Linux Guide

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Table of contents

1. Introduction

The Portux is a single board computer with an Atmel ® AT91RM9200 microcontroller. A powerful ARM920T core with 180MHz is working inside it.
The AT91RM9200 has a huge number of integrated devices like USB, Ethernet and USARTS.
The Portux is delivered with an customized Linux and the bootloader U-Boot.

This document will describe how to install and customize the Portux's operation system. It will also describe how to handle the drivers for the matrixkeyboard, display and touchscreen.

Furthermore it will describe how to setup an development system and you will be given small examples that demonstrate how to compile your own applications and how to use the matrixkeyboard and the display in your applications.

Because of the wide variety of existing operating systems taskit can only give support for the ***Debian GNU/Linux*** operating system.
Taskit is utilising the Linux-based operating system Debian (www.debian.org) as development system because it is one of the most reliable operating systems.
Furthermore it is easy to install additional software on Debian because you only need the tool **apt-get** to automatically download software packages that are installed and configured automatically.
Debian can be downloaded free from the internet and the installation is also very easy because you only need to download a portion (http://www.uk.debian.org/distrib/netinst) and the remaining parts will be automatically downloaded and installed from the internet.

A cross-platform toolchain for cross compiling on Debian can be found on the starter-kit CD.
Developing on MS Windows is not supported by taskit.

Instructions for the first start-up of the Portux are located in the **Portux Quick Start Guide**. If you want to develop your own drivers or hardware extensions you will have to work the appropriate **Technical Reference** and **Atmel manual** for your product over.

2. Supported products

The specifications in this document apply to the following products:

- Portux 920T EU / SW
- Portux Panel-PC
- Panel-Card

All specifications concerning memory addresses are exemplary. The accurate memory address specifications for your product can be found in the appendix (memory map).

It is possible to skip some chapters of the document, depending on the configuration of your product. For instance if your product isn't equipped with a display, you can skip the chapter “The Display”.

3. Mounting MMC or SD-cards

An MMC- or SD-card can be used to save larger amounts of data.
Before you can mount a card you have to create a directory as mountpoint: **mkdir /data** .

To map a card mounted in the MMC slot to a FAT file system, use the following command:
mount -t vfat /dev/mmc/blk0/part1 /data
If an ext2 file system is on the MMC card, the command is:
mount -t ext2 /dev/mmc/blk0/part1 /data
Nowadays some vendors deliver their cards without any partition. These cards can then be mounted by accessing the entire disc:
mount -t ext2 /dev/mmc/disc/part1 /data

When using MMC/SD-card have in mind that the driver doesn't support hotplugging. As a result it is necessary that the SD/MMC-card you want to use, has to be inserted before the operating system boots up. SