init.d executes the S and K scripts upon change
# of runlevel.
#
# Runlevel 0 is halt.
# Runlevel 1 is single-user.
# Runlevels 2-5 are multi-user.
# Runlevel 6 is reboot.

l0:0:wait:/etc/init.d/rc 0
l1:1:wait:/etc/init.d/rc 1
l2:2:wait:/etc/init.d/rc 2
l3:3:wait:/etc/init.d/rc 3
l4:4:wait:/etc/init.d/rc 4
l5:5:wait:/etc/init.d/rc 5
l6:6:wait:/etc/init.d/rc 6
[...]
```

As the comments in the file tell, the first script to be run on boot is **/etc/init.d/rcS**, which executes all start scripts in **/etc/rcS.d**. Afterwards, the default runlevel (5) is entered, which makes the start scripts in **/etc/rc5.d** being executed.

All scripts starting with the character **S** are executed with the argument **start** appended, while all scripts starting with the character **K** are executed with the argument **stop** appended. Furthermore, the naming convention states that the **S**/**K** character is followed by a number which determines the (numeric) execution order.

The actual scripts live in the directory **/etc/init.d** (e.g. **/etc/init.d/myapp**) while the **/etc/rc*** folders contain links to those scripts (e.g. **/etc/rc5.d/S95myapp**).

Those script having the following basic layout, though not all scripts in the image contain the header between **### BEGIN** and **### END**. Further documentation for the script format can be found here:

- https://wiki.debian.org/LSBInitScripts .

```
#!/bin/sh
### BEGIN INIT INFO
# Provides:          myapp
# Required-Start:    $all
# Required-Stop:
# Default-Start:     2 3 4 5
# Default-Stop:      0 1 6
# Short-Description: Start myapp at boot time
# Description:
### END INIT INFO
```

```
. /etc/profile

case "$\$$1" in
start)
        # Add here command that should execute during system startup.
        ;;
stop)
        # Add here command that should execute during system shutdown.
        ;;
*)
        echo "Usage: ... " >&2
        exit 1
        ;;
esac
```

To create the startup links, put the above script into **/etc/init.d/myapp** execute:

```
root@gufboardll:~# update-rc.d myapp defaults 95 05
 Adding system startup for /etc/init.d/myapp.
```

Here **95** is the startup level (late) and **05** is the stop level (early). If those numbers are omitted the level are determined by the dependencies given in the header of the init script.

Make sure the executable bit is set with:

```
root@gufboardll:~# chmod +x /etc/init.d/myapp
```

It is also possible to create the individual links with:

```
root@gufboardll:~# ln -s  /etc/init.d/myapp /etc/rc5.d/S95myapp
```

A service is disabled using:

```
root@gufboardll:~# update-rc.d -f myapp remove
update-rc.d: /etc/init.d/myapp exists during rc.d purge (continuing)
 Removing any system startup links for myapp ...
  /etc/rc0.d/K20myapp
  /etc/rc1.d/K20myapp
  /etc/rc2.d/S20myapp
  /etc/rc3.d/S20myapp
  /etc/rc4.d/S20myapp
  /etc/rc5.d/S20myapp
  /etc/rc6.d/K20myapp
```

In chapter [▶ 7.5 Autostart mechanism for user applications] this mechanism will be used for automatic application start up.

#### 4.1.1 Udev

The **udev** service dynamically creates the device nodes in the **/dev** directory on system start up, as they are reported by the Linux kernel.

Furthermore, udev is user-configurable to react on asynchronous events from device drivers reported by the Linux kernel like hotplugging. The according rules are located in the root file system at **/lib/udev/rules.d**.

Additionally, udev is in charge of loading firware if a device driver requests it. Drivers that use the firmware subsystem have to place their firmware in the folder **/lib/firmware**.

The udev service has a startup link that points to the corresponding start script:

- **/etc/rcS.d/S04udev -> /etc/init.d/udev**

Udev can be configured in **/etc/udev/udev.conf**.

More information about udev can be found at:

- https://www.kernel.org/pub/linux/utils/kernel/hotplug/udev/udev.html

#### 4.1.2 D-Bus

The **dbus** service is a message bus system, a simple way for applications to communicate with each another. Additionally, D-Bus helps coordinating the process lifecycle: it makes it simple and reliable to code a **single instance** application or daemon, and to launch applications and daemons on demand when their services are needed.

Garz & Fricke systems are shipped with dbus bindings for glib and Qt. Therefore, the corresponding APIs can be used for application programming. Furthermore, Garz & Fricke systems are configured to support **HALD** that allows to detect hotplugging events in applications asynchronously.

The dbus service has a startup link that points to the corresponding start script:

- **/etc/rc5.d/S02dbus-1 -> /etc/init.d/dbus-1**

More information about dbus can be found at:

- http://www.freedesktop.org/wiki/Software/dbus

More information about the Qt dbus bindings can be found at:

- http://qt-project.org/doc/qt-4.7/intro-to-dbus.html

More information about the glib dbus bindings can be found at:

- http://dbus.freedesktop.org/doc/dbus-glib

#### 4.1.3 SSH service

The **ssh** service allows the user to log in on the target system. Futhermore, the SFTP and SCP functionalities are activated to allow secure file transfers. The communication is encrypted.

The ssh service has a startup link that points to the corresponding start script:

- **/etc/rc5.d/S09sshd -> /etc/init.d/openssh**

The startup script simply starts **/usr/sbin/sshd** as a daemon. The sshd configuration can be found in the target's root file system at **/etc/ssh/sshd_config**.

More information about OpenSSH can be found at:

- http://www.openssh.org

**Login** Garz & Fricke devices are configured to use passwords for authentication also on the ssh service. As there is no password set for root by default, this is a widely open door for attackers. See the [▶ 10 Securing the device] chapter how to handle this issue.

**SSH Keys** The Garz & Fricke yocto images are containing default SSH Keys that are the same on every image. Those keys are used to identify the device when connecting to it from a remote host, to make sure you send your password to the correct device ( and not some Man-in-the-middle ). To make use of this feature you should generate your own keys with:

```
root@gufboardll:~# rm /etc/ssh/ssh_host_*key*
root@gufboardll:~# /etc/init.d/sshd restart
  generating ssh RSA key...
  generating ssh ECDSA key...
  generating ssh DSA key...
```

```
  generating ssh ED25519 key...
Restarting OpenBSD Secure Shell server: sshdstopped /usr/sbin/sshd (pid 1108)
root@gufboardll:~# ll /etc/ssh/*key*
-rw-------    1 root     root          668 Sep 23 13:06 /etc/ssh/ssh_host_dsa_key
-rw-r--r--    1 root     root          607 Sep 23 13:06 /etc/ssh/ssh_host_dsa_key.
    ↪ pub
-rw-------    1 root     root          227 Sep 23 13:06 /etc/ssh/ssh_host_ecdsa_key
-rw-r--r--    1 root     root          179 Sep 23 13:06 /etc/ssh/ssh_host_ecdsa_key.
    ↪ pub
-rw-------    1 root     root          411 Sep 23 13:06 /etc/ssh/
    ↪ ssh_host_ed25519_key
-rw-r--r--    1 root     root           99 Sep 23 13:06 /etc/ssh/
    ↪ ssh_host_ed25519_key.pub
-rw-------    1 root     root         1675 Sep 23 13:06 /etc/ssh/ssh_host_rsa_key
-rw-r--r--    1 root     root          399 Sep 23 13:06 /etc/ssh/ssh_host_rsa_key.
    ↪ pub
root@gufboardll:~#
```

For more information see the official OpenSSH documentation. The ssh keys can also be used as replacement for the password authentication of the remote user. Please see the official documention for this feature.

**SFTP only with restricted folder visibility** Sometimes it is enough, when a remote user is able to download log files or change config files in one specific folder. To reduce the security risk of a open remote service, it is possible to restrict the ssh service access to the SFTP feature, locking the user into for example his home folder. Folowing steps are needed for setup:

Create the user:

```
root@santaro:~# adduser service
```

Change the owner of his home directory to root (needed by sftp changeroot):

```
root@santaro:~# chown -R root:service  /home/service
```

Edit the ssh config:

```
root@santaro:~# /etc/ssh/sshd_config
```

In the config file, change the sftp subsystem:

```
# override default of no subsystems
# Subsystem      sftp     /usr/lib/openssh/sftp-server
Subsystem sftp internal-sftp
```

And append the following to the configuration:

```
Match User service
        ChrootDirectory /home/service
        ForceCommand internal-sftp
        AllowTCPForwarding no
        X11Forwarding no
```

Now it is possible to use for example filezilla to access the device with the new user and its password but the root folder shown in filezilla is the home folder on the device.

**Note:** By default the user is also able to login using telnet or the serial console with access to the complete root filesystem. If this is not desired, further configuration steps are needed.

### 4.1.4 Telnet service

The telnet service allows the user to log in on the target system.

**Note:** Due to the fact that telnet does not use encryption, it is recommended to deactivate this service in final products in order to avoid security leaks. Disabling services is described in the chapter [▶ 4.1 Services].

The telnet service has a startup link that points to the corresponding start script:

- /etc/rc.d/S20telnet -> /etc/init.d/telnet

The startup script simply starts /usr/sbin/telnetd as a daemon. The usage of telnetd is shown by executing:

```
root@santaro:~# telnetd --help
BusyBox v1.22.1 (2015-09-17 20:08:55 CEST) multi-call binary.

Usage: telnetd [OPTIONS]
```

Following options are available and configured directly in the start script /etc/init.d/telnet:

```
Options:
        -l LOGIN        Exec LOGIN on connect
        -f ISSUE_FILE   Display ISSUE_FILE instead of /etc/issue
        -K              Close connection as soon as login exits
                        (normally wait until all programs close slave pty)
        -p PORT         Port to listen on
        -b ADDR[:PORT]  Address to bind to
        -F              Run in foreground
        -i              Inetd mode
        -w SEC          Inetd 'wait' mode, linger time SEC
        -S              Log to syslog (implied by -i or without -F and -w)
```

### 4.1.5 Module loading

The **modules** service is responsible for external module loading at system startup. It has a startup link that points to the corresponding start script:

- /etc/rcS.d/S05modutils.sh -> /etc/init.d/modutils.sh

The startup script simply looks which modules are listed in /etc/modules and loads them using /sbin/modprobe.

To ensure that the module loading works correctly, the module dependencies in /lib/modules/<kernel version>/modules.dep have to be consistent.

### 4.1.6 Network initialization

The **network initialization** service is responsible for initializing all network interfaces at system startup. Garz & Fricke systems use ifplugd to detect if an ethernet cable or an WLAN stick is plugged.

The network interfaces are listed on the target system in the configuration file /etc/network/interfaces. On conventional Linux systems, the user configures the network interfaces by hand using this file. On Garz & Fricke systems, there is a service called **sharedconf** as described in [▶ 4.1.8 Garz & Fricke shared configuration] that generates this file automatically according to the settings in the global XML configuration.

If the user wants to change the network settings, it is recommended to use the **sconfig** script as described in [▶ 4.2.1 Garz & Fricke system configuration].

**Note:** Changes that are made to /etc/network/interfaces directly will be overwritten by the sharedconf service on the next system startup and have no effect.

### 4.1.7 Watchdog

Generally a watchdog is a subsystem that monitors the system state in some way and executes a reset when a malfunction is detected.

The watchdog service is built of a hardware watchdog device and a linux service.

The hardware watchdog device on SANTAROis capable to execute a hardware reset when not triggered in time. The device node for the hardware watchdog is /dev/watchdog.

The watchdog service is able to monitor different system parameters, like the system load, and can take different actions if any system parameter is out of a defined range. Those repair actions can be simple cleanup scripts or the execution of a reboot or shutdown.

The service opens the hardware watchdog and triggers it regularly. When the service chrashes or the execution of a repair script fails, the hardware watchdog isn't triggered in time and a hardware reset will be executed.

The default state of the service is **disabled**.

The service can be started by executing:

```
root@santaro:~# /etc/init.d/watchdog.sh start
```

To start the service automatically on startup, create the startup links with:

```
root@santaro:~# update-rc.d  watchdog.sh defaults
```

The watchdog service is configured using the configuration file /etc/watchdog.conf:

```
#ping                   = 172.31.14.1
#ping                   = 172.26.1.255
#interface              = eth0
#file                   = /var/log/messages
#change                 = 1407

# Uncomment to enable test. Setting one of these values to '0' disables it.
# These values will hopefully never reboot your machine during normal use
# (if your machine is really hung, the loadavg will go much higher than 25)
#max-load-1             = 24
#max-load-5             = 18
#max-load-15            = 12

# Note that this is the number of pages!
# To get the real size, check how large the pagesize is on your machine.
#min-memory             = 1

#repair-binary          = /usr/sbin/repair
#repair-timeout         =
#test-binary            =
#test-timeout           =

watchdog-device = /dev/watchdog

# Defaults compiled into the binary
#temperature-device     =
#max-temperature        = 120

# Defaults compiled into the binary
#admin                  = root
#interval               = 1
#logtick                = 1
#log-dir                = /var/log/watchdog

# This greatly decreases the chance that watchdog won't be scheduled before
# your machine is really loaded
realtime                = yes
priority                = 1

# Check if rsyslogd is still running by enabling the following line
#pidfile                = /var/run/rsyslogd.pid
```

#### 4.1.8 Garz & Fricke shared configuration

The **sharedconf** service reads shared configuration settings from the XML configuration and configures the Linux system accordingly. This includes network (as described in [▶ 4.1.6 Network initialization]) and touch configuration.

The sharedconf service has a startup link that points to the corresponding start script:

- **/etc/rcS.d/S24sharedconf -> /etc/init.d/sharedconf**

#### 4.1.9 Autocopy

This service is executed after the OS has booted and when a storage medium has been inserted. It is triggered together with the the **Autostart** service (see chapter [▶ 4.1.10 Autostart]) via UDEV. **Autocopy** always runs before **Autostart**.

The **Autocopy** service provides a comfortable installation and/or update functionality as well as copy mechanism for specific files that are not included in the OS (e.g. for runtime libraries).

Subfolders and files within a folder named **autocopy** on a USB stick, SD card or in the NAND flash will be copied to the root of the device resp. its equivalent targets. Non-existing folders will be created automatically.

The autocopy mechanism includes the following components:

- **/etc/udev/rules.d/automount.rules**: UDEV rule that triggers the mount.sh script when a storage media is plugged/unplugged
- **/etc/udev/scripts/mount.sh**: Script that implements the autocopy and automount functionality.

**Example:** The user has created and application **myapp** that should be installed to **/usr/bin/myapp** on the target and a library **mylib.so** used by this application that should be installed to **/usr/lib/mylib.so**. The layout of the storage medium is shown in figure [▶ Figure 4.1.9].

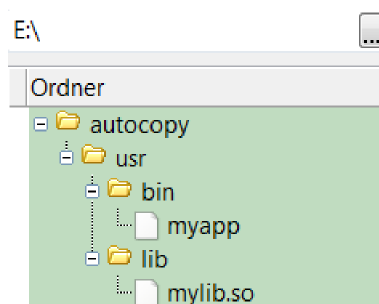


Figure 3: Layout of the storage medium after preperation with the custom files

After the target device is up and the storage media is plugged, the following message on the target's console is shown:

```
mount.sh/automount Auto-mount of [/media/sda1] successful
mount.sh/automount Found an autocopy folder. Copying files...done
```

[▶ Figure 4] illustrates what happens in background. The files are properly transferred to the target.

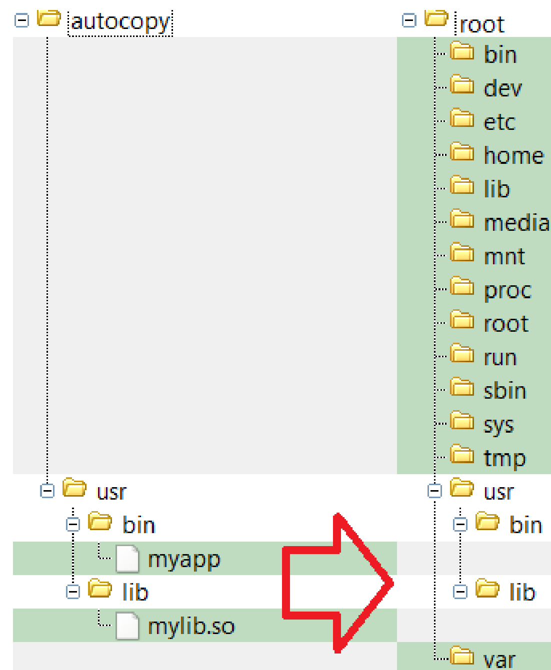


Figure 4: Automatic transfer process from storage medium (left hand) to the targets root file system (right hand) after plugging the storage

**Warning:** The user should be carefull by copying system files that may lead to an unusable system. Garz & Fricke refuses to carry responsibility for damages caused by the users copying process. Further, the user should consider to disable or restrict this mechanism to copy only carefully selected files by customizing the /etc/udev/scripts/mount.sh script in the field to prevent missuse. Again, the responsibility is up to the user.

**Enabling/Disabling:** Starting with OS Release 33 and newer the autocopy function may be enabled/disabled via XML-configuration and the sconfig tool.

For backward compatibility the autocopy function is still enabled by default if the XML-configuration contains no explicit setting for this function. To be able to configure each of the autojob functions individually, you may have to install an XML-configuration file specifying explicit state-settings for the autojob functions. At least two such configuration files are available from Garz & Fricke:

- rbcfg-enable-autojobs.xml: Enables all autojob functions (default behaviour).
- rbcfg-disable-autojobs.xml: Disables all autojob functions.

These may be installed like all other XML-configuration files via the xconfig tool, e.g.:

```
root@santaro:~# export TFTP=172.20.0.146
root@santaro:~# curl tftp://$TFTP/rbcfg-enable-autojobs.xml > /tmp/cfg.xml
root@santaro:~# xconfig import -y /tmp/cfg.xml
```

Afterwards you can query and enable/disable each autojob individually using sconfig.

Enable autocopy function:

```
root@santaro:~# sconfig autocopy all
```

Disable autocopy function:

```
root@santaro:~# sconfig autocopy off
```

Query current state of autocopy function:

```
root@santaro:~# sconfig autocopy
off
```

**Notes:**

- If sconfig replies with its usage-information you still have an OS installed, which doesn't support enabling/disabling individual autojob functions. Please update your OS in this case.
- If querying an autojob function returns no reply, at all, your XML-configuration probably doesn't contain explicit settings for the autojob functions, yet. Please install one of the provided XML-configuration files as shown above.
- The possible values of all and off have been chosen on purpose to allow future extension to enable/disable the functions for different storage media individually. When this extension will be implemented and how exactly the syntax for this will look like is still to be defined.

### 4.1.10 Autostart

The autostart service on Garz & Fricke Linux platforms uses nearly the same mechanism as autocopy described in chapter [▶ 4.1.9 Autocopy] except for the autostart specific part in /etc/udev/scripts/mount.sh.

The autostart simply searches for an autostart folder in the root directory of the storage media. If found, the executable files are executed in alphabetic order. Filenames starting with digits are executed before those starting with letters in numeric order. Files in subfolders of the autostart are ignored.

The execution of the autostart files is shown in the Linux console during start up:

```
mount.sh/automount Auto-mount of [/media/sda1] successful
mount.sh/automount Found an autostart folder. Executing files...
mount.sh/automount Executing /media/sda1/autostart/test.sh...
Finished executing autostart files
```

As already stated in [▶ 4.1.9 Autocopy] autocopy is executed before autostart.

The user may desire to autostart an application from a storage media with command line args. In this case a start script can be placed in the autostart folder that starts the aplication itself in a subfolder of autostart with the desired command line args. It is important to place the application itself in a subfolder. Otherwise the autostart mechanism will try to start this application without the command line args in parallel to the start script.

**Example:** The user created a Qt application (e.g. myapp) to run on X Server. This makes it necessary to set the environment variable DISPLAY=:0.0 before calling myapp. The application is placed e.g. in the folder /autostart/custom on the storage media. Consequently, the start script (e.g. myapp.sh) must have the following contents:

```
#!/bin/sh
export DISPLAY=:0.0
./custom/myapp
```

The start script must be placed in the folder /autostart on the storage media. The layout of the storage medium is shown in figure [▶ Figure 5].

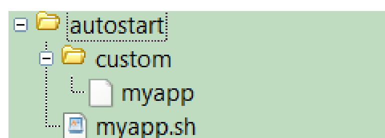


Figure 5: Layout of the storage medium after preperation with the custom files

After plugging the storage media into the target system. The start script and the apllication should start properly.

**Enabling/Disabling:** Starting with OS Release 33 and newer the autostart function may be enabled/disabled via XML-configuration and the sconfig tool.

For backward compatibility the autostart function is still enabled by default if the XML-configuration contains no explicit setting for this function. To be able to configure each of the autojob functions individually, you may have to install an XML-configuration file specifying explicit state-settings for the autojob functions. At least two such configuration files are available from Garz & Fricke:

- **rbcfg-enable-autojobs.xml**: Enables all **autojob** functions (default behaviour).
- **rbcfg-disable-autojobs.xml**: Disables all **autojob** functions.

These may be installed like all other XML-configuration files via the **xconfig** tool, e.g.:

```
root@santaro:~# export TFTP=172.20.0.146
root@santaro:~# curl tftp://$TFTP/rbcfg-enable-autojobs.xml > /tmp/cfg.xml
root@santaro:~# xconfig import -y /tmp/cfg.xml
```

Afterwards you can query and enable/disable each **autojob** individually using **sconfig**.

Enable **autostart** function:

```
root@santaro:~# sconfig autostart all
```

Disable **autostart** function:

```
root@santaro:~# sconfig autostart off
```

Query current state of **autostart** function:

```
root@santaro:~# sconfig autostart
off
```

**Notes:**

- If **sconfig** replies with its usage-information you still have an OS installed, which doesn't support enabling/disabling individual **autojob** functions. Please update your OS in this case.
- If querying an **autojob** function returns no reply, at all, your XML-configuration probably doesn't contain explicit settings for the **autojob** functions, yet. Please install one of the provided XML-configuration files as shown above.
- The possible values of **all** and **off** have been chosen on purpose to allow future extension to enable/disable the functions for different storage media individually. When this extension will be implemented and how exactly the syntax for this will look like is still to be defined.

### 4.1.11 Cron

The **cron** service allows execute commands automatically to a given time.

The crond service has a startup link that points to the corresponding start script:

- **/etc/rc5.d/S20crond -> /etc/init.d/crond**

The startup script simply starts **/usr/sbin/crond** as a daemon.

The cron task are configured with **crontab**.

```
crontab -e
```

An example script is shown in the editor and can be modified.

```
#-----------------------------------------------------------------------------------
# Shell variable for cron
SHELL=/bin/bash
# PATH variable for cron
PATH=/usr/local/bin:/usr/local/sbin:/sbin:/usr/sbin:/bin:/usr/bin:/usr/bin/X11

#-----------------------------------------------------------------------------------
# Minute   Hour   Day of Month      Month          Day of Week       Command
# (0-59)  (0-23)     (1-31)    (1-12 or Jan-Dec)  (0-6 or Sun-Sat)
#   */10     *          *              *                *            date > /root/
    ↪ crontest
#-----------------------------------------------------------------------------------
```

See the official cron documentation for syntax of this file.

## 4.2 Utilities

### 4.2.1 Garz & Fricke system configuration

The /etc/init.d/sharedconf script (see [▶ 4.1.8 Garz & Fricke shared configuration]) can be used to change the shared system configuration. For this purpose, there is a link to the script at /usr/bin/sconfig which can be called without the absolute path:

```
root@santaro:~# sconfig
```

If called without any parameters, the command prints the usage:

```
Usage: /usr/bin/sconfig {start | list | <setting> [value]}
   Call without [value] to read a setting, call with [value] to write it.
Available settings:
   serialdiag  switch serial debug console on or off
   dhcp        switch DHCP on or off
   ip          set IP address
   mask        set subnet mask
   gateway     set standard network gateway
   mac         set MAC address
   name        set device name
   serial      set serial number (affects MAC address and device name)
   rotation    set display rotation
If a 2.Ethernet is present, it may be configured via serial2, mac2, etc.
```

If the script is called with a setting as parameter, the setting is read from the XML configuration and displayed on the console. If additionally a value is appended, this value is written to the according setting in the XML configuration.

The 'name' set with sconfig is also used as hostname for the device. It defaults to GFMM<serial number>.

**Example 1:** To activate DHCP on the device, type:

```
root@santaro:~# sconfig dhcp on
```

**Example 2:** To deactivate DHCP and set a static IP address, type:

```
root@santaro:~# sconfig dhcp off
root@santaro:~# sconfig ip 192.168.1.123
```

**Note:** The settings require a reboot to take effect.

### 4.2.2 Power down mode

The system can enter a power down mode to reduce power consumption when the system is not in use. In this mode all PLLs are disabled, CPU voltages are lowered and several hardware components are powered down. The overall power consumption should be less than 500 mW in this mode but actually depends on the device and its hardware assembly option.

Power down mode is entered using the following command:

```
root@santaro:~# echo mem > /sys/power/state
```

The average time it takes to enter power down mode has been measured 364 $\pm$ 5 ms (last byte on UART RX until voltage drop on VDDSOC).

There are different possibilities to make the system wake up from the power down mode. Wakeup sources have to be configured before entering power down mode, otherwise the system cannot be woken up.

**RTC:** The CPU internal RTC can be configured to wake up the system after a specified time. The following command wakes the system up at 20 seconds after the command has been executed:

```
root@santaro:~# echo +20 > /sys/class/rtc/rtc0/wakealarm
```

**RS232/RS485/MDB:** All serial interfaces can be configured to wake up the system on incoming bytes. The following command wakes the system up as soon as a byte is received on the serial debug port:

```
root@santaro:~# echo enabled > /sys/class/tty/ttymxc0/power/wakeup
```

The average time it takes to wake up from power down mode using the serial debug port has been measured 1326 $\pm$ 4 ms (first byte on UART RX until last byte on UART TX).

**Note:** The first few incoming bytes after and including the wakeup byte might be truncated and not received by the UART driver.

### 4.2.3 Reboot, Halt and Poweroff

As you probably have noticed already, none of our Garz & Fricke devices are equipped with any kind of power-button. This means, they will start booting and running an OS as soon as an external power-supply is connected and turned-on and the only way to turn the device off is to turn off the external power-supply.

The devices are not designed to be turned-off under software-control.

The common Unix/Linux utilities to shutdown the system behave accordingly:

- **reboot**: will stop all login-services, stop all running applications, flush all caches, unmount all filesystems and safely reboot the system.
- **halt**: will stop all login-services, stop all running applications, flush all caches, unmount all filesystems and just "halt" the system, so that a user may safely disconnect the power-supply without risking any data-loss.
- **poweroff**: according to Unix/Linux conventions for systems, that cannot turn-off themselves, will do just the same as **halt**.

This means, as per Linux/Unix convention for systems, that can't turn-off themselves, none of these commands will turn-off device power; not even the display power. The **halt-** and **poweroff-**commands will only ensure that the system is put in a state, where no user-processes are running anymore and all data has been written back to storage media.

If you'd like to, e.g. turn-off the display, when the **halt-** and **poweroff-**commands are issued, you may do so yourself using a start/stop-script as described in [▶ 4.1 Services].

### 4.2.4 Kernel command line

The kernel command line can be used to change some kernel features.

**Note:** Be careful changing the command line, as it can easily break the booting process of your device. If booting fails after those changes, you will need to boot into **Flash-N-Go System** and correct the settings. In this case, please refer to the **Flash-N-Go System** manual.

To change the kernel command line, the boot partition needs to be mounted.

```
mount /dev/mmcblk0p2 /mnt
```

Calling

```
nano /mnt/boot.cfg
```

will bring up the editor with the boot configurations.

The boot configuration normally looks similar to this:

```
load -b 0x13000000 -p config config.xml
load -b 0x13080000 -o logo.png
devtree -b  0x05:0x61:0x13040000 imx6-santoka-dl.dtb
devtree -b  0x05:0x63:0x13040000 imx6-santoka-q.dtb
devtree -b  0x07:0x61:0x13040000 imx6-santaro-dl.dtb
devtree -b  0x07:0x63:0x13040000 imx6-santaro-q.dtb
load linuximage
exec "console=ttymxc0,115200 root=/dev/mmcblk0p3 xmlram=0x13000000 logo=0x13080000"
```

The last line is the kernel command line. Options can be added to the end.

**Example 1:** Enable the SPI interface on the keypad connector:

```
exec "console=ttymxc0,115200 root=/dev/mmcblk0p3 xmlram=0x13000000 logo=0x13080000
    ↪ keypad=gpio,spi"
```

#### 4.2.5 Bootlogo

Garz & Fricke systems shipped with displays or HDMI controllers can show a PNG bootlogo on system start up. For this purpose, a custom PNG logo support has been added to the Linux kernel. Custom bootlogos can only be shown under one of the following conditions:

- A generic bootlogo license (XML file) is installed on the system
- The PNG logo to be shown contains a bootlogo license

Both features are subject to a license fee. Garz & Fricke offers two license models:

- The economic **basic license** contains one single PNG file, that will be signed with an invisible watermark by Garz & Fricke containing the license. This PNG can be used for all Garz & Fricke systems, independent from quantity and system type.
- The flexible **corporate license** contains a generic bootlogo license file as well as the **logolic** Windows tool. The XML file (**rb-logolicense.xml**) allows the usage of any PNG file, signed or not, which makes it easier for the end-user to modify the bootlogo. The **logolic** Windows tool enables the user to prepare a simple PNG file into a signed bootlogo PNG file. This license model is also totally independent from the quantity of operated systems.

For more information about logo licensing or the **logolic** Windows tool, please contact the Garz & Fricke sales.

**Example 1** shows how to install the generic logo license from a TFTP server with the IP address **192.168.1.100**:

```
root@santaro:~# tftp -g -r rb-logolicense.xml 192.168.1.100
root@santaro:~# xconfig import -b rb-logolicense.xml
```

Because the bootlogo has to be shown as early as possible, the Linux kernel cannot wait until the file system is up. Hence, the booloader has to pass the PNG file via a main memory area. The bootloader can be instructed to load a PNG file from one of the eMMC boot partitions. This can be done by placing the following command **before** the **exec** command in the **boot.cfg** file on **/dev/mmcblk0p2**:

```
load -b <physical memory address> [-p <partition name>] <file name>
```

Furthermore, the kernel has to be informed about the physical memory address where the file is located and the file size via the **logo** kernel command parameter. The following format has to be used:

```
logo=<physical address>
```

Apart from the above format, a display test logo can be shown with the **logo** kernel command line parameter (without any bootlogo license) as follows:

```
logo=test
```

The logo can be disabled with:

```
logo=black
```

The orientation of the bootlogo is bound to the global **rotation** system setting. The **rotation** can be adjusted with the **sconfig** tool described in [▶ 4.2.1 Garz & Fricke system configuration].

**Example 2** shows how to load a PNG bootlogo **logo.png** with a file size of **30515 bytes** to **/dev/mmcblk0p2** from a TFTP server with the IP address **192.168.1.100** and how to configure the bootloader and the kernel to pass and show this bootlogo.

First step: upload the logo.

```
root@santaro:~# mount /dev/mmcblk0p2 /mnt
root@santaro:~# tftp -g -r logo.png -l /mnt/logo.png 192.168.1.100
```

Second step: configure bootloader and kernel. Edit the file **/mnt/boot.cfg** (e.g. with **nano** or **vi**) and add the highlighted sections:

```
load -b 0x13000000 -p config config.xml
load -b 0x13080000 -o logo.png
devtree -b  0x05:0x61:0x13040000 imx6-santoka-dl.dtb
devtree -b  0x05:0x63:0x13040000 imx6-santoka-q.dtb
devtree -b  0x07:0x61:0x13040000 imx6-santaro-dl.dtb
devtree -b  0x07:0x63:0x13040000 imx6-santaro-q.dtb
load linuximage
exec "console=ttymxc0,115200 root=/dev/mmcblk0p3 xmlram=0x13000000 logo=0x13080000"
```

```
root@santaro:~# umount /mnt
```

### 4.2.6 Sendmail

The **sendmail** tool can be used to send emails from the device. The sendmail tool is based on busybox and has no configuration files. Everything is passed via command line.

The mail is passed using stdin. For a simple test, the following can be put to into mail.txt

```
From: <fromaddress@mailserver.com>
To: <toaddress@mailserver.com>
Subject: Mail Header

Hello,

This is the mail body text.
```

Note that the empty line between subject and email text is part of the mail format and needs to be preserved!

This mail can be sent with:

```
sendmail  -f <fromaddress@mailserver.com> -S <smtpserver>  <toaddress@mailserver.com>
    ↪   < mail.txt
```

The example requires an SMTP server at <smtpserver> on port 25 without authentication. For enabling authentication and encryption read the manuals for sendmail/busybox sendmail.

# 5 Add-On Packages

Some specific packages are not integrated into the prebuilt OS images provided by Garz & Fricke, but instead shipped separately as installable RPM packages. This is done to not burden the prebuilt OS images with larger packets and to allow choices, which particular version of a package to install on a specific device.

Each add-on package consists of a bunch of RPM package files. These files can be transferred to the device using any protocol or storage-medium supported by the system. The package manager in Yocto is called **smart**. Before we can install the packages, we have to register our package directory as a "channel":

```
$ smart channel -y --add tmp type=rpm-dir path=/path/to/add-on;
```

In the above command **/path/to/add-on** has to be replaced with the actual directory containing the add-on RPM files. The package manager **smart** now knows where to look for RPM packages. We can install the add-on using the **smart install** command, e.g. for the CUPS add-on we call:

```
$ smart install add-on-cups
```

Afterwards the channel should be removed again:

```
smart channel -y --remove tmp
```

Installed add-on packages are listed during the boot sequence on the serial debug console. The list can be displayed manually by calling the Garz & Fricke specific command **add-ons**:

```
$ add-ons
Installed add-ons:
 * add-on-cups-35.0+r5982+0-r0.0.all
 * add-on-chromium-35.0+r5982+0-r0.0.all
 * add-on-openjdk-35.0+r5982+0-r0.0.all
```

For a more detailed insight, installed RPM packages can be listed separately using the **rpm** command:

```
$ rpm -qa --last
```

This outputs a list of all RPM packages installed in the system, starting with the newest.

Deinstallation of an add-on works with the **add-ons remove** command:

```
$ add-ons remove add-on-cups
```

Please note that deinstallation will fail if multiple add-ons containing common packages are installed on the system. In this case, the packages have to be removed manually, either using the **smart** or the **rpm** command line tool, or the Yocto image has to be re-flashed. Please note further that removing the add-on package alone will not have any effect, since the add-on package is basically an empty package only defining dependencies to other packages.

## 5.1 Chromium

The Chromium add-on is intended to be used for HTML-based applications starting automatically during system boot, which won't display the regular browser GUI, i.e. URL-bar, navigation buttons, etc.

### 5.1.1 Installation

The Chromium add-on is installed using the **rpm** command as described in [▶ 5 Add-On Packages]. As soon as the installation completes, Chromium should start automatically.

Note: Installing multiple different versions at the same time on a system is not supported, i.e. if you want to install a version different from the one you already may have installed on your device, you must deinstall the previous version first.

### 5.1.2 Automatic start on system boot

The prebuilt Yocto OS images provided by Garz & Fricke usually start a small Qt-based demo application automatically on system boot. The Chromium add-on package will disable the autostart of this demo application and configure the Chromium browser for autostart instead.

### 5.1.3 Manual Start/Stop of Chromium

You can start and stop Chromium during runtime with the following commands:

```
$ /etc/init.d/chromium stop
```

```
$ /etc/init.d/chromium start
```

### 5.1.4 "Kiosk"-Mode

For normal application use, Chromium is configured to start in so-called "kiosk"-mode. This means that it runs in full-screen mode without displaying the regular browser GUI, e.g. navigation buttons, URL-bar, access to the Chromium menu, etc. Only your webpage and, if necessary, scroll-bars are displayed.

For development or testing purposes you may want to use Chromium in normal-mode showing the navigation bar. You can temporarily do so by first stopping Chromium, as described above, and then calling it manually with any URL(s) and command-line options you like, e.g.:

```
$ /etc/init.d/chromium stop
$ Chromium http://www.google.com
```

This will temporarily re-start Chromium with the full GUI. Note that upon reboot of the system it will automatically start in Kiosk-mode again.

### 5.1.5 Configuration

**URL:** The Chromium packages shipped by Garz & Fricke load the Garz & Fricke webpage by default. This is intended for first demonstration purposes only, of course, and may be changed to a different URL of your choice with the following command:

```
$ echo "<Your URL>" >/etc/chromium.conf
$ sync
```

E.g. to re-configure the Garz & Fricke website as default URL to be opened, execute:

```
$ echo "http://www.garz-fricke.com" >/etc/chromium.conf
$ sync
```

**Command-Line Options:** If you want Chromium to start with command-line options different from the default configuration, please modify the file **/etc/init.d/chromium** accordingly, e.g. you may remove the **--kiosk** command-line option if you want Chromium to automatically start in normal-mode with the navigation-bar enabled.

Supplying command-line options to the **/etc/init.d/chromium start** call is not supported. You may test command-line options by starting Chromium manually, though, e.g.:

```
$ /etc/init.d/chromium stop
$ Chromium --show-fps --kiosk --incognito http://www.garz-fricke.com
```

A list of all Chromium command-line options is available here:

- http://peter.sh/experiments/chromium-command-line-switches/

Not all command-line options are supported by all versions or builds of the Chromium browser, though, and Chromium does not complain about command-line options it does not recognize, but just ignores them silently, instead.

**Disable context menu:** Garz & Fricke added a commend line option **--disable-context-menu** to prevent the context menu from appearing on the screen by a long press touch down (approx. 3s) for security reasons. This option can be added to the **/etc/init.d/chromium** options if this shall be the start up behaviour of chromium.

**Chromium Settings:** If you want to change Chromium settings, install Chromium extensions, use the Chromium developer tools, etc. you must (temporarily) start Chromium in normal-mode. These features and tools are not available in kiosk-mode

**Chromium Apps and Extensions:** When started in normal-mode you may install Chromium extensions via the Chromium menu. Please note, though, that the Chromium-Webstore, which is used to find, download and install extensions, is shared with the Chrome-Webstore you may know from the Desktop Google Chrome browser.

Chromium is the open-source part of Chrome and does not support all functions of the full Chrome browser, which unfortunately is not available for Linux-ARM systems. Due to the larger market-share of the regular PC-Chrome browser, most apps and extensions will probably be tested only on this browser and platform and may not work on the Chromium browser of Garz & Fricke devices, e.g. while the "Virtual Keyboard"-extension from xonTAB.com works on Garz & Fricke devices and is in fact currently installed by default in the Garz & Fricke Chromium package (see below), e.g. the "Google Input Tools" do not work properly on our devices.

Therefore please understand that some apps and extensions, you may want to install, may fail to work on our devices.

To install the same set of extensions (or Chromium preferences) on multiple devices, the easiest way is to configure one single device as desired and then take a "snapshot" of the device's **/root/.chromium**-folder, which can then be unpacked on any other device desired.

### 5.1.6 Soft-Keyboard

As already briefly mentioned, the Chromium RPM packages provided by Garz & Fricke come with the free "Virtual Keyboard"-extension from xonTAB.com pre-installed, because there is currently no system-wide soft-keyboard available in our Yocto-BSP, which can be used in the Chromium kiosk-mode.

More information on the xonTAB.com "Virtual Keyboard" Chromium extension can be found on the manufacturer web-page:

- http://xonTAB.com.com/Apps/VirtualKeyboard

This extension allows you to try regular web-pages without modification. This soft-keyboard will not work in the Chromium URL-bar or in any Chromium dialogs that you may open, though. It is a Javascript-based extension only intended to enter text into forms of web-pages (but may even have issues with some web-pages).

To still easily allow opening different web-pages for testing, the keyboard is configured to include an URL-button, by default. If you want to use this soft-keyboard with your HTML-application, you may want to disable this URL-button on the options-page of the extension. You can also enable/disable different international keyboard layouts (by default English and German layouts are enabled), change the soft-keyboard to a floating window, etc.

For your final HTML-based application you may want to replace the xonTAB.com "Virtual Keyboard" with a different Chromium extension providing a soft-keyboard, use other third-party Javascript-based keyboards embedded directly in your web-page without any Chromium extensions being installed, or provide your own soft-keyboard via Javascript, HTML5, etc.

Quite a lot of free third-party Javascript-based soft-keyboards to be integrated in web-pages may be found here:

- http://mottie.github.io/Keyboard

Using the Chromium URL-bar or text-input fields in Chromium dialog boxes is only supported via external USB-keyboards.

## 5.2 CUPS

The CUPS add-on adds printer support to the Garz & Fricke Yocto BSP. Please note that only a very limited number of actual printers is officially supported and tested by Garz & Fricke (see the release notes for details). If your printer supports PCL, chances are good that it will work with CUPS on Yocto. However, Garz & Fricke cannot guarantee support for any given printer except for those listed in the release notes.

### 5.2.1 Installation

The CUPS add-on is installed using the **rpm** command as described in [▶ 5 Add-On Packages]. After installation a reboot is required:

```
$ reboot
```

### 5.2.2 Configuration

CUPS provides a web front-end to configure printers. On the device itself, the MiniBrowser may be used to access the configuration page via **localhost**:

```
$ MiniBrowser http://localhost:631
```

Access to this interface can also be allowed remotely by calling:

```
$ cupsctl --remote-any
```

Assuming the device has the IP address **192.168.1.1**, afterwards the configuration interface can be displayed in any web browser running on a device in the same network by opening the URL **http://192.168.1.1:631**.

For further information on how to use CUPS, please refer to the official documentation:

- https://www.cups.org/documentation.php?VERSION=1.7

## 5.3 OpenJDK

The OpenJDK add-on adds Java support to the Garz & Fricke Yocto BSP. For information, please refer to the official documentation:

- http://openjdk.java.net/

### 5.3.1 Installation

The OpenJDK add-on is installed using the **rpm** command as described in [▶ 5 Add-On Packages].

# 6 Accessing the hardware

This chapter gives a short overview of how to access the different hardware parts and interfaces from within the Linux operating system. It is written universally in order to fit all Garz & Fricke platforms in general.

## 6.1 Digital I/O

The digital I/O pins for a platform are controlled by the kernel's GPIO Library interface driver. This driver exports a sysfs interface to the user space. For each pin, there is a virtual folder in the file system under /sys/class/gpio/ with the same name as in the hardware manual.

Each folder contains the following virtual files that can be accessed like normal files. In the command shell, there are the standard Linux commands cat for read access and echo for write access. To acces those virtual files from C/C++ code, the standard POSIX operations open(), read(), write() and close() can be used.

| sysfs file | Valid values | Meaning |
|---|---|---|
| value | 0, 1 | The current level of the GPIO pin. The acive_low flag (see below) has to be taken into account for interpretation. |
| direction | in, out | The direction of the GPIO pin. |
| active_low | 0, 1 | Indicates if the pin is interpreted active low. |

Most of the Garz & Fricke hardware platforms include a dedicated connector with isolated digital I/O pins. On these pins, the direction cannot be changed, since it is determined by the wiring. Thus, the direction file is missing here. Some platforms also have a keypad connector, which can be used as a bi-directional GPIO port.

The following examples show how to use the virtual files in order to control the GPIO pins.

**Example 1:** Verify that the GPIO pin keypad_pin7, which is pin 7 on the keypad connector, is interpreted as active high, configure the pin as an output and set it to high level in the Linux shell:

```
root@santaro:~# cat /sys/class/gpio/keypad_pin7/active_low
0
root@santaro:~# echo out > /sys/class/gpio/keypad_pin7/direction
root@santaro:~# echo 1 > /sys/class/gpio/keypad_pin7/value
```

**Example 2:** Verify that keypad_pin12 is an input pin and interpreted as active low and verify that the level LOW is recognized by this pin in the Linux shell:

```
root@santaro:~# cat /sys/class/gpio/keypad_pin12/direction
in
root@santaro:~# cat /sys/class/gpio/keypad_pin12/active_low
1
root@santaro:~# cat /sys/class/gpio/keypad_pin12/value
1
```

**Example 3:** C function to set / clear the dig_out1 output pin:

```
void set_gpio(unsigned int state)
{
        int fd = -1; // GPIO file handle
        char gpio[4];

        fd = open("/sys/class/gpio/dig_out1/value", O_RDWR);
        if (fd == -1)
        {
                printf("GPIO-ERR\n");
                return;
        }
        sprintf(gpio, "%d", state);
        write(fd, gpio, strlen(gpio));
        close(fd);
}
```

A more detailed documentation of the GPIO handling in the Linux kernel can be found in the documentation directory of the Linux kernel source tree.

## 6.2 Serial interfaces (RS-232 / RS-485 / MDB)

Most of the serial interfaces are exported as TTY devices and thus accessible via their device nodes under **/dev/ttymxc<number>**. Depending on your hardware platform (and maybe its assembly option), different transceivers (RS232, RS485, MDB) can be connected to these TTY devices. See the following table for the mapping between device nodes and hardware connectors on i.MX6:

| TTY device | Hardware function |
|---|---|
| /dev/ttymxc0 | RS-232 #1 (X13) |
| /dev/ttymxc1 | RS-232 #2 / MDB (X13) |
| /dev/ttymxc2 | RS-485 (X39) |
| /dev/ttymxc3 | internal UART (X11) |

RS485 can be used in half duplex or full duplex mode. This mode has to be set on the hardware (see the according hardware manual) as well as in the software. Per default, the interface is working in full duplex mode. See the following C code example for setting the RS485 interface to half duplex mode:

```
#include <termios.h>

void set_rs485_half_duplex_mode()
{
    struct serial_rs485 rs485;
    int fd;

    /* Open port */
    fd = open ("/dev/ttymxc2", O_RDWR | O_SYNC);

    /* Enable RS485 half duplex mode */
    rs485.flags = SER_RS485_ENABLED | SER_RS485_RTS_ON_SEND;
    ioctl(fd, TIOCSRS485, &rs485);

    close(fd);
}
```

For a full source code example, see the BSP folder **sources/meta-guf/meta/recipes-guf/ltp-guf-tests/ltp-guf-tests/testcases/rs485pingpong**.

Interfaces with an MDB transceiver should not be accessed directly via their device nodes. Instead, there is a library for MDB communication in the BSP. Please see the folder **sources/meta-guf/meta/recipes-guf/mdbtest** for a full source code example.

## 6.3 Ethernet

If all network devices are properly configured as described in [▶ 4.2.1 Garz & Fricke system configuration] and [▶ 4.1.6 Network initialization] they can be used by the POSIX socket API.

There is a huge amount of documentation about socket programming available. Therefore it is not documented here.

The POSIX specification is available at:

▶ http://pubs.opengroup.org/onlinepubs/9699919799/functions/contents.html

## 6.4 Real Time Clock (RTC)

All Garz & Fricke systems are equipped with a hardware real time clock. The system time is automatically set during the boot sequence by reading the RTC. You can read the current time and date using the Linux **hwclock** command:

```
root@santaro:~# hwclock --show
Fri Jun  1 14:51:12 UTC 2012
```

The RTC time cannot be adjusted directly in one command because only the current system time can be transferred to the RTC. Thus, the system time has to be set first, using the **date** command, and can then be written to the RTC:

```
root@santaro:~# date -s "2010-09-09 16:50:00"
Thu Sep  9 16:50:00 CEST 2010
root@santaro:~# hwclock --systohc
```

## 6.5 Keypad connector

The so called keypad connector is a general purpose connector. It can be used in different modes. The mode is selected using the kernel command line. See [▶ 4.2.4 Kernel command line] how it can be modified.

The actual pin mapping is described in the hardware guide for your device.

There are three available functions.

**GPIO:**

```
keypad=gpio
```

All pins are available as gpios. You can access them in usermode using the sysfs entries:

```
/sys/class/gpio/keypad_pin<3-18>
```

See [▶ 6.1 Digital I/O] for usage.

**I2C:**

```
keypad=i2c
```

The i2c 1 interface is mapped to the keypad connector pins 11 and 12. It is available in usermode as:

```
/dev/i2c-1
```

See [▶ 6.7 I2C] for usage.

**SPI:**

```
keypad=spi
```

The spi interface is mapped to the pins 12 till 18. The interface is available in usermode as:

```
/dev/spidev0.0
/dev/spidev0.1
/dev/spidev0.2
```

See [▶ 6.6 SPI] for usage.

**Combination:** The options can be combined to use multiple functions at the same time, for example:

```
keypad=gpio,i2c,spi
```

will enable all three functions. This leads to the following mapping:

- pins 3-10 are used as gpios
- 11 and 12 are used for i2c

- 13-18 are used for spi

**Default:**

The default setting is:

```
keypad=gpio,i2c
```

## 6.6 SPI

There are two ways of controlling SPI bus devices from a Linux system:

- Writing a kernel SPI device driver and accessing this driver from user space by using its interface.
- Accessing the SPI bus via the Linux kernel's **spidev** API directly.

Describing the process of writing a Linux SPI device driver is out of the scope of this manual. The AT25 SPI eeprom can serve as a good and simple example for such a driver. It is located in the kernel directory under:

- **drivers/misc/eeprom/at25.c**

The interface provided to the user space by such a kernel driver depends of the sort of this driver (e.g. character misc driver, input subsystem device driver, etc.). A very common usecase for an SPI driver is a touchscreen driver that uses the input event subsystem.

Accessing the SPI bus from userspace directly via spidev is described in the Linux kernel documentation and available in the kernel directory under:

- **Documentation/spi/spidev**

Additionally, there is an example C program available in the same location:

- **Documentation/spi/spidev_test.c**

The header for spidev is available under:

- **include/linux/spi/spidev.h**

**Note:** If spidev is used to access the SPI bus directly, the user is responible for keeping the interoperability consistent with all other SPI devices that are controlled by the Linux kernel.

## 6.7 I2C

There are two ways of controlling I2C bus devices from a Linux system:

- Writing a kernel I2C device driver and accessing this driver from user space by using its interface.
- Accessing the I2C bus via the Linux kernel's **i2c-dev** API directly.

Describing the process of writing a Linux I2C device driver is out of this scope of this manual. The AT24 I2C eeprom can serve as a good and simple example for such a driver. It is located in the kernel directory under:

- **drivers/misc/eeprom/at24.c**

The interface provided to the user space by such a kernel driver depends of the sort of this driver (e.g. character misc driver, input subsystem device driver, etc.). A very common usecase for an I2C driver is a touchscreen driver that uses the input event subsystem.

Accessing the I2C bus from userspace directly via spidev is described in the Linux kernel documentation and avauilable inside the kernel directory under:

- **Documentation/i2c/dev-interface**

The header for i2c-dev is available under:

- **include/linux/i2c-dev.h**

**Note:** If i2c-dev is used to access the I2C bus directly, the user is responible for keeping the interoperability consistent with all other I2C devices that are controlled by the Linux kernel.

## 6.8 CAN

CAN bus devices are controlled through the SocketCAN framework in the Linux kernel. As a consequence, CAN interfaces are network interfaces. Applications receive and transmit CAN messages via the BSD Socket API. CAN interfaces are configured via the netlink protocol. Additionally, Garz & Fricke Linux systems are shipped with the **canutils** package to control and test the CAN bus from the command line.

On i.MX6 the CAN bus is physically available on connector X39.

**Example 1** shows how a CAN bus interface can be set up properly for 125 kBit/s from a Linux console:

```
root@santaro:~# canconfig can0 bitrate 125000
root@santaro:~# ifconfig can0 up
```

**Note:** Due to the use of the busybox version of the **ip** tool the following sequence does **NOT** work on Garz & Fricke Linux systems:

```
root@santaro:~# ip link set can0 type can bitrate 125000
root@santaro:~# ifconfig can0 up
```

As already stated above, CAN messages can be sent through the BSD Socket API. The structure for a CAN message is defined in the kernel header **include/linux/can.h**:

```
struct can_frame {
        u32 can_id; /* 29 bit CAN_ID + flags */
        u8 can_dlc; /* data length code: 0 .. 8 */
        u8 data[8];
};
```

**Example 2** shows how to initialize SocketCAN from a C program:

```
int iSock;
struct sockaddr_can addr;

iSock = socket(PF_CAN, SOCK_RAW, CAN_RAW);

addr.can_family = AF_CAN;
addr.can_ifindex = if_nametoindex("can0");

bind(iSock, (struct sockaddr *)&addr,
        sizeof(addr);
```

**Example 3** shows how a CAN message is sent from a C program:

```
struct can_frame frame;

frame.can_id = 0x123;
frame.can_dlc = 1;
frame.data[0] = 0xAB;

nbytes = write(iSock, &frame,
        sizeof(frame));
```

**Example 4** shows how a CAN message is received from a C program:

```
struct can_frame frame;

nbytes = read(iSock, &frame, sizeof(frame));

if (nbytes > 0) {
        printf("ID=0x%X DLC=%d data[0]=0x%X\n",
        frame.can_id,
```

```
        frame.can_dlc,
        frame.data[0]);
}
```

**Example 5** shows how a CAN message with four bytes with the standard ID 0x20 is sent on **can0** from the Linux shell, using the **cansend** tool. The CAN bus has to be physically prepared properly and there has to by at least one other node that is configured to read on this message ID for this task. Furthermore, all nodes must have the same bittiming.

```
root@santaro:~# cansend can0 -i 0x20 0xca 0xbe 0xca 0xbe
```

**Example 6** shows how all CAN messages are read on **can0** using the **candump** tool:

```
root@santaro:~# candump can0
```

A more detailled documentation of the CAN bus handling in the Linux kernel can be found in the documentation directory of the Linux kernel source tree.

## 6.9 USB

There are two general types of USB devices:

- **USB Host**: the Linux platform device is the host and controls several devices supported by corresponding Linux drivers
- **USB Device**: the Linux platform device acts as a USB device itself by emulating a specific device type

Additionally, if supported, an OTG-enabled port can automatically detect, which of the above roles the platform plays during the plugging process.

### 6.9.1 USB Host

For USB Host functionality, Garz & Fricke platforms per default support the following devices:

- USB Mass Storage
- USB Keyboard

There are many more device drivers available in the Linux kernel. They are not activated by default, because Garz & Fricke cannot maintain and test the huge amount of existing drivers. Instead, the customer may do this himself or engage Garz & Fricke to implement his special use case. Existing drivers can easily be activated by reconfiguring and rebuilding the Linux kernel inside the BSP.

The USB Host bus can also be directly accessed by using **libusb**. This library is installed on Garz & Fricke platforms per default.

Further information about libusb can be found under:

▶ http://libusb.sourceforge.net/api-1.0

**Note:** If libusb is used to access the USB bus directly, the user is responsible to keep the interoperability consistent with all other USB devices that are controlled by the Linux kernel.

### 6.9.2 USB Device

For USB Device functionality, the following device emulations are supported per default:

- USB Serial Gadget

Again, further drivers can be activated by reconfiguring the Linux kernel. The USB Device drivers are not compiled into the kernel by default, but are located as modules in the file system. In order to use the Serial Gadget for example, the according module has to be loaded:

```
root@santaro:~# modprobe g_serial
```

The Serial Gadget creates a virtual serial port over USB, accessible via the device node **/dev/ttyGS0**.

## 6.10 Display power

The display can be powered on or off by software. The value is exported as a virtual file in the sysfs under **/sys/class/graphics/fb0/blank**. It can be accessed using the standard file operations open(), read(), write() and close().

**Example 1:** Turn display off:

```
root@santaro:~# echo 4 > /sys/class/graphics/fb0/blank
```

**Example 2:** Turn display on:

```
root@santaro:~# echo 0 > /sys/class/graphics/fb0/blank
```

Please note that this value is not persistent, i.e. it gets lost when the device is rebooted.

## 6.11 Display backlight

The brightness of the display backlight can be adjusted in a range from 0 to 255. The value is exported as a virtual file in the sysfs under **/sys/class/backlight/pwm-backlight.0/brightness**. It can be accessed using the standard file operations open(), read(), write() and close().

**Example 1:** Reading and adjusting the current backlight brightness on the console:

```
root@santaro:~# cat /sys/class/backlight/pwm-backlight.0/brightness
255
root@santaro:~# echo 100 > /sys/class/backlight/pwm-backlight.0/brightness
```

Please note that this value is not persistent, i.e. it gets lost when the device is rebooted. In order to change the brightness permanently, it has to be set in the XML configuration, which can be done using the **xconfig** tool.

**Example 2:** Adjusting the backlight brightness permanently on the console:

```
root@santaro:~# xconfig addattribute -p /configurationFile/variables/display/
    ↪ backlight -n level_ac -v 100
```

Please note that adjusting this value does not affect the brightness immediately. A reboot is required for this setting to take effect. If you want to adjust the brightness immediately and permanently, you have to execute both examples.

## 6.12 SD cards and USB mass storage

SD cards and USB mass storage devices can be accessed directly by using their devices nodes. The SD card can be found under **/dev/mmcblk1**, its single partitions are located under **/dev/mmcblk1pX** with X being a positive number. The USB mass storage devices can be found under **/dev/sdX** with X=a..z, its single partitions under **/dev/sdXY** with Y being a positive number.

**Example 1:** Create a FAT32 file system on the first partition of an SD card:

```
root@santaro:~# mkfs.vfat /dev/mmcblk1p1
```

If the first partition on an SD card or a USB mass storage device already contains a file system when it is plugged into the device, it is mounted automatically by the **udev** service. SD card partitions are mounted to mount point **/media/mmcblk1pX** with X being a positive number, and USB mass storage devices are mounted to mount point **/media/sdXY** with X=a..z and Y being a positive number.

All further partitions or partitions with a newly created file system have to be mounted manually, like shown in the following examples.

**Example 2:** Mount the first partition on an SD Card into a newly created directory:

```
root@santaro:~# mkdir /my_sdcard
root@santaro:~# mount /dev/mmcblk1p1 /my_sdcard
```

**Example 3:** Mount the first partition on a USB mass storage device into a newly created directory:

```
root@santaro:~# mkdir /my_usb_drive
root@santaro:~# mount /dev/sda1 /my_usb_drive
```

## 6.13 Temperature Sensor

Most Garz & Fricke systems are equipped with an on-board hardware temperature sensor. The sensor is a Texas Instruments LM73 connected via $I^2C$. To poll the currently measured temperature you can read the corresponding sysfs file in **/sys/class/hwmon/hwmon0/device/**.

For example:

```
root@santaro:~# cat /sys/class/hwmon/hwmon0/device/temp1_input
+38.0
```

The sensor generates an alert when the measured temperature exceeds the maximum temperature defined in **temp1_max**. The alert flag will be set to 0 (active low) and an interrupt is generated. The interrupt will trigger an event on the **temp1_alrt** sysfs entry, that can be catched using the **poll()** function.

Read the temperature alert flag (active low):

```
root@santaro:~# cat /sys/class/hwmon/hwmon0/device/temp1_alrt
1
```

To reset the temperature alert flag the currently measured temperature needs to be below the maximum temperature value. Then the flag can be reset by writing 1 to the **temp1_alrtrst** sysfs entry.

Reset the temperature alert flag:

```
root@santaro:~# echo 1 > /sys/class/hwmon/hwmon0/device/temp1_alrtrst
```

## 6.14 Touchscreen

The touchscreen device is used by the application framework (e.g. Qt) via the **Linux input subsystem** kernel API, i.e. its device node **/dev/input/event0**.

For resistive touchscreens, which require a calibration, the **tslib** library is used as an inter-layer. Garz & Fricke provides optimized signal filtering for the touchscreens that are shipped with their products by choosing a suitable set of filters with suitable parameters in tslib. The filter configuration can be altered in the configuration file **/etc/ts.conf** in the target's root filesystem. This should only be done if the user is familar with tslib's filter system and the properties and characteristics of its filters. It is also important to reboot the system properly after altering this configuartion file or executing the **sync** command. Otherwise, the changes may get lost during a hard reset.

## 6.15 Audio

Garz & Fricke systems with an integrated audio codec make use of ALSA (Advanced Linux Sound Architecture) as a software interface. This project includes a user-space library (alsa-lib) and a set of tools (aplay, arecord, amixer, alsactl) for controlling and accessing the audio hardware from user applications or the console. Please refer to the official ALSA webpage for a full documentation:

- http://www.alsa-project.org

For a quick start here are three short examples of how to play/record an audio file and how to adjust the playback volume.

**Example 1:** Play the audio file **my_audio_file.wav** from the console using **aplay**:

```
root@santaro:~# aplay my_audio_file.wav
```

**Example 2:** Record the audio file **my_recorded_audio_file.wav** from the console using **arecord**:

```
root@santaro:~# arecord -f cd -t wav > my_recorded_audio_file.wav
```

**Example 3:** Set the playback volume to half of the maximum:

```
root@santaro:~# amixer sset 'PCM' 50%
```

The **amixer** command can be used for several settings regarding the audio hardware. Called without parameters, it gives a list of all available settings along with their possible values.

ALSA is also used in conjuction with playing multimedia files with GStreamer via the **alsasink** plugin after decoding the audio data from an audio stream.

**Example 4:** Play a sine signal with a frequency of 440 Hz (default settings) with GStreamer's **adiotestsrc** and **alsasink** plugins:

```
root@santaro:~# gst-launch audiotestsrc ! audioconvert ! alsasink
```

## 6.16 SRAM

The battery-backed SRAM is controlled by the MTD subsystem in the Linux kernel. Therefore, it can be handled like a typical MTD device via the device handles **/dev/mtdX** and **/dev/mtdblockX**, where **X** is the logical number of the device. This number can be found by executing:

```
root@santaro:~# cat /proc/mtd | grep SRAM
```

Per default, the SRAM is located at **/dev/mtd0**.

A very common use of the SRAM in conjuction with the MTD subsystem is to create a file system on top of it, like shown in the following example.

**Example**: Create a JFFS2 file system on **/dev/mtd0** with the mtd-utils and mount it to **/mnt**

```
root@santaro:~# flash_eraseall /dev/mtd0
root@santaro:~# mkfs.jffs2 /dev/mtdblock0
root@santaro:~# mount /dev/mtdblock0 -t jffs2 /mnt
```

## 6.17 HDMI

The HDMI port can be used as primary or secondary display on i.MX6. Furthermore, an audio-enabled HDMI device can be used as secondary sound card.

There are a few different use case for the HDMI display:

### 6.17.1 HDMI as primary display

To start the X-Server on the HDMI output only, no display configuration should be enabled in the system. This way the hdmi screen is set as primary screen in the system.

The resolution is configured automatically via EDID. The monitor is registered as framebuffer **/dev/fb0**. To overwrite the resolution from the EDID an xml file can be used [▶ 6.17.4 HDMI XML configuration].

**Note:** The bootlogo will still come up in the resolution read from the EDID, but the X Server will use the resolution configured via xml.

### 6.17.2 HDMI as secondary display

The HDMI output can also be used as secondary display. This mode is automatically selected when a xml display configuration is configured in the system (this is the default for devices with internal display).

The HDMI device connected to i.MX6 is configured automatically via EDID. The monitor is registered as a separate framebuffer **/dev/fb2**. By default the HDMI display is **blanked**. It can be unblanked by

```
hdmiconfig unblank
```

To unblank the HDMI monitor during startup, an xml file needs to be imported. The xml file can also be used to specify a custom resolution [▶ 6.17.4 HDMI XML configuration].

**Note:** Currently there is a limitation in the X Server display driver, so the secondary display can't be used from the X Server out of the box.

### 6.17.3 HDMI as mirror of the internal display

The HDMI mirror mode is available uppon request from Garz & Fricke.

### 6.17.4 HDMI XML configuration

Different settings of the HDMI output can be configured by an xml file. The format of this file can be seen in the example below:

```
<?xml version="1.0" encoding="ASCII" standalone="yes" ?>
<configurationFile xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                                   xmlns:xsd="http://www.w3.org/2001/XMLSchema">
        <!--
                   Defines the settings for hdmi interface
                        Mandatory settings:
                                default="1"
                                to unblank the monitor during startup with the
                                    ↪ default resolution.
                        or:
                                xres="800" yres="600" refresh="60"
                                to set a custom resolution.

                        Optional settings, everything supported by fbset in the
                            ↪ subnode <fbset>:
                                  Display geometry:
                                        vxres=<value>      : virtual horizontal
                                            ↪ resolution (in pixels)
                                        vyres=<value>      : virtual vertical
                                            ↪ resolution (in pixels)
                                        depth=<value>      : display depth (in bits
                                            ↪ per pixel)
                                        nonstd=<value>     : select nonstandard video
                                            ↪ mode
                                  Display timings:
                                        pixclock=<value>   : pixel clock (in
                                            ↪ picoseconds)
                                        left=<value>       : left margin (in pixels)
                                        right=<value>      : right margin (in pixels)
                                        upper=<value>      : upper margin (in pixel
                                            ↪ lines)
                                        lower=<value>      : lower margin (in pixel
                                            ↪ lines)
                                        hslen=<value>      : horizontal sync length (
                                            ↪ in pixels)
                                        vslen=<value>      : vertical sync length (in
                                            ↪ pixel lines)
                                  Display flags:
```

```
                                        accel=<value>     : hardware text
                                            ↪ acceleration enable (false or true)
                                        hsync=<value>     : horizontal sync polarity
                                            ↪ (low or high)
                                        vsync=<value>     : vertical sync polarity (
                                            ↪ low or high)
                                        csync=<value>     : composite sync polarity (
                                            ↪ low or high)
                                        gsync=<value>     : synch on green (false or
                                            ↪ true)
                                        extsync=<value>   : external sync enable (
                                            ↪ false or true)
                                        bcast=<value>     : broadcast enable (false
                                            ↪ or true)
                                        laced=<value>     : interlace enable (false
                                            ↪ or true)
                                        double=<value>    : doublescan enable (false
                                            ↪ or true)
                                        rgba=<r,g,b,a>    : recommended length of
                                            ↪ color entries
                                        grayscale=<value> : grayscale enable (false
                                            ↪ or true)

        -->
  <variables>
          <hdmi name="800x600p-60"
                        xres="800" yres="600" refresh="60"
                        >
                        <fbset
                                depth="16"
                                vxres="800"
                                vyres="600"
                                />

          </hdmi>
  </variables>
</configurationFile>
```

The generated xml file can be imported with:

```
        xconfig import hdmi.xml
```

# 7 Building and running a user application

There are two general ways of building your own native application for the target: it can be built either manually, using the cross toolchain of the SDK, or integrated into the BSP, using Yocto and bitbake as a build system. Integrating the application into the BSP build process is the more complex way and useful only if you have modified the BSP and want to deploy a complete root file system image to the target anyway (see [▶ 8 Building a Garz & Fricke Yocto Linux system from source]). For a single application, using the BSP in its original state as provided by Garz & Fricke, the SDK is recommended to be used. The following sections describe how to build a simple **Hello Wold!** application using the SDK.

In addition to running native applications, the device can also be configured to display a website using Qt Webkit. The Garz & Fricke Linux BSP comes with a configurable web demo application, which is covered in a separate section of this chapter.

## 7.1 SDK installation

The SDK contains the cross-toolchain and several files like headers and libraries necessary to build software for i.MX6. It is available as download from the Garz & Fricke support website. The sdk was tested with Ubuntu 14.04 Desktop (amd64), other destributions might work but 32bit systems will not. In that case you have to build the sdk yourself using the bsp as described in [▶ 8.3 Building the BSP for the target platform with Yocto]

▶ http://support.garz-fricke.com/projects/Santaro/Linux-Yocto/Releases/Yocto-jethro-4.1-r6741-0/sdk

The SDK file is a self-extracting archive that is supposed to run on Linux based machines. It is named something like **GUF-Yocto-jethro-4.1-r6741-0-sdk.sh**. Run this file on your development PC:

```
$sh <SDK location>/GUF-Yocto-jethro-4.1-r6741-0-sdk.sh
```

The installer will ask you if you want to install the SDK into a subfolder in **/opt**. Supposed this is what you want press the **y** key.

Example output:

```
Enter target directory for SDK (default: /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk):
You are about to install the SDK to "/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk".
    ↪ Proceed[Y/n]?
Extracting SDK...done
Setting it up...done
SDK has been successfully set up and is ready to be used.
```

Now that the SDK is installed you may proceed and write your first application for the embedded device.

## 7.2 Simple command-line application

We will create a simple C++ "Hello World!" application that uses a Makefile and the supplied SDK. Create a directory in your home directory on the host system and change to it:

```
$ cd ~
$ mkdir myapp
$ cd myapp
```

Create the empty files **main.cpp** and **Makefile** in this directory:

```
$ touch main.cpp Makefile
```

Edit the contents of the main.cpp file as follows:

```
#include <iostream>

using namespace std;

int main(int argc, char *argv[])
```

```
{
  cout << "Hello World!" << endl;
  return 0;
}
```

Edit the contents of the **Makefile** as follows:

```
myapp: main.cpp
        $(CXX) $(CXXFLAGS) -o $@ $<
        $(STRIP) $@

clean:
        rm -f myapp *.o *~ *.bak
```

It is necessary to setup your build environment so that the complier, headers and libraries can be found. This is done by "sourcing" a build environment configuration file. If the toolchain is installed in the default directory, this example compiles for the target system by typing

```
$ source
    ↪ /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/environment-setup-imx6guf-guf-linux-gnueabi
$ make
```

in the **myapp** directory. The first line is needed only once as it configures the current shell and sets the necessary environment variables.

After a successful build, the **maypp** executable is created in the **myapp** directory. You can transfer this application to the target system's **/usr/bin** directory using one of the ways described in chapter [▶ 3 Accessing the target system] and execute it from the device shell. It might be necessary to change the access rights of the executable first, so that all users are able to execute it.

You can find further information about how to build applications for Yocto-based platforms at:

- https://www.yoctoproject.org/docs/current/adt-manual/adt-manual.html

## 7.3 Qt-based GUI user application

Create a new directory in your home directory on the host system and change to it:

```
$ cd ~
$ mkdir myqtapp
$ cd myqtapp
```

Create the empty files **main.cpp** and **myqtapp.pro**.

```
$ touch main.cpp myqtapp.pro
```

Edit the contents of the file **main.cpp** as follows:

```
#include <QApplication>
#include <QPushButton>

int main(int argc, char *argv[])
{
        QApplication app(argc, argv);
        app.setOverrideCursor(Qt::BlankCursor);
        QPushButton hello("Hello World!");
        hello.setWindowFlags(Qt::FramelessWindowHint);
        hello.resize(800, 480);
        hello.show();
        return app.exec();
}
```

Edit the contents of the file **myqtapp.pro** as follows:

```
TEMPLATE = app
TARGET = myqtapp

QT = core gui widgets

SOURCES += \
    main.cpp
```

Setup the build environment.

```
$ source
    ↪ /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/environment-setup-imx6guf-guf-linux-gnueabi
```

**Note:** The above command assumes that you have extracted the SDK in the default directory under **/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk**. If the SDK is located in a different directory, you have to change the directory accordingly.

Execute the following command to create a **Makefile** and build the binary in the **myqtapp** directory:

```
$ qmake myqtapp.pro
$ make
```

Now, there is the **myqtapp** executable in the **myqtapp** directory. You can transfer this application to the target system's **/usr/bin** directory in one of the ways described in chapter [▶ 3 Accessing the target system] and run it from the device shell.

## 7.4 Using the Qt Creator IDE

Apart from compiling Qt applications on the command line, Qt Creator can be used as a comfortable IDE for developing, building and deploying applications for the target system. This section describes how to set up Qt Creator and how to compile and deploy a sample application.

### 7.4.1 Configuring Qt Creator

To use Qt with the cross toolchain shipped with the Garz & Fricke BSP, the Qt version must be set up properly. Furthermore, the device configuration for automatic deployment must be set up properly.

Our tests were performed using a virtual machine installation of Ubuntu 14.04 Desktop (amd64). Anyway the QT version available in the repos for Ubuntu 14.04 is older then the qt version of the sdk (5.5.1).

To install a recent version, the released version needs to be downloaded from QT directly:

```
$ wget http://download.qt.io/official_releases/qt/5.5/5.5.1/qt-opensource-linux-x64
    ↪ -5.5.1.run
$ chmod +x qt-opensource-linux-x64-5.5.1.run
$ ./qt-opensource-linux-x64-5.5.1.run
```

A wizard is started to install QT 5.5.1. Just follow the instruction of the wizard.

SFTP is used to deploy your program to the target device, thus SSH has to be installed as well:

```
$ sudo apt-get install ssh
```

To accept the ssh key of the Garz & Fricke device, create a manual ssh connection:

```
user@localhost$ ssh  root@172.20.56.212
The authenticity of host '172.20.56.212 (172.20.56.212)' can't be established.
ECDSA key fingerprint is a3:bf:37:99:04:37:81:91:46:5b:bc:76:d4:f1:56:dc.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '172.20.56.212' (ECDSA) to the list of known hosts.
Last login: Wed Sep 23 14:05:41 2015 from 172.20.42.189
root@santaro:~#
```

This needs to be repeated when the IP address or the ssh key of the device changes.

Each time the Qt Creator is startet some environment variables need to be set. It is the same process as in the chapters [▶ 7.2 Simple command-line application] and [▶ 7.3 Qt-based GUI user application]. Open a console and type

```
$ source
    ↪ /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/environment-setup-imx6guf-guf-linux-gnueabi
```

Now that this console session is prepared, start the Qt Creator:

```
$ qtcreator &
```

During the first start after installation you need to configure the Qt Creator to use the correct toolchain and to deploy to the correct device. Open the **Tools->Options** dialog. We will configure the target device first.

On the left pane of the dialog open the **Devices** view. Add a new **Generic Linux Device** and configure IP and credentials according to your target settings. The IP address depends on the configuration, factory default is the static adress 192.168.1.1 but dhcp is also possible. Make sure that you can access the target as described in [▶ 3 Accessing the target system] with ssh or telnet before.

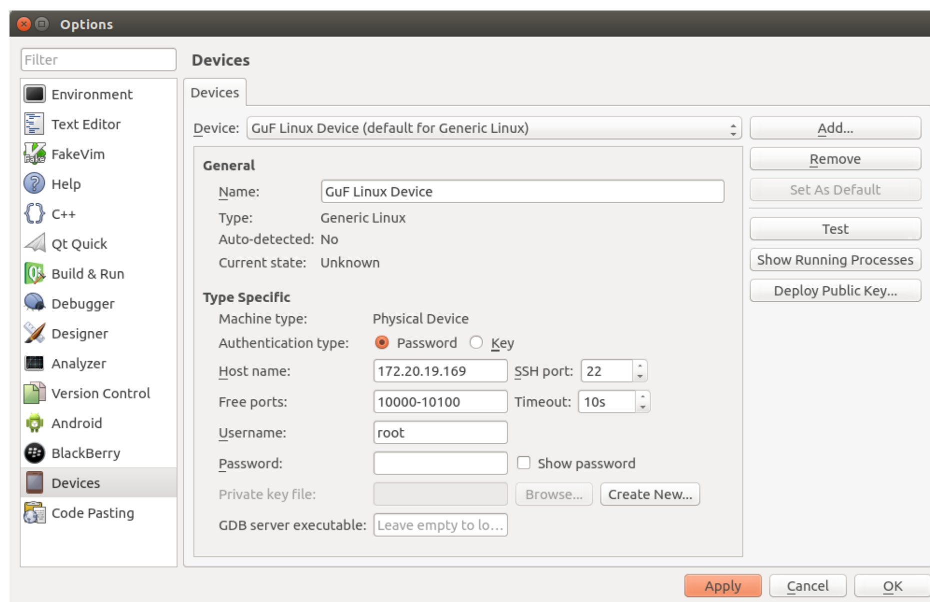


Figure 6: Qt Creator device options

You can press the **Test** button to test your configuration. The test dialog should display:

```
Device test finished successfully.
```

Now that the device is configured we need to set up the toolchain. This is done in the **Build & Run** pane. The first thing we want to add is the cross compiler in the **Compilers** section. The **Compiler path** is everything that is needed here.

```
/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/x86_64-gufsdk-linux/usr/bin/arm-
    ↪ guf-linux-gnueabi/arm-guf-linux-gnueabi-g++
```

The dialog should look similar to [▶ Figure 7].

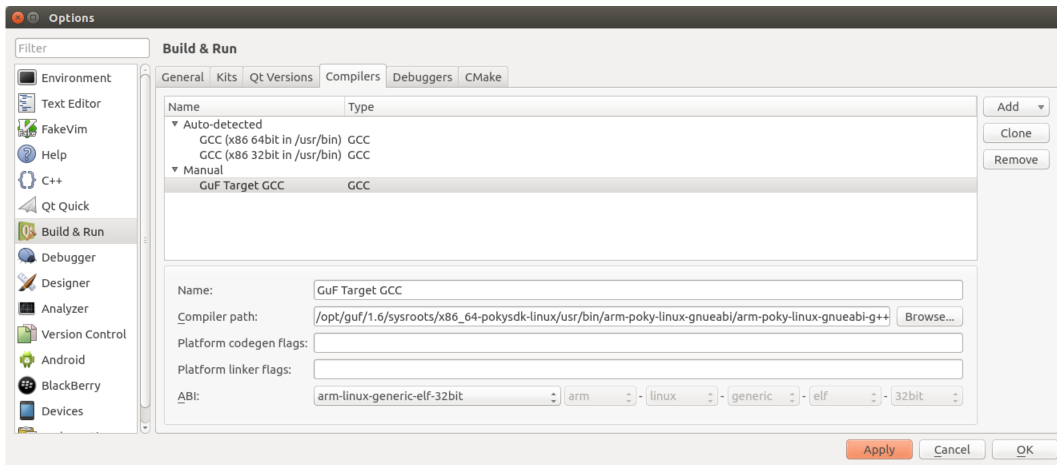


Figure 7: Qt Creator compiler options

Optionally the debugger could be configured in the the **Debuggers** section. Press add to create a new debugger entry and enter the **Path** here:

```
/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/x86_64-gufsdk-linux/usr/bin/arm-
    ↪ guf-linux-gnueabi/arm-guf-linux-gnueabi-gdb
```

The next step is checking the version the **Qt Versions** section. It should be set to

```
/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/x86_64-gufsdk-linux/usr/bin/qt5/
    ↪ qmake
```

as seen in [▶ Figure 8].

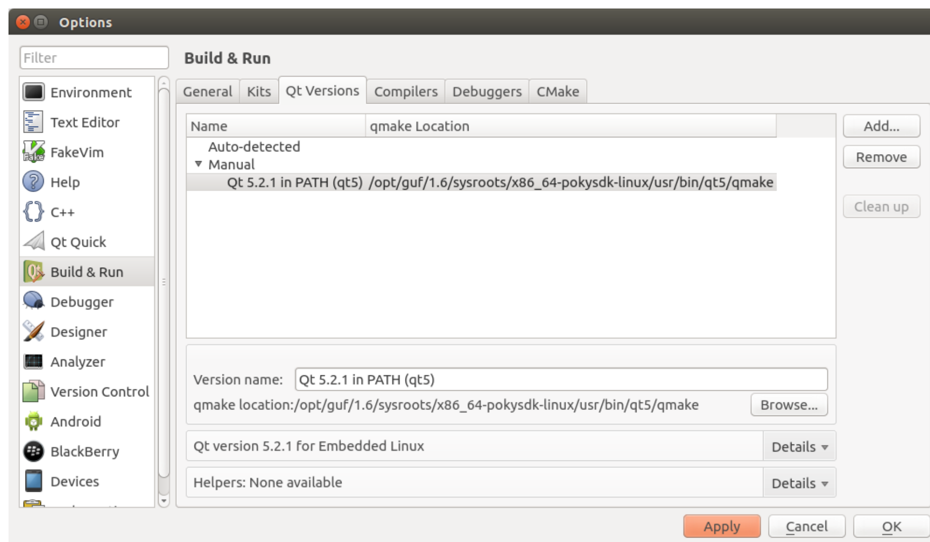


Figure 8: Qt Creator Qt Versions

In the last configuration step we combine the previous configuration steps to a kit in the **Kits** section. Add a new **Generic Linux Device** and set the options so that the previously created settings are used. The **Sysroot** setting needs to be set to something like

```
/opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-linux-gnueabi
```

and the **Qt mkspec** is set to

```
linux-oe-g++
```

Please note that the **Qt mkspec** will hide after setting.

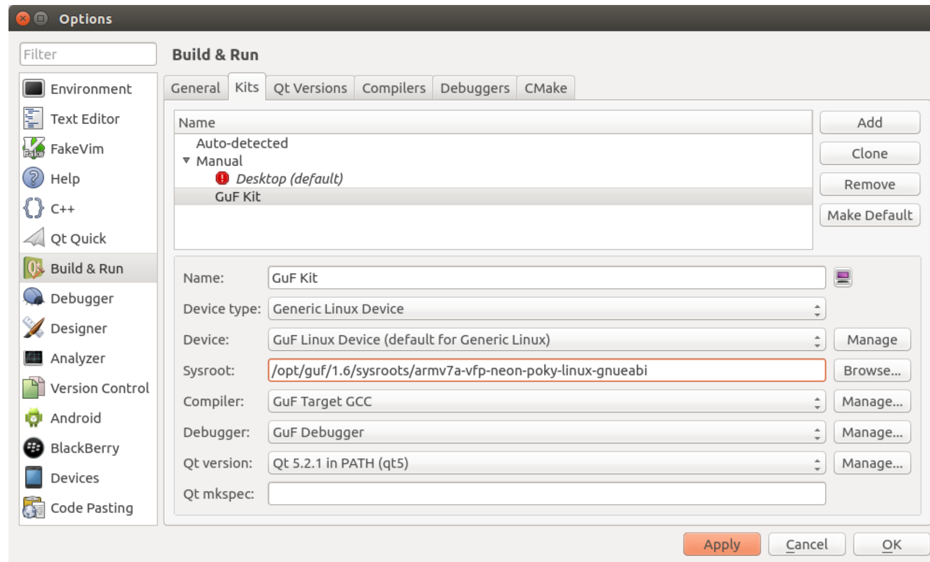


Figure 9: Qt Creator kits options

If you want to use the debugger open the **Debugger** view on the left pane of the dialog. In the **GDB** section add the following into the **Additional Startup Commands** box:

```
handle SIGILL nostop
```

You can now begin to develop a Qt Application using the Qt Creator.

### 7.4.2 Developing with Qt Creator

In this section we will create and deploy a simple Qt Quick Application. The application will be the default sample application that comes with the Qt Creator IDE.

To create a new project select **File->New File or Project...**. Make sure that in the top right corner of the wizard dialog the option **Embedded linux Templates** is selected. Choose an **Applications** project and select **Qt Quick Application**.

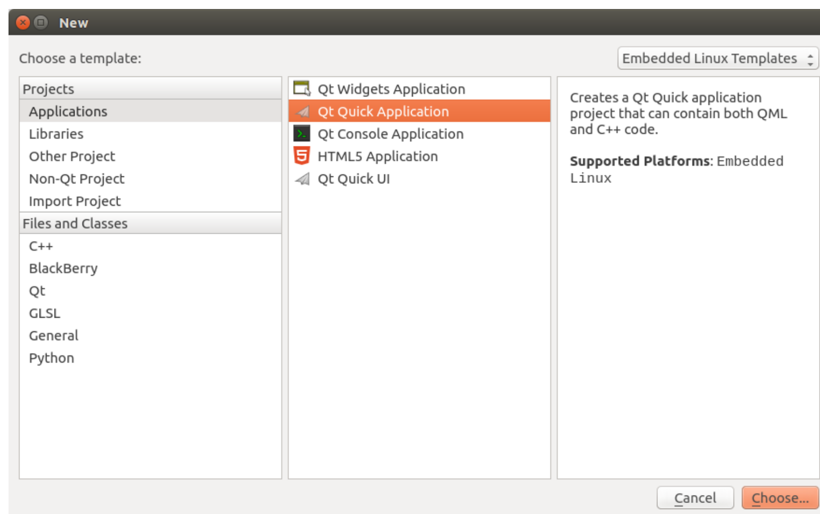


Figure 10: Qt Creator new project screen

Click on **Choose** and give your application a name. After a click on the **Next** button you can choose which component set you want to use. For this example we select **Qt Quick 2.0**. Another click on the **Next** button shows the Kits selection. You only need the kit that you created in the previous section.

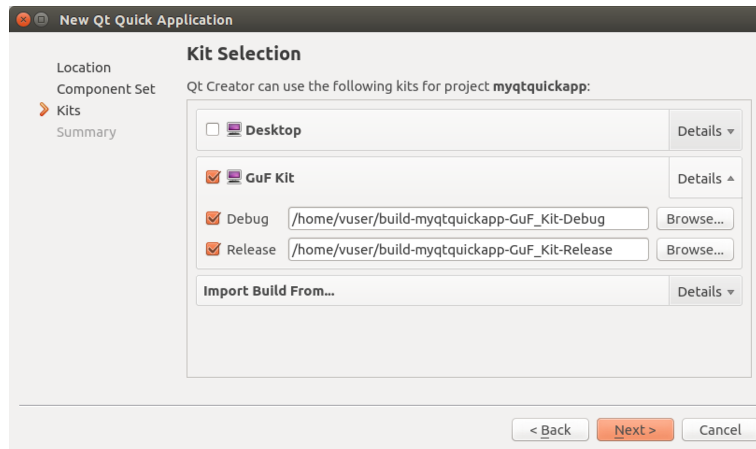


Figure 11: Qt Creator kit selection

After finishing the wizard you should see the opened **main.qml** and the project files.

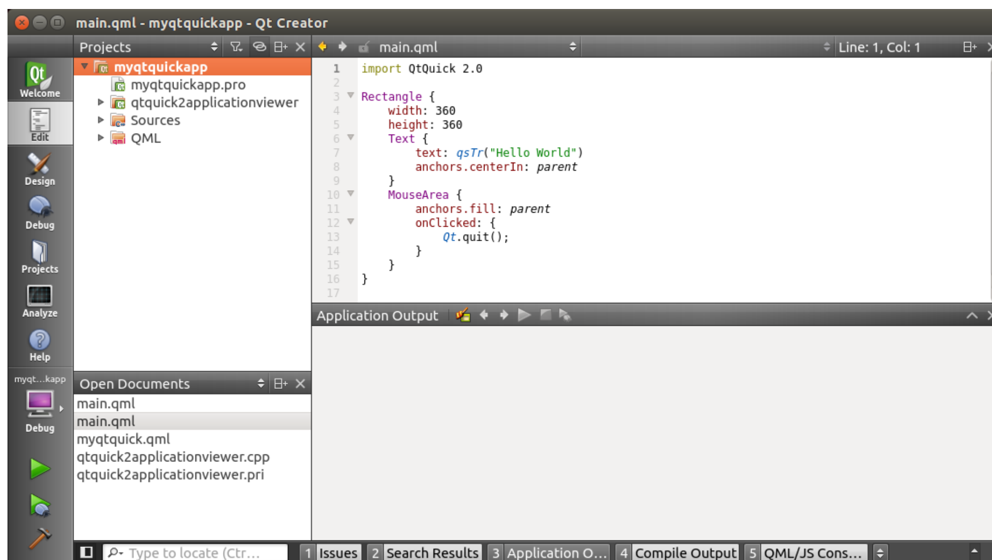


Figure 12: The first Qt Quick application in Qt Creator

You can now build and deploy the application by clicking the **Run** button (the play button in the left bottom corner) or using the shortcut **Ctrl-R**. Now the Qt Creator builds your application and automatically deploys it to the device. On the device, you should see an application showing **Hello World** now.

For further information on how to use Qt Creator and how to program Qt applications see the online Qt documentation:

- http://qt-project.org/doc/qtcreator-3.0/index.html
- http://qt-project.org/doc/

## 7.5 Autostart mechanism for user applications

In order to make the target system start your application automatically during the boot process you have to create a start/stop script in the **/etc/init.d** directory. As described in chapter [▶ 4.1 Services], this directory contains a number of scripts for various services on your system. Each script will be run as a command of the following form:

```
root@santaro:~# /etc/init.d/<COMMAND> <OPTION>
```

Where **COMMAND** is the actual command to run and **OPTION** can be one of the following:

- start
- stop

The command can be called by hand to start or stop a specific service. In order to start a service automatically during system boot, a link to the script has to be created in the **/etc/rc.d** directory. See chapter [▶ 4.1 Services] for the link creation procedure.

For your demo application, create a new script at **/etc/init.d/myapp** on the target system:

```
root@santaro:~# nano /etc/init.d/myapp
```

Change the contents of this file as follows:

```
#!/bin/sh
### BEGIN INIT INFO
# Provides:          myapp
# Required-Start:    $all <what ever my be needed>
# Required-Stop:
# Default-Start:     2 3 4 5
# Default-Stop:      0 1 6
# Short-Description: Start myapp at boot time
# Description:
### END INIT INFO

[ -f /etc/profile.d/tslib.sh ] && . /etc/profile.d/tslib.sh
[ -f /etc/profile.d/qt5-touch-config.sh ] && . /etc/profile.d/qt5-touch-config.sh

export DISPLAY=:0

case "$1" in
start)
        # We don't want this script to block the rest of the boot process
        if [ "$2" != "background" ]; then
                $0 $1 background &
        else
                while [  -f /var/run/starting_xserver ]
                do
                        sleep 1;
                done

                start-stop-daemon -m -p /var/run/myapp.pid -b -a /usr/bin/myapp -S
        fi
        ;;
stop)
        start-stop-daemon -p /var/run/myapp.pid -K
        ;;
*)
        echo "Usage: /etc/init.d/myapp {start|stop}" >&2
        exit 1
        ;;
esac
```

Save the changes by pressing **Ctrl+O** and accept the target file name as suggested by pressing **[RETURN]**. Leave the nano editor by pressing **Ctrl+X**.

Make **/etc/init.d/myapp** executable:

```
root@santaro:~# chmod a+x /etc/init.d/myapp
```

Create startlinks in **/etc/rc*.d/**:

```
root@santaro:~# update-rc.d myapp defaults 95 5
```

If the Garz & Fricke demo application is installed on your device, its startlink should be deleted so that your application is the only application automatically started:

```
root@santaro:~# update-rc.d -f qt4-guf-demo remove
```

After system reboot your application will start automatically.

# 8 Building a Garz & Fricke Yocto Linux system from source

This chapter describes how to build a Yocto based Linux BSP for a Garz & Fricke platform from source. All steps, including the installation of the build system and the required toolchains, are covered here.

## 8.1 General information about Garz & Fricke Yocto Linux systems

Garz & Fricke uses the **Yocto Project** build system for building embedded Linux systems for their platforms by providing a Board Support Package (BSP). The Yocto Project is lead by the Linux foundation with the aim to produce tools and processes to create embedded Linux distributions.

The Yocto project includes a configurable build system specializing in building embedded Linux systems. This chapter contains information about the handling of Linux with **Yocto** and Yocto based toolchains for Garz & Fricke systems. For further information regarding the **Yocto Project** please refer to the official **Yocto website**:

- https://www.yoctoproject.org

Documentation regarding several Yocto topics can be found at:

- https://www.yoctoproject.org/documentation/current

In order to build a Yocto based Linux system, the following list of packages should be installed (Debian and Ubuntu package names):

- autoconf
- automake
- build-essential
- dblatex
- docbook-utils
- fop
- libglib2.0-dev
- libsdl1.2-dev
- libtool
- make
- xmlto
- xsltproc
- xterm
- git
- texinfo
- chrpath
- python-dev
- python3-dev
- sed

See also:

- https://www.yoctoproject.org/docs/1.6/ref-manual/ref-manual.html#required-packages-for-the-host-development-system .

On Debian based Linux distributions packages can be installed using the **apt-get** command:

```
$ sudo apt-get install <package_Name>
```

To install all the above packages, type:

```
$ sudo apt-get install autoconf automake dblatex diffstat docbook-utils fop libglib2
    ↪ .0-dev libsdl1.2-dev libtool make xmlto xsltproc xterm git texinfo chrpath
    ↪ python-dev python3-dev
```

In contrast to a desktop Linux system, which is completely built with a native GNU toolchain, an embedded Linux system is built with a GNU cross toolchain. A cross toolchain must have the ability to produce target specific opcode while running on a different host system. When building a BSP with Yocto the toolchain will be supplied and built alongside with the target system. There is no need to install a GNU Compiler Collection (GCC) host and cross toolchain separately.

To distinguish between the native GNU toolchain and the GNU cross toolchain, the GNU cross tools are prefixed with a triplet. E.g. if the toolchain produces opcode for an **ARMv5TE** core having library routines that can deal with Linux system calls satisfying the **GNU EABI**, the compiler is named **arm-v5te-linux-gnueabi-gcc**, the assembler is named **arm-v5te-linux-gnueabi-as**, and so on. Sometimes a toolchain prefix is only named **arm-linux-** or something else. This depends on the toolchain vendor. Garz & Fricke uses the naming convention stated before.

The build of the embedded Linux system is divided into two steps, covered in the following chapters:

- Downloading and Installing a Yocto BSP [▶ 8.2 Download and install the Garz & Fricke Yocto BSP]
- Building the BSP for the target platform [▶ 8.3 Building the BSP for the target platform with Yocto]

## 8.2 Download and install the Garz & Fricke Yocto BSP

Yocto supports Linux as a host system only. To install a Garz & Fricke Yocto BSP the following files from the CD / USB stick shipped with the starter kit for i.MX6 have to be extracted:

- **GUF-Yocto-jethro-4.1-r6741-0.tar.bz2**

This archive can also be found on the Garz & Fricke support website:

▶ http://support.garz-fricke.com/projects/Santaro/Linux-Yocto/Releases/

This archive contains the necessary files to build a cross toolchain and a Yocto based target image. To install the Garz & Fricke BSP, simply extract the file.

For example:

```
$ cd ~
$ mkdir yocto
$ cd yocto
$ cp /media/sda1/Tools/GUF-Yocto-jethro-4.1-r6741-0.tar.bz2 .
$ tar -xvf GUF-Yocto-jethro-4.1-r6741-0.tar.bz2
```

If everything went right, we have a **GUF-Yocto-jethro-4.1-r6741-0** directory now, so we can change into it:

```
$ cd GUF-Yocto-jethro-4.1-r6741-0
```

## 8.3 Building the BSP for the target platform with Yocto

In the Yocto directory, the following command selects the platform to be built:

```
$ MACHINE=imx6guf source setup-environment build-imx6guf
```

After that the shell should have changed the current working directory to the platform specific build directory **build-imx6guf**. To build packages and complete images, the Yocto build tool **bitbake** is used. It is documented in the official Yocto documentation and online in the **OpenEmbedded Bitbake Manual**:

▶ http://www.yoctoproject.org/docs/1.6.1/bitbake-user-manual/bitbake-user-manual.html

Yocto builds the images from build descriptions called **recipes**. The recipe to build the Garz & Fricke Linux image is called **guf-image**. To build this image, call:

```
$ bitbake guf-image
```

This step automatically downloads all necessary parts from the web, builds the native toolchains as well as the target binaries. As this step is fairly complex, and many packages will be created and compiled, it takes quite some time. On our development machines, a complete build takes approximately 60 minutes.

After the build has finished, the images will be located in your build directory under **tmp/deploy/images/imx6guf**. In this directory, several files should be located. The most important ones are the last kernel build (**uImage-imx6guf.bin**) , the devicetree files (**uImage-imx6-santaro-q.dtb, uImage-imx6-santaro-dl.dtb, uImage-imx6-santoka-dl.dtb, uImage-imx6-santoka-q.dtb**) and the last target root file system (**guf-image-imx6guf.tar.gz**). The latter is also often called **rootfs**.

The devicetree files are describing the hardware to the kernel. The kernel uses it to create and configure platform devices and start the appropriate drivers.

Rather than files itself, these are symbolic links to the former build artifacts in the same directory. Every successive build of the image creates new artifacts with a recent timestamp in its name.

# 9 Deploying the Linux system to the target

A Garz & Fricke Yocto image can be installed on the system's internal eMMC flash memory using the Garz & Fricke **Flash-N-Go System**. This is a small RAM-disk-based Linux which is installed on your **i.MX6** in parallel to the regular operating system. This chapter describes how to boot your device into **Flash-N-Go System** and how to use it to install your Yocto image.

## 9.1 Booting Flash-N-Go System

There are two ways of booting your device into **Flash-N-Go System**. If the device already has a working Yocto image installed, you can switch to **Flash-N-Go System** by issuing the following commands on the device console:

```
root@santaro:~# bootselect alternative
root@santaro:~# reboot
```

The device will reboot and show the **Flash-N-Go System** splash screen on the display. On the serial console (see [▶ 3.1 Serial console]), the command prompt should appear:

```
---------------------------------
 Garz & Fricke Flash-N-Go System
---------------------------------

FLASH-N-GO:/
```

The change of the bootmode using the **bootselect** command is permanent, i.e. the next boot of the device will start **Flash-N-Go System** again, until the bootmode is set back to regular operation:

```
FLASH-N-GO:/ bootselect regular
```

Alternatively, the bootmode can be switched temporarily by pressing down and holding the **bootmode switch** while the power supply is switched on. The location of the **bootmode switch** is shown in [▶ Figure 13].

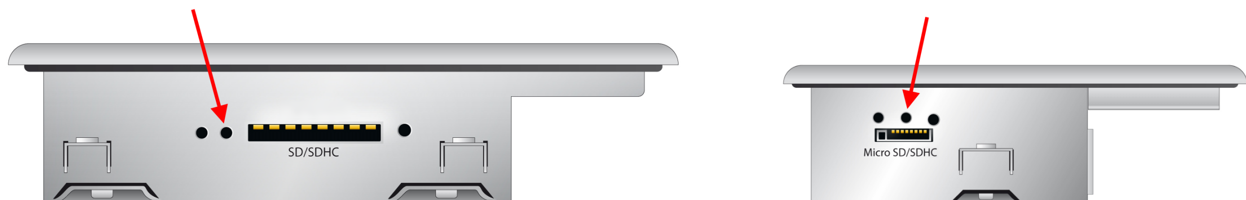


Figure 13: Location of the bootmode switch on the side of the device

This method changes the bootmode only for a single boot. The next boot of the device (without the **bootmode switch** pressed) will boot the regular operating system again.

For more detailed information concerning the Garz & Fricke **Flash-N-Go System** please consult the **Flash-N-Go System Manual**.

## 9.2 Installing a Yocto image on the device

Garz & Fricke provides a shell script for installing a Yocto image on the device, called **fng-install.sh**. The files can be installed either locally on the device (e.g. a USB drive or an SD card) or remotely via TFTP. Regardless which solution you prefer, you will need the following files from your **deploy** folder (see [▶ 8.3 Building the BSP for the target platform with Yocto]):

- fng-install.sh
- uImage-imx6guf.bin
- guf-image-imx6guf.tar.gz

- uImage-imx6-santaro-q.dtb, uImage-imx6-santaro-dl.dtb, uImage-imx6-santoka-dl.dtb, uImage-imx6-santoka-q.dtb
- boot-imx6guf.cfg

If you have not built the image yourself but rather want to install a Garz & Fricke prebuilt Yocto image, the filenames will differ slightly. The file extensions should be equal, though, so it should not be difficult to determine the correct files.

**Note:** The installation via **fng-install.sh** removes any previously installed regular operating system. If the installation fails for some reason, the device will always boot into **Flash-N-Go System** afterwards.

### 9.2.1 Over the network via TFTP

During development, the most comfortable way of installing the images on the device is by loading them over the network via TFTP. For this purpose, a TFTP server is needed on your development host machine (please see [▶ 3.4 Uploading files with TFTP] on how to install and configure it). The TFTP server directory has to be set to your **deploy** folder, e.g. **/home/user/yocto/GUF-Yocto-jethro-4.1-r6741-0/build-imx6guf/tmp/deploy/images/imx6guf/**. The ethernet connection on the device has to be configured as described in [▶ 4.2.1 Garz & Fricke system configuration], so that it can access the TFTP server.

The script can be loaded to the device and executed there via the **Flash-N-Go System** shell. Assuming, that your TFTP host has the IP address 192.168.1.100, type:

```
FLASH-N-GO:/ export TFTP=192.168.1.100; curl tftp://$TFTP/fng-install.sh > /tmp/a.sh;
    ↪  sh /tmp/a.sh
```

The above command loads the **fng-install.sh** script from your TFTP server to the **/tmp** directory of the **Flash-N-Go System** and executes it from there. During execution of the script, the Yocto image files will be loaded from the TFTP server and written directly to the eMMC flash memory.

The installation procedure will take some minutes. You can observe the output messages of the process on the terminal console. After successful installation the script returns to the Flash-N-Go prompt:

```
Update successful
FLASH-N-GO:/
```

### 9.2.2 From a local folder using an external storage device

If you do not have a network connection to your device, the **fng-install.sh** can be copied to an external storage device, e.g. a USB driver or an SD card, along with the Yocto images. Simply put all files into the same folder and insert the storage device into your i.MX6.

The TFTP environment variable must not be set. Usually the variable is not set, so you do not have to worry about this. If you have tried using TFTP before, though, it probably contains your TFTP server IP address and has to be unset explicitly:

```
FLASH-N-GO:/ unset TFTP
```

To start the installation, simply call the script from the shell:

```
FLASH-N-GO:/ sh /mnt/mstick1/fng-install.sh
```

The installation procedure will take some minutes. You can observe the output messages of the process on the terminal console. After successful installation the script returns to the Flash-N-Go prompt:

```
Update successful
FLASH-N-GO:/
```

**Note:** The installation from a local folder requires Flash-N-Go System 4.0 or higher.

### 9.2.3 Control the installation process using parameters

With Yocto version 25.0 and above it is possible to add paramters to the update-script call. This can be used to control the update process, add files and install additional features.

The options available are:

`-b|--BS` Boot script

`-d|--DTB` Device tree

`-f|--FS` Root file system archive

`-i|--Image` Boot logo

`-o|--OS` Kernel image

`-p|--ParamFile` Parameter file (each parameter on a separate line)

`-r|--RPM` Additional RPM packages

`-t|--TFTP` Additional file (Format: `<filename>:<target>`)

`-u|--UserPartition` User partition (Format: `<filesystem>:<megabytes>:<label>`, supported filesystems: vfat, ext2, ext3, ext4)

The following line can be used to install a boot logo (that is also located in your TFTP-Server directory):

```
FLASH-N-GO:/ export TFTP=192.168.1.100; curl tftp://$TFTP/fng-install.sh > /tmp/a.sh;
    ↪ sh /tmp/a.sh --Image=my-logo.png
```

**Note:** Be aware that the boot logo needs a license, either embedded into logo itself or as general XML-license file.

The parameter file (denoted by the `--ParamFile` flag) provides a way of specifing multiple parameters in one file. This makes a call with many parameters easier to handle.

A parameter file consists of the same parameters line by line. For example, one can write a parameter file that installs a custom boot logo and a custom kernel by writing the following lines into a file `customconfig.txt` located in the TFTP server directory.

```
--Image=my-logo.png
--OS=custom-linuximage.bin
```

Calling the install script with the `-p customconfig.txt` parameter will install the custom files.

Before installing files with `--TFTP` all eMMC partitions are mounted to `/mnt/emmcp<n>`. By this it is possible to install files to the target root file-system.

# 10 Securing the device

The meaning of security for embedded systems is often underestimated. This chapter should sensitize customers to the needs of security and disclose some of the typical security holes. It also provides some tips and hints for the implementation of well chosen security mechanisms. Since we cannot cover the big amount of security issues in this manual we strongly recommend to read further secondary lecture regarding this topic.

**Note:** For the following list of security risks, no claim of completeness can be made. There may arise other risks or - on the opposite - limitations in the design of your application by following the instructions provided in this chapter.

## 10.1 Services

The default configuration of a Garz & Fricke device can be described as "developer friendly". This means, all services are available and activated. Depending on the final application, this might be either helpful or a security risk. Once the development has been finalized, we recommend a review of the required services and to disable all services and features which are not used. See the chapter [▶ 4.1 Services] on how to disable.

Special care needs to be taken, for example for:

**Telnet** The chapter [▶ 4.1.4 Telnet service] describes the telnet service. For production devices it should be carefully decided if this feature is needed and how it is secured. At least the password and user suggestions from [▶ 10.2 User permissions concept] should be implemented.

**SSH** There is a ssh services enabled by default on Garz & Fricke devices with Yocto. Additionally to the password and user suggestions from [▶ 10.2 User permissions concept] there are more hints on securing the ssh service in the chapter [▶ 4.1.3 SSH service]. It is possible to restrict the users allowed using this service, lock a sftp access to a subfolder only and create custom crypto keys.

## 10.2 User permissions concept

Linux is designed as a multiuser system and provides a mechanism known as **file permissions**. Each file has an owner, a group and flags that grant **write**, **read** and/or **execute** permissions to the owner, the group or anybody. Additionally there is a super user, called root, who has access to all files. More information on this concept can be found at: ▶ http://www.tldp.org/LDP/gs/node5.html

Customers should follow the principle of minimal privilege for user rights on the devices. Please note that Garz & Fricke tools are usually assigned with access rights for all users since it is more developer friendly.

### 10.2.1 Root password

Since Garz & Fricke is an OEM manufacturer and we are delivering serial-produced devices to several customers a default root password would lead to a form of pseudo security. Moreover a default password for all devices is highly vulnerable. For this purpose our devices usually have no root password set. Is is essential that a password will be set by customers before the devices are deployed. This is the minimum security measure to be done.

Setting the root password on the device:

```
root@santaro:~# passwd root
Changing password for root
Enter the new password (minimum of 5 characters)
Please use a combination of upper and lower case letters and numbers.
New password:<enter your secure password>
Re-enter new password:<enter your secure password>
passwd: password changed.
root@santaro:~#
```

**What does it mean if no root password is set?** Without root password attackers might connect to the device via serial console, SSH or FTP and have full system control since the root user usually have all permissions.

**Blocking root access** Linux offers the opportunity to disable the root-login for specific services like ssh, or the serial console. Since the root login is is always a popular target for attackers this easy mechanism will decrease the risk for those kinds of brute force attacks.

This can be done by setting the root account's shell to /sbin/nologin in the /etc/passwd file:

```
root:x:0:0:root:/root:/sbin/nologin
...
```

**Note:** Ensure that another user account with the posibility to gain super user (su) rights is created before the root access is disabled. Otherwise, you might completely lose accessibility to the device.

### 10.2.2 Non root user

Normally a non root user should be used for "everyday tasks" on the system.

To create a non root user use the tool adduser:

```
root@santaro:~# adduser <user name>
Changing password for <user name>
Enter the new password (minimum of 5 characters)
Please use a combination of upper and lower case letters and numbers.
New password:<enter your secure password>
Re-enter new password:<enter your secure password>
passwd: password changed.
```

This creates a new user <user name> with group <user name> and the home directory /home/<user name>/. The new user can be used to login immediately. See the man page of adduser for more options.

### 10.2.3 super user privileges for non root user

sudo is a tool to allow non-root users to access single commands with root user privileges. If you disable login for the root user this method could be used to do system tasks with a normal user's account. To enable usages of this feature, the group sudo should be enabled in the sudoer file and the user needs to be added to this group. Edit the file /etc/sudoers with the command:

```
visudo
```

and uncomment the following line:

```
## Uncomment to allow members of group sudo to execute any command
%sudo   ALL=(ALL) ALL
```

This enables the sudo privilege for users in the group "sudo". To add a user to this group, execute the following command:

```
usermod -G sudo -a user
```

Now it is possible to execute commands with root previleges when logged in as <user name>:

```
user@santaro:~$ cat /etc/sudoers
cat: can't open '/etc/sudoers': Permission denied
user@santaro:~$ sudo cat /etc/sudoers
Password:
## sudoers file.
##
## This file MUST be edited with the 'visudo' command as root.
## Failure to use 'visudo' may result in syntax or file permission errors
## that prevent sudo from running.
...
```

## 10.3 autostart

Garz & Fricke devices are equipped with an [▶ 4.1.10 Autostart] and [▶ 4.1.9 Autocopy] service. As this service executes anything with root privileges without further checking, this is a possible vulnerability.

Restricting the physical access to the interfaces by the mechanical construction is one way to reduce the risk of attacks. To disable this feature completely, execute:

```
mv /etc/udev/rules.d/automount.rules /etc/udev/rules.d/automount.rules.disabled
```

**Note:** Updating the device with **Flash-N-Go Update** or any other automatic update tool is not possible without the autostart feature.

It should be possible to add special security checks to the mount script to allow only an automatic update but suppressing all other executables.

## 10.4 Flash-N-Go System

Newer Garz & Fricke devices are equipped with an **Flash-N-Go System** as backup OS. Within Flash-N-Go the user has full control of the device's configuration and the partitions on the flash disk respectively eMMC without a password or further authentication.

As described in [▶ 9 Deploying the Linux system to the target] booting into **Flash-N-Go System** can be triggered by pressing the **bootmode switch** or with the bootselect tool from the yocto OS.

The bootselect tool can only change the bootmode when called with root privileges, so following password and user suggestions from [▶ 10.2 User permissions concept] should solve this issue.

The bootmode switch should be secured with restricing physical access by the mechanical construction.

If this is impossible, it is possible to disable the Backup OS with the following command sequence:

```
root@gufboardll:~# mount /dev/mmcblk0p2 /mnt/
root@gufboardll:~# mv /mnt/boot.cfg /mnt/boot-alt.cfg
root@gufboardll:~# umount /mnt/

root@gufboardll:~# mount /dev/mmcblk0p1 /mnt/
root@gufboardll:~# mv /mnt/boot-alt.cfg /mnt/boot-alt.cfg.bak
root@gufboardll:~# umount /mnt/
```

**Note:** This change disables the access to the backup OS **Flash-N-Go System** completely. If the normal OS becomes inaccesible for some reason, there is no way for a custumer to fix the device.

**Note:** Updating the system normally without the backup OS **Flash-N-Go System** is impossible. Though it is possble to revert the change and reenable **Flash-N-Go System** from the normal OS, if it is functional.

## 10.5 Networking

### 10.5.1 Firewall - netfilter/iptables

By default, all network communication is allowed. Linux can be configured to block certain IP packets depending on its header (e.g. by port or by protocol) using **iptables**, which is basically a firewall. As this mechanism is very powerful and complex it is not documented here in detail. Please take a look at the following link for a basic introduction:

▶ https://help.ubuntu.com/community/IptablesHowTo

As a first start we show some basic usecases here.

Note: If you call these commands from a network login, your connection will/could break. Without physical access to the serial or USB console, you won't be able to access the device anymore.

Block all network traffic:

```
root@santaro:~# iptables -F
root@santaro:~# iptables -A INPUT -j DROP
```

This is the first step is a mandatory preparation for the following steps

Open SSH access only:

```
root@santaro:~# iptables -I INPUT 1 -i eth0 -p tcp --dport 22 -m state --state NEW,
    ↪ ESTABLISHED -j ACCEPT
root@santaro:~# iptables -I OUTPUT 1 -o eth0 -p tcp --sport 22 -m state --state
    ↪ ESTABLISHED -j ACCEPT
```

Open network access on port 80 and dns replies on port 53 from the device:

```
root@santaro:~# iptables -I INPUT 1 -p udp --source-port 53 -j ACCEPT
root@santaro:~# iptables -I OUTPUT 1 -o eth0 -p tcp --dport 80 -m state --state NEW,
    ↪ ESTABLISHED -j ACCEPT
root@santaro:~# iptables -I INPUT 1 -i eth0 -p tcp -m state --state ESTABLISHED -j
    ↪ ACCEPT
```

Save the firewall configuration persistent:

```
root@santaro:~# iptables-save > /etc/iptables.rules
root@santaro:~# echo "iptables-restore < /etc/iptables.rules" > /etc/network/if-pre-
    ↪ up.d/iptables
root@santaro:~# chmod +x /etc/network/if-pre-up.d/iptables
```

Disable the firewall:

```
root@santaro:~# iptables -F
```

### 10.5.2 Using secure network protocols

We strongly recommend the usage of secure network protocols. E.g HTTPS instead of HTTP, FTPS instead of FTP or SSH instead of telnet.

Further mechanisms regarding the security for network connected linux systems are described here:

- http://embedded-computing.com/articles/improving-security-for-network-connected-linux-based-systems

## 10.6 Restrict physical access

Each physical interface like USB, SD-Card or ethernet socket can serve as an entrance gate for hackers. If you limit the number of easily accessible interfaces you in turn decrease the possibility for attackers to connect with the target device. You need less concern about security mechanism for those interfaces which are not accessible or not equipped at all.

## 10.7 Application security

Application security is seldom a high priority for embedded devices. But it is, of course, essential to take account of identifying risks in embedded applications. Since application development is a very complex subject and it is out of scope for Garz & Fricke developement we will refer to secondary lecture at this point.

# 11 Debugging

## 11.1 Important hints

Before starting debugging several important topics have to be discussed.

### 11.1.1 The debugger needs access to the debug symbols

When the debugger is instructed to set a breakpoint on e.g. a function **foo**, it needs to look up which address corrsponds to that **symbol**. This and some further informmation is encoded into the compile output artifact, no matter if it is an executable, a shared library/object, the Linux kernel or a kernel module.

The compiler can be instructed to add debug info by adding the compile flag **-g** or even better for debugging with GDB with **-ggdb** that adds some more GDB specific debug info.

Further, the debug info doesn't need to be included to just execute the above stated artifacts without debugging. Moreover, for Linux BSPs, it's a common practice to compile the whole BSP with **-g** first and then remove that symbols before installation on the target system to reduce memory footprint drastically while keeping a untouched copy inside the BSP and/or the SDK on the development host for debugging purposes. Otherwise, the debug symbols consume a lot of disk space on the target device. This process is known as **stripping** and it is done by a tool called **<compiler-prefix>-strip**. So it's reasonable, that native debugging on the target device is not possible without further steps to make the symbols available to the debugger.

### 11.1.2 The debugger needs access to the source files

Apart from the symbols, the debugger needs to have access to the source code belonging to the components beeing debugged. This is needed to step through the various source lines as they were in your code editor. Likewise, it wouldn't make sense to istall source code on the target device, since it is not needed for normal operation and would consume a lot of disk space.

### 11.1.3 Optimization compiler flags destroy high level language code stepping

Optimization prevents the debugger from relating the high level lines of code to their assembler counterparts because optimization e.g. eliminates duplicated assembler sequences and instead, introduces jumps and returns to already existing ones. The one to one relation between C/C++ source to assembler code gets lost.

To be able to step properly through high level code lines it's necessary to compile the code to be degugged with **-O0** optimization.

This is an easy task for code compiled outside the BSP with the SDK such as a custom application. But almost all of the already built BSP components are compiled with **-O2**. That means, if a library function such as **printf** is called from the custom application and the developer wants to step into printf with the debugger, she/he will find the debuger jumping on weird C/C++ code lines inside **printf** function though it's own application is compiled with **-O0**.

The only way to overcome this issue is to compile the BSP by yourself and set **-O0** compilation on the component recipes of interest. This is beyond the scope of this manual and not recommended to do by yourself until she/he is familar with Yocto BSP devlopment.

The same issue applies to the Linux kernel and external compiled modules. The kernel can't be compiled entirely with **-O0** since some parts relay on optimization. Instead, the developer has to set the optimization flag for the driver/subsystem of intersest in the submakefile.

### 11.1.4 The symbol files have to originate from the same compile run as their installed stripped counterparts on the target system

This is obvious but a common mistake. If a binary is recompiled and we need a stripped and a unstripped copy the unstripped counterparts have to be reinstalled on the target.

### 11.1.5 Remote vs. native debugging

To be able to debug Embedded Linux system with low memory footprint GDB is extended to be run from a remote development host by connecting to a minimal debug agent called **gdbserver** for user space degugging and **kgdb** or **kgdboe** for kernel debugging. The communication can be done through RS232, Ethernet or even USB.

This technique allows the developer to keep both the debug symbol copies of the binaries and the source code just on the host system.

In contrast native debugging can be done on the target system too. A native GDB is also available on Garz & Fricke Yocto systems. However, this is more complicated since the directories for the symbol files and the source files must be made available from the SDK through e.g. a network file system.

So the recommended way for debugging is remote debugging out of the Yocto SDK that is shipped with Garz & Fricke Yocto systems.

### 11.1.6 User space code vs. kernel code debugging

As already stated above the kernel is treated differently with respect to debugging. Apart from the already explained different debug agents to use, kernel debugging requires a deeper understanding of the OS aspects such as virtual memory mapping, interrupt processing etc. and is currently beyond the scope of this manual.

### 11.1.7 Known issues

**Static instanciation in implicitly implemented C++ methods causes a GDB segmentation fault in newer Glibc versions**

Since the switch from **EGlibc** to **GLibc** in Yocto the following exception is known when instantiating static variables in implicitely implemented C++ member methods.

GDB complains with the following exception

```
Program received signal SIGSEGV, Segmentation fault.
_dl_debug_initialize (ldbase=1447, ns=195728) at dl-debug.c:55
55        if (r->r_map == NULL || ldbase != 0)
```

if something like the following code excerpt is implemented:

```
...
class AnotherClass
{
public:
  AnotherClass();
};
...
class AClass
{
public:
  void pub()
  {
    static Anotherclass crashingInstance; // Crash here ... move pub() to void AClass
        ↪ :pub()
  }
};
...
MainClass::MainClass()
{
  AClass anInstance;
  anInstace.pub();
}
...
```

The error is gone if the method is converted to an explicit implementation:

```
...
class AnotherClass
{
public:
  AnotherClass();
};
...
class AClass
{
public:
  void pub()
};

void TestClass2::pub()
{
  static Anotherclass crashingInstance;
}
...
MainClass::MainClass()
{
  AClass anInstance;
  anInstace.pub();
}
...
```

## 11.2 Simple command line application debugging

We will take the C++ Hello World application **myapp** from chapter [▶ 7.2 Simple command-line application] here to show how to set up a remote debugging session with GDB using the Yocto SDK.

Though, most of the readers are intersted in using a debugger GUI this chapter is eesential since most debugger GUIs for Linux, **including Eclipse CDT and QtCreator**, are frontends to GDB and the setup require an understanding how GDB works in the background.

Modify thee **Makefile** as follows:

```
myapp: main.cpp
#       $(CXX) ${CXXFLAGS} -o $@ $<
        $(CXX) ${CXXFLAGS} -O0 -o $@ $<
#       $(STRIP) $@

clean:
        rm -f myapp *.o *~ *.bak
```

Since the code is debugged with **-O2** optimization, the debugger can't cleanly relate object code to high level source lines. That will result in problems on high level language (C/C++ in this case) stepping (the cursor will jump arround) as already discussed in [▶ 11.1 Important hints]. We add **-O0** to allow proper stepping.

Further, we do not strip the debug symbols, since they are needed for debugging. This topic was also already discussed in [▶ 11.1 Important hints].

Now, we have to assure that the development host and the target device are connected to the same IP network.

Check the IP address of the target device:

```
root@santaro:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 00:07:8E:1C:38:B2
          inet addr:172.20.55.89  Bcast:172.20.255.255  Mask:255.255.0.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:84 errors:0 dropped:0 overruns:0 frame:0
          TX packets:22 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:6792 (6.6 KiB)  TX bytes:4551 (4.4 KiB)
...
```

In this case **172.20.55.89** is used.

Now, recompile **myapp** and transfer it to the target (with **scp** in this case):

**Note:** For all the following steps the SDK environment has to be sourced.

```
$ source
    ↪ /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/environment-setup-imx6guf-guf-linux-gnuea
$ make
```

```
$ make clean
$ make
$ scp myapp root@172.20.55.89:/tmp/myapp
```

If necesary, stop the automatically started demo application. This can be done from the development host with **ssh**:

```
$ ssh root@172.20.55.89 '/etc/init.d/qt-guf-demo stop'
```

Start the **gdbserver** on the device (again from the host through **ssh**):

```
$ ssh root@172.20.55.89 'gdbserver :2345 /tmp/myapp' &
```

Now, the gdbserver is waiting for the remote debugger to connect on the specified port **2345**. The output should look like this:

```
Process /tmp/myapp created; pid = 1266
Listening on port 2345
```

Start the remote debugger out of the **myapp** source directory:

```
$ arm-guf-linux-gnueabi-gdb `find /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/
    ↪ imx6guf-guf-linux-gnueabi/usr/src/debug/ -type d -printf '-d %p '` -d $PWD
    ↪ myapp
```

The embedded find command assures that the debugger can access all SDK source codes that are eventually accessed by the debug session (e.g. setpping into a library call). Every source path found in the specified directory is passed to GDB with the **-p** option. The source pathes inside the ELF debug information may be relative or absolute. This depends how they are passed to the compiler. So this is the only way to assure that every source path of the whole Yocto BSP is known by the debugger and every source file is found when referenced.

After executing GDB with the above command the GDB shell is entered.

Set the sysroot for the debugger, where it can find the linker and the system libraries:

```
(gdb) set sysroot /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-
    ↪ linux-gnueabi
(gdb) set auto-load safe-path /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/
    ↪ imx6guf-guf-linux-gnueabi
```

Connect to the target device:

```
(gdb) target remote 172.20.55.89:2345
```

The output from the debugger should look like this:

```
Remote debugging using 172.20.55.89:2345
Reading symbols from /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-
    ↪ linux-gnueabi/lib/ld-linux-armhf.so.3...Reading symbols from /opt/guf/
    ↪ GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-linux-gnueabi/lib/.debug
    ↪ /ld-2.22.so...done.
```

```
done.
0x76fcfac0 in _start () from /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/
    ↪ imx6guf-guf-linux-gnueabi/lib/ld-linux-armhf.so.3
```

The execution is halted at the **_start** entry point before **main**. Set a breakpoint to **main** and let the debugger continue execution:

```
(gdb) b main
...
(gdb) c
```

The debugger will continue and the breakpoint will be hit. This should look like this:

```
Continuing.

Breakpoint 1, main (argc=1, argv=0x7efffe14 at main.cpp:7)
7               cout << "Hello World!" << endl;
```

From now on debugging is almost like using a dgb natively on the target.

The following examples demonstrate the most basic use cases applyd to the **myapp** example:

Show call stack:

```
(gdb) bt
#0 main (argc=1, argv=0x7efffe14) at main.cpp:7
```

Show the contents of a variaable or more complex data type:

```
(gdb) p *argv
$1 = 0x7effff05 "/tmp/myapp"
```

Step over:

```
(gdb) n
8          return 0;
```

List code:

```
(gdb) l
3       using namespace std;
4
5       int main(int argc, char *argv[])
6       {
7               cout << "Hello World!" << endl;
9               return 0;
10      }
```

Command to stop the gdbserver on the target from the host remotely, if needed:

```
$ ssh root@172.20.55.89 'killall gdbserver' &
```

For more information consult the GDB documentation:

- https://www.gnu.org/software/gdb/documentation

### 11.2.1 KDbg as simple GUI debug frontend

Most developers don't want to use GDB from the command line. As said previously, there are a lot of frontends available to GDB. For those that don't want to use a full featured IDE such as Eclipse or Qt Creator to just debug from a front end **KDbg** may be a good choice.

**KDbg** can be installed on Ubuntu with the following command:

```
sudo apt-get install kdbg
```

The cross debugger to be used by KDbg is set up by starting **KDbg** on the development host once without connecting to the target:

```
$ kdbg
```

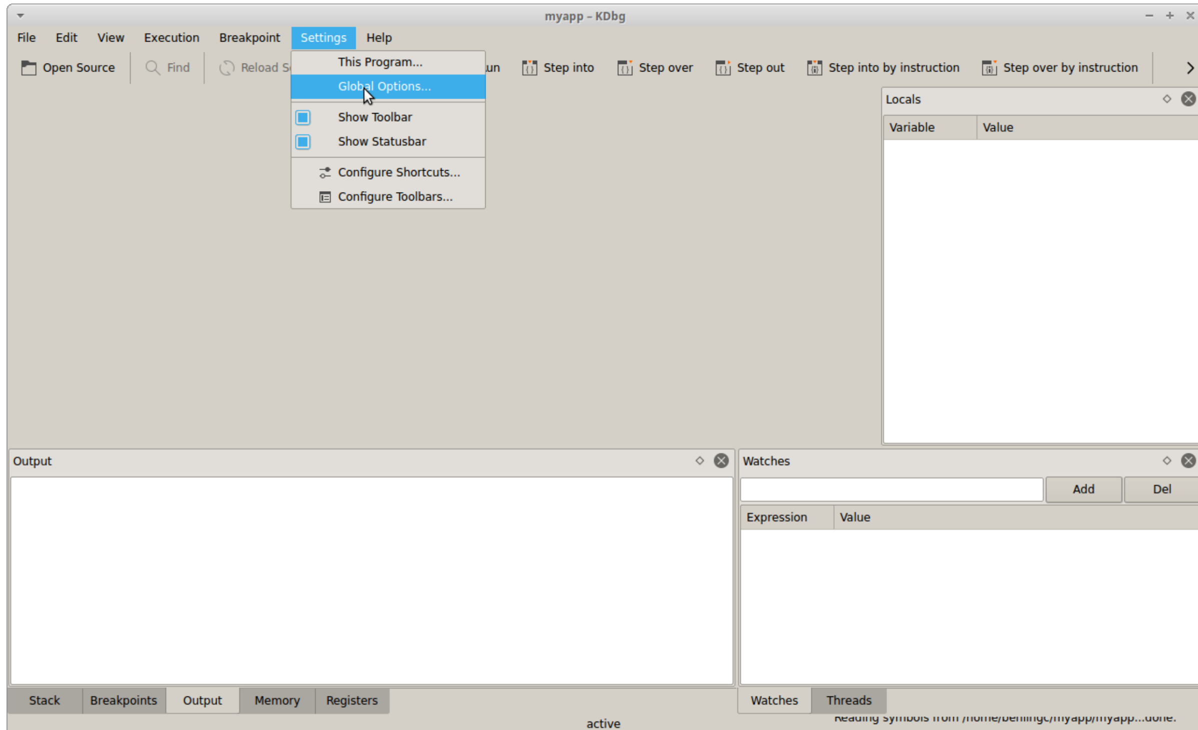


Figure 14: KDbg global options

The GDB command to invoke can be set up under the dialog opened with **Settings->Global Options...** as shown in [▶ Figure 14].

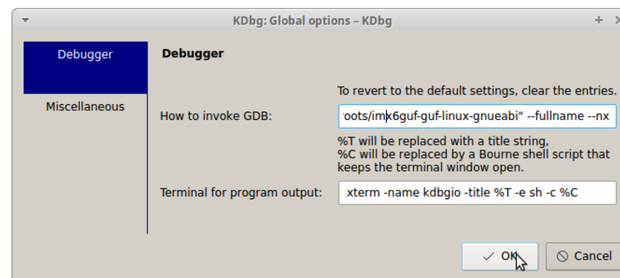


Figure 15: KDbg global options dialog

Set up **How to invoke GDB** in the dialog as shown in [▶ Figure 15] as follows:

```
$ arm-guf-linux-gnueabi-gdb -iex "set sysroot /opt/guf/
    ↪ GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-linux-gnueabi set auto-
    ↪ load safe-path /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/imx6guf-guf-
    ↪ linux-gnueabi" `find /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/sysroots/
    ↪ imx6guf-guf-linux-gnueabi/usr/src/debug/ -type d -printf '-d %p '` -d $PWD --
    ↪ fullname --nx
```

**KDbg** does not have the possibility to enter gdb commands. So the sysroot setup is done through GDB's **-iex** command line parameter instead.

Exit from **KDbg** now.

The gdbserver controlling **myapp** on the target is started as in the GDB command line scenario descriped priviously:

```
$ ssh root@172.20.55.89 'gdbserver :2345 /tmp/myapp' &
```

Start **KDbg** again with connecting to target device with the follwoing command out of the **myapp** directory:

```
$ kdbg -r 172.20.55.89 myapp
```

The **KDbg** opens again while connecting to the target.

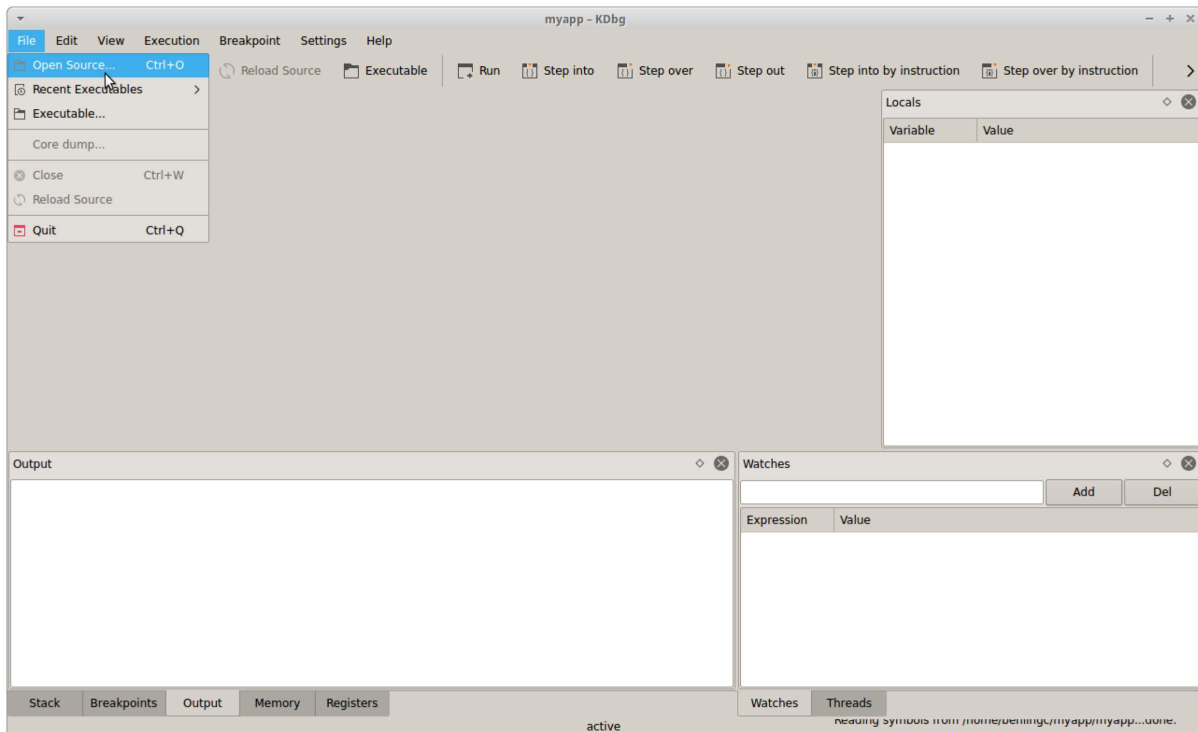


Figure 16: KDbg source navigation

Source files can be opened through **File->Open Source...** as shown in [▶ Figure 16].

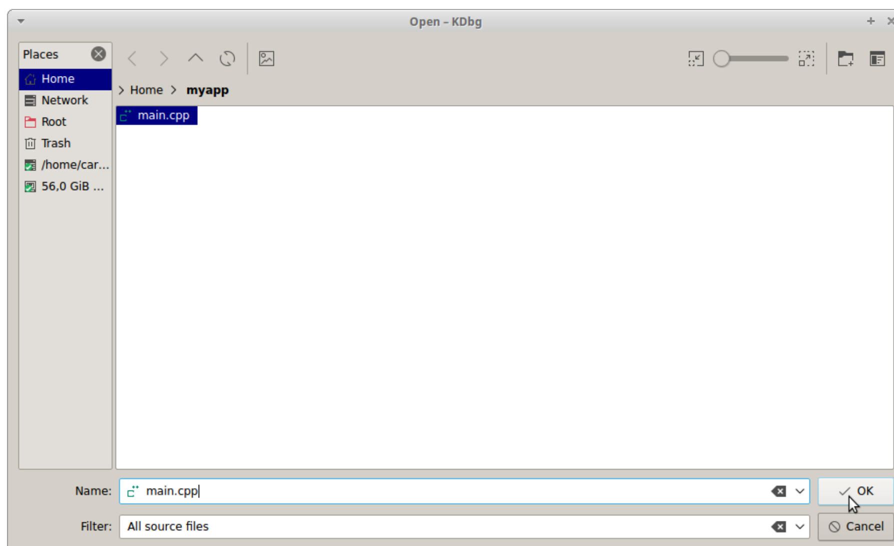


Figure 17: KDbg source file selection

Select **main.cpp** as shown in [▶ Figure 17].

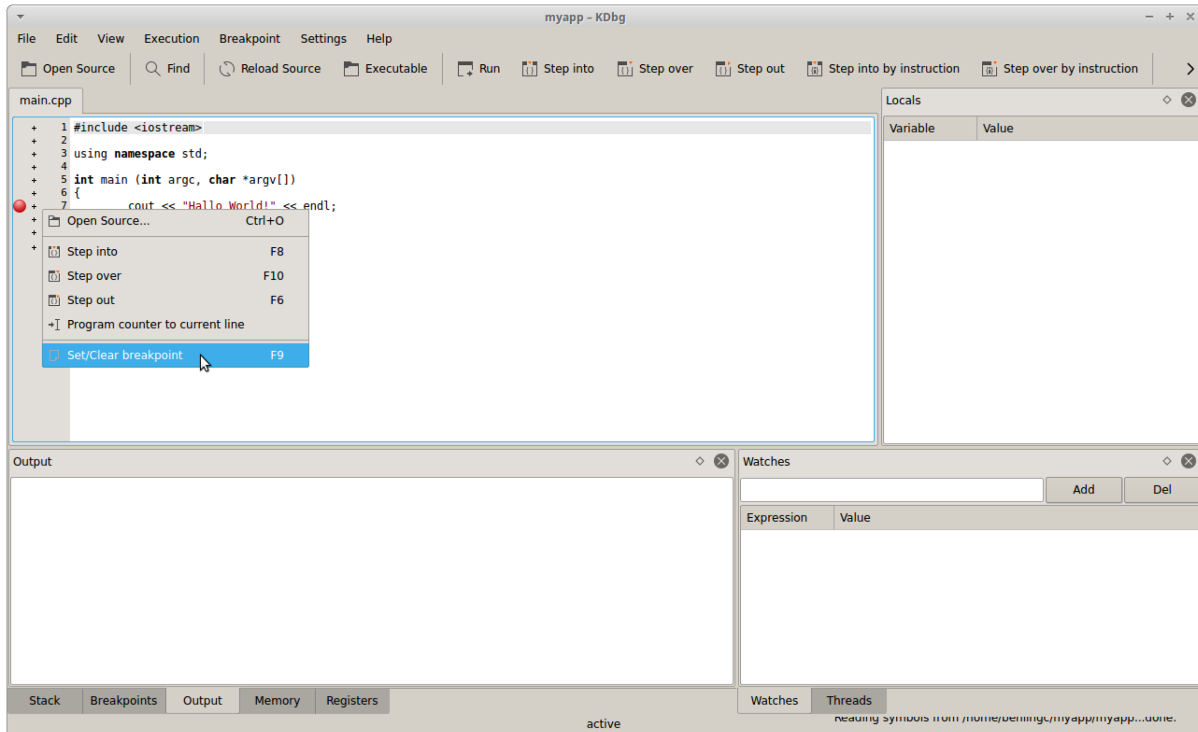


Figure 18: KDbg breakpoint setup

Now, a breakpoint can be set by right-clicking on the deired instruction as shown in [▶ Figure 18].

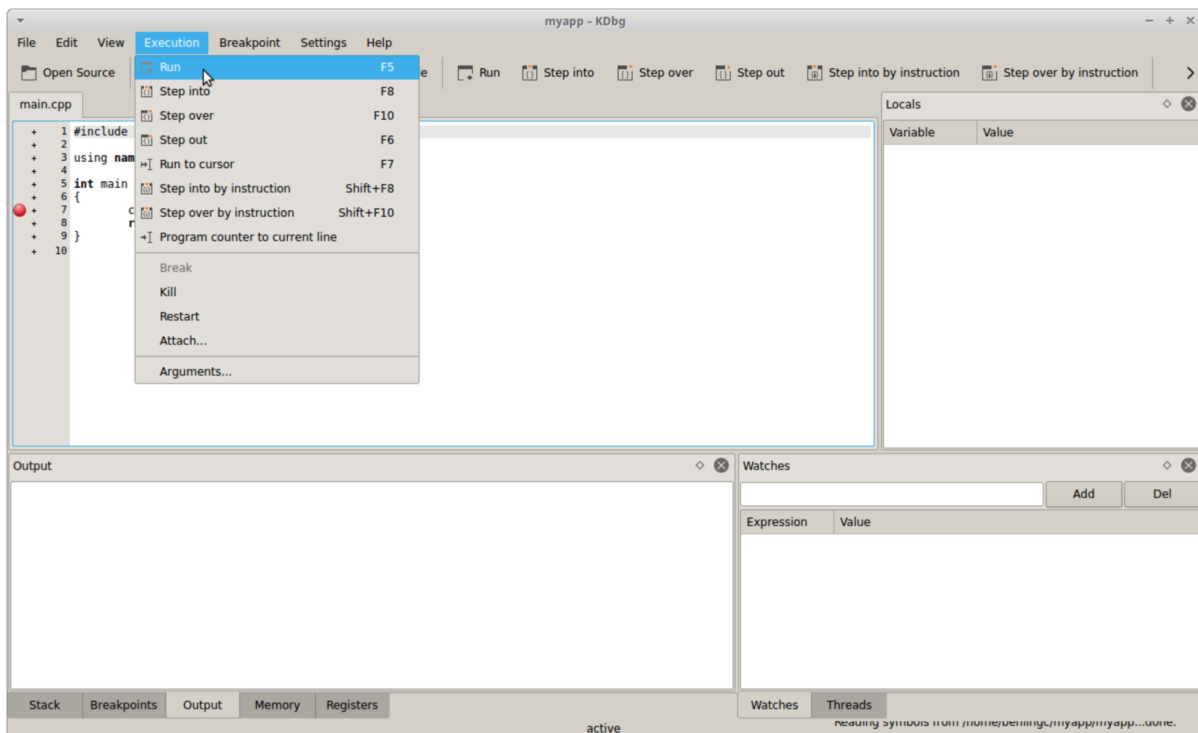


Figure 19: KDbg run command

By selecting **Execution->Run** the execution can be started as shown in [▶ Figure 19].

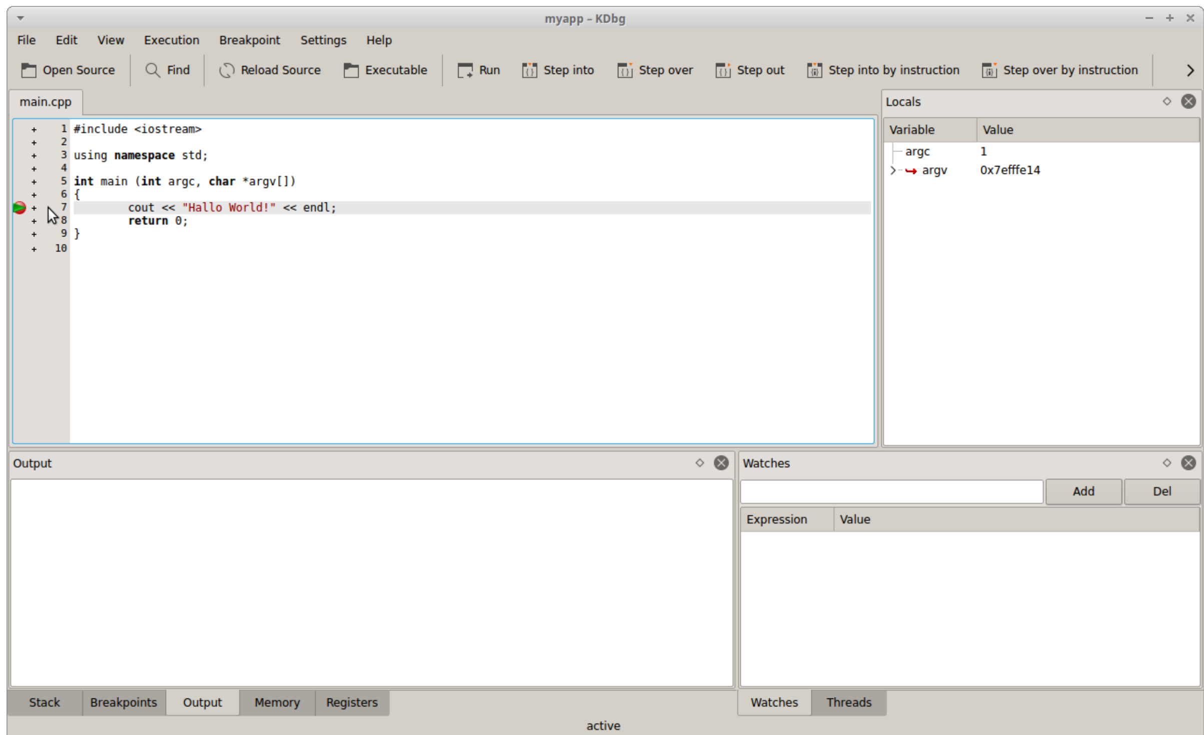


Figure 20: KDbg breakpoint hit

The breakpoinrt hit is indicated by the green arrow as shown in [▶ Figure 20].

The further usage of KDbg is self-explaining. Fur further documentation please consult the KDbg reference manual:

▶ http://www.kdbg.org/manual

## 11.3 Qt application debugging

Based on the Qt Creator setup discussed in [▶ 7.4 Using the Qt Creator IDE], this chapter demonstate a simple Qt Widget application debugging session.

Make sure that all Qt Creator setup steps are already done up to [▶ 7.4.2 Developing with Qt Creator]

**Note:** For all the following steps the SDK environment has to be sourced.

```
$ source
    ↪ /opt/guf/GUF-Yocto-jethro-4.1-r6741-0-sdk/environment-setup-imx6guf-guf-linux-gnuea
$ make
```

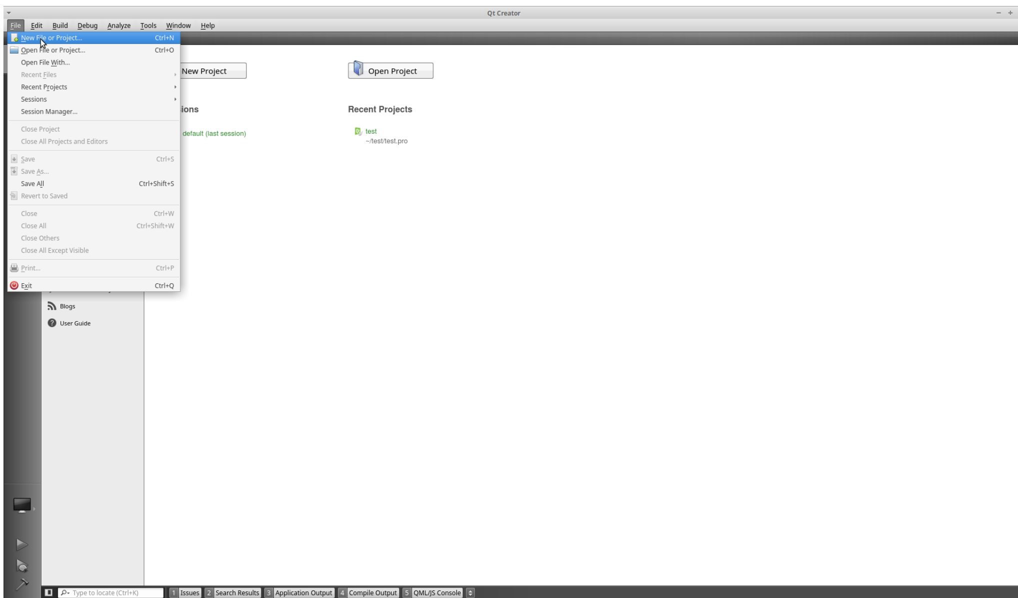


Figure 21: Qt Creator new project creation

Create a new project through **File->New file or project...** as shown in [▶ Figure 21].

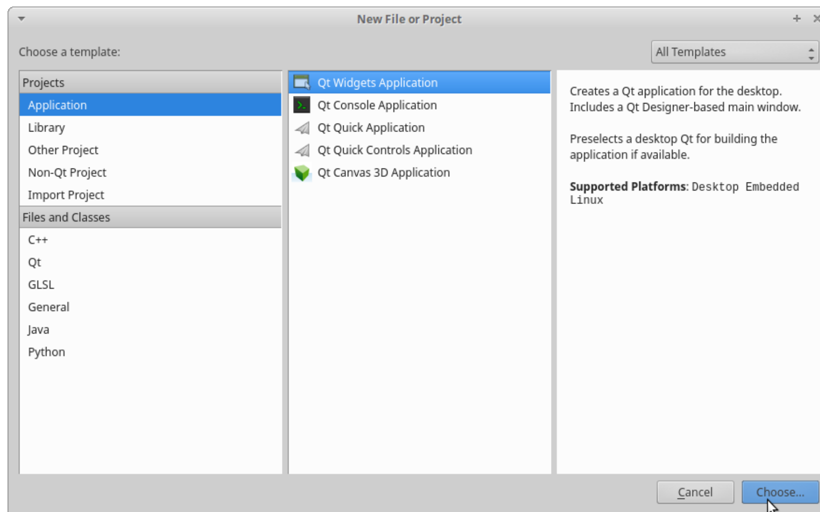


Figure 22: Qt Creator Qt Widget Application project type selection

Select **Qt Widgets Application** as shown in [▶ Figure 22].

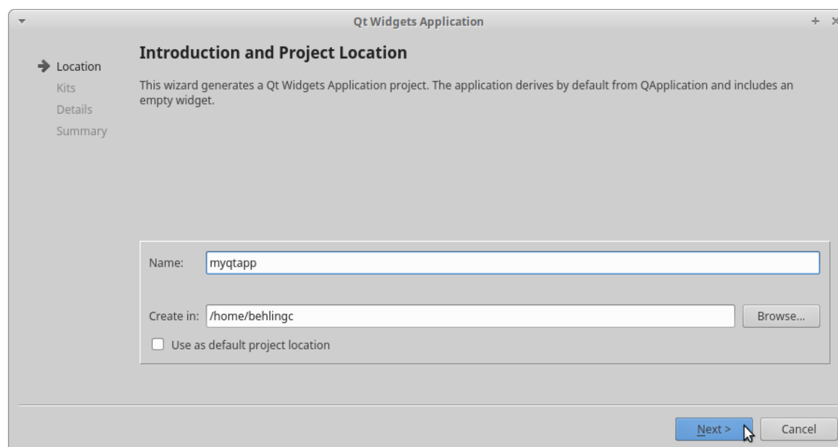


Figure 23: Qt Creator project naming

Name the project **myqtapp** as shown in [▶ Figure 23].

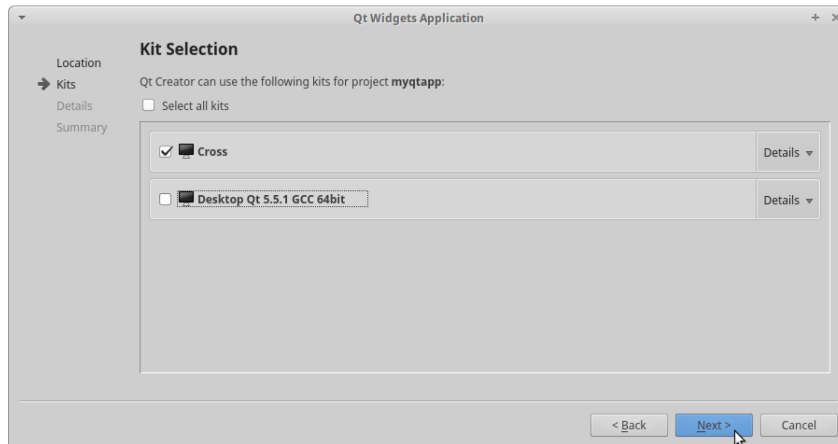


Figure 24: Qt Creator kit selection

Select the cross development kit that was created and configured in [▶ 7.4.2 Developing with Qt Creator] as shown in [▶ Figure 24].

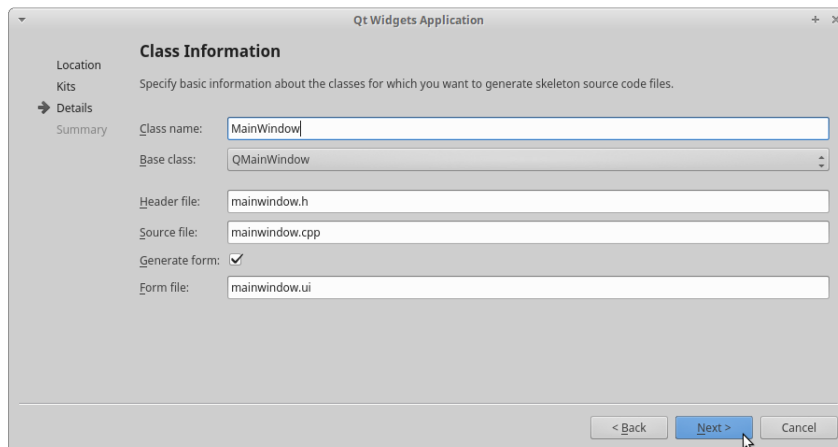


Figure 25: Qt Creator project main class information

Leave the default widget class creation setup as shown in [▶ Figure 25].

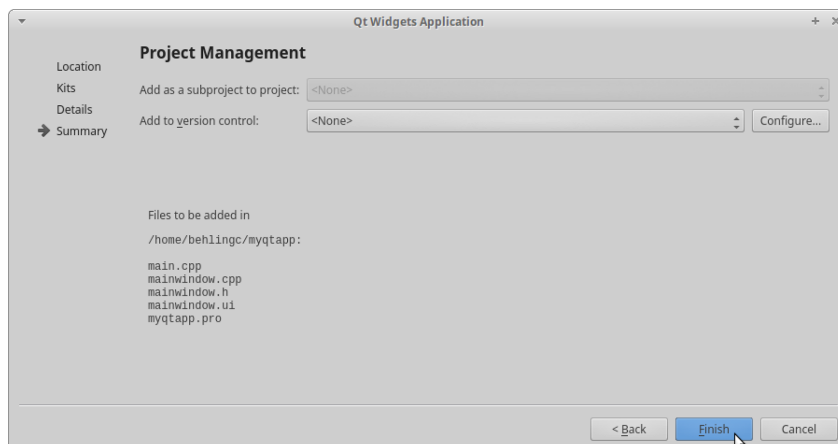


Figure 26: Qt Creator project version control setup

Do not setup any version control system as shown in [▶ Figure 26].

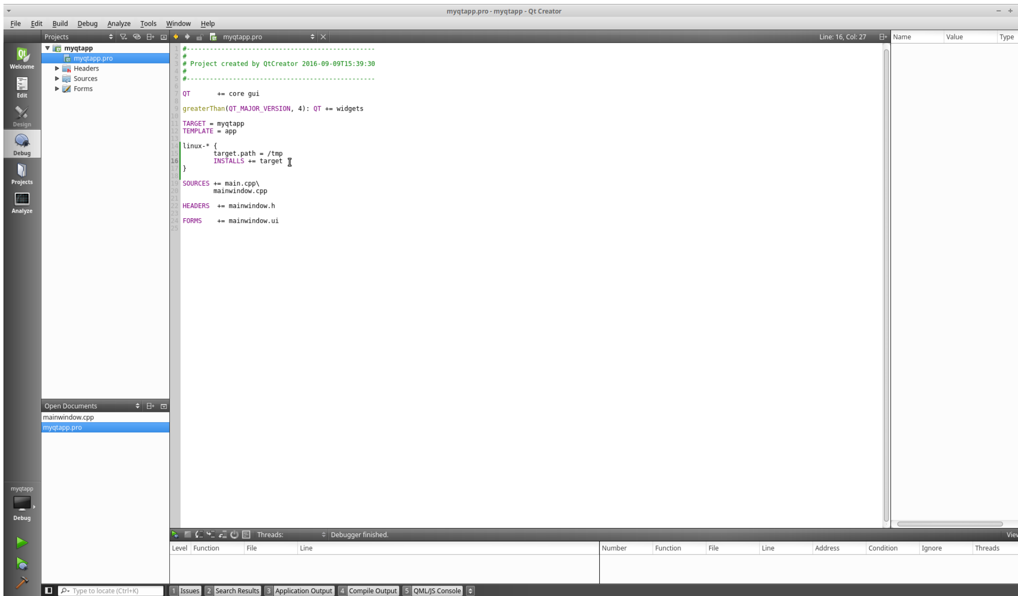

Figure 27: Qt Creator target installation path setup

Add the following lines to **myqtapp.pro** to set up the installation path of the **myqtapp** application:

```
...
linux-* {
        target.path = /tmp
                INSTALLS += target
}
...
```

as shown in [▶ Figure 27]. We select **/tmp** here.

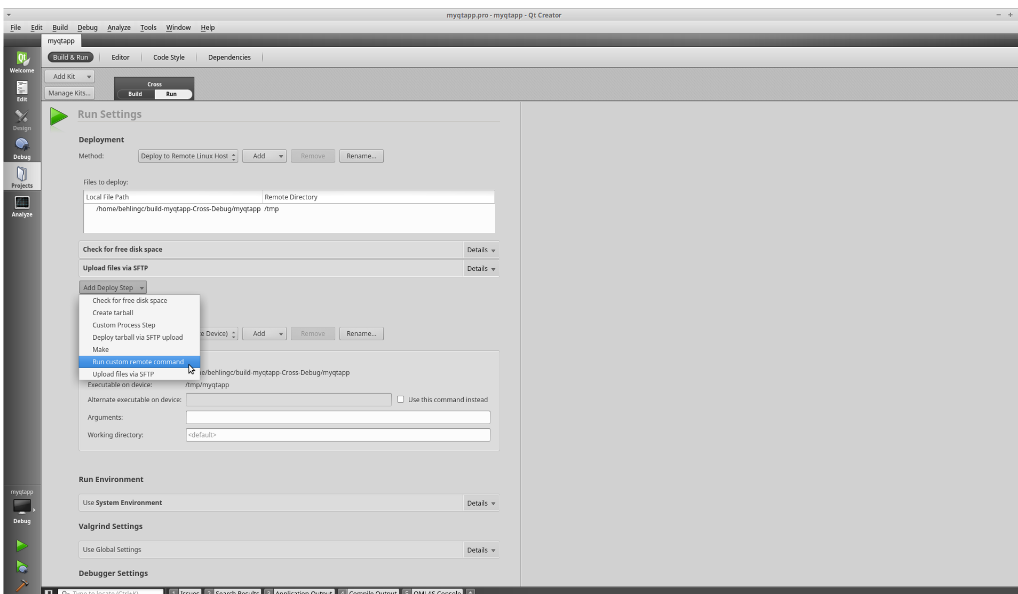

Figure 28: Qt Creator custom remote command insertion

Select **Projects->Build & Run->Run->Add Deploy Step** and select **Run custom remote command** as shown in [▶ Figure 28].

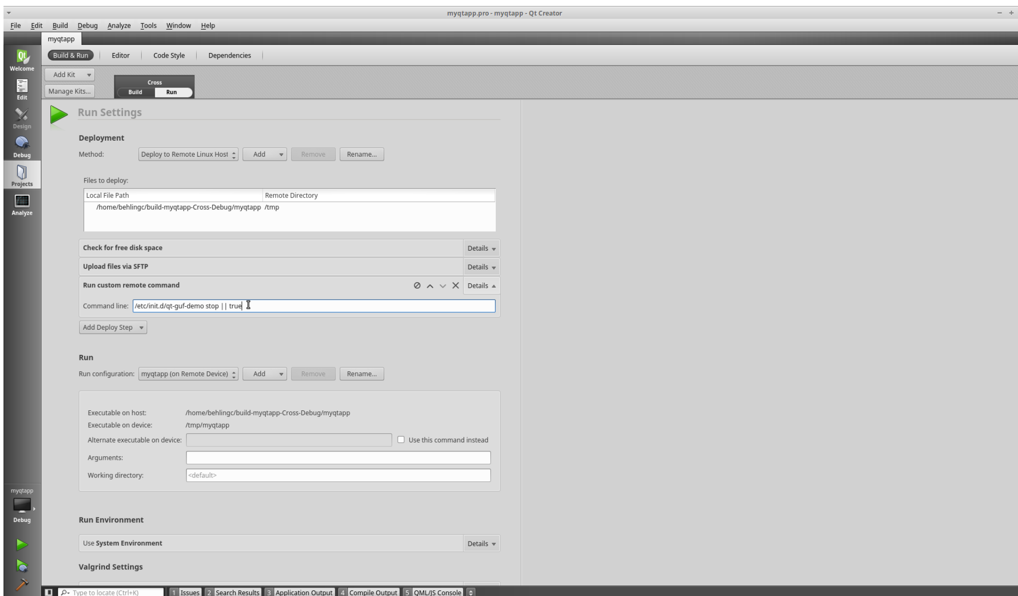


Figure 29: Qt Creator custom remote command to terminate demo app if running

Add the command

```
/etc/init.d/qt-guf-demo stop || true
```

as shown in [▶ Figure 29] to make sure that the automatically Garz & Fricke demo is stopped if it's running.

From [▶ Figure 29] we can further see, that the remote installation directory we set up previously is now known under **Files to Deeploy:**.

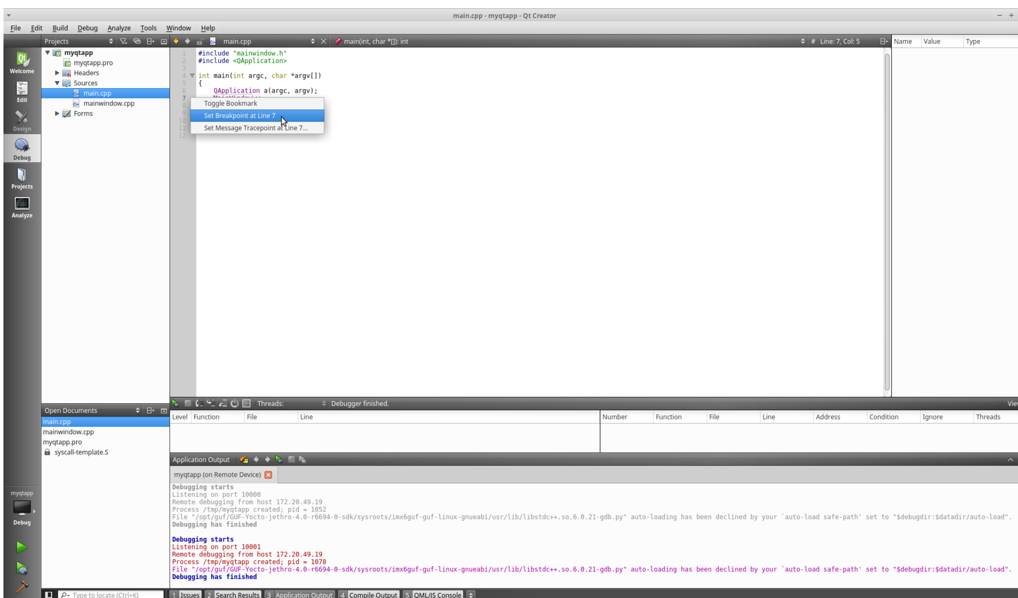

Figure 30: Qt Creator breakpoint setup

Now, set up a breakpoint s shown in [▶ Figure 30] by reight-clicking the desired line through the context menu.

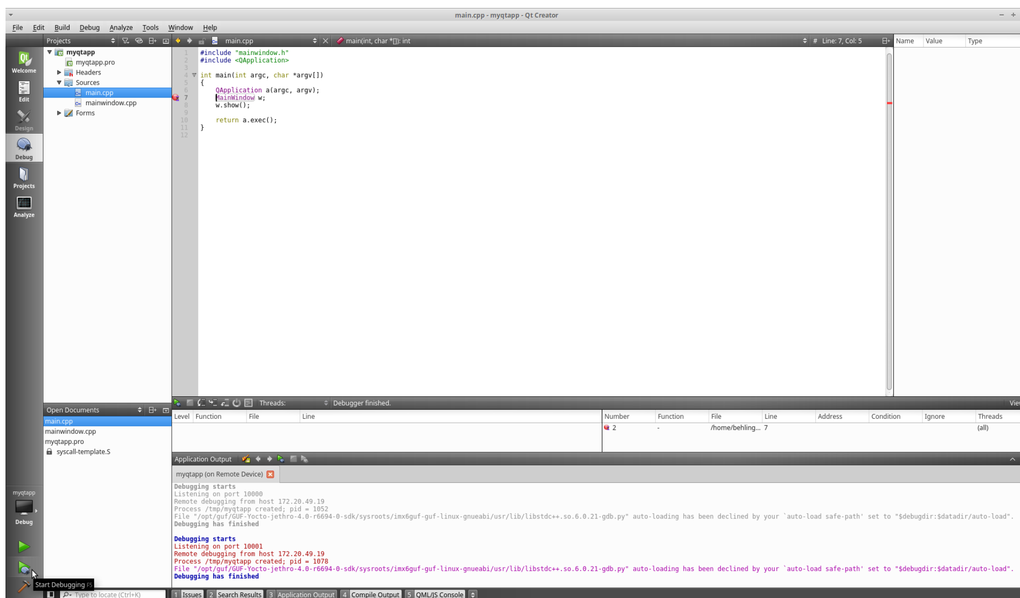


Figure 31: Qt Creator debug start and breakpint hit

Finally, debugging can be started s shown in [▶ Figure 31].

For more information about Qt Creator debugging consult the debugging part of the reference manual:

- ▶ http://doc.qt.io/qtcreator/creator-debugging.html

## 12 Related documents and online support

This document contains product and OS specific information. Additional documentation is available for the use of the bootloader.

| Title | File Name | Description |
|---|---|---|
| GUF Yocto Release Notes | GUF-Yocto-jethro-4.1-r6741-0-SANTARO-release-notes.html | Contains details about the Yocto release: change history, known restrictions, performed tests, etc. |
| Flash-N-Go System User Manual | GF_Flash-N-Go_Manual-<version>.pdf | Contains relevant information about the BIOS, boot logo, display settings, etc. in the case that Flash-N-Go Boot is used as the bootloader. |
| Red-Boot User Manual | GF_RedBoot_User_Manual_<revision>.pdf | Contains relevant information about the BIOS, boot logo, display settings, etc. in the case that RedBoot is used as the bootloader. |

Support for your Garz & Fricke embedded device is available on the Garz & Fricke website. You can find a list of the available documents, as well as their latest revision and updates for your system under the following link:

- http://www.garz-fricke.com/santaro-download

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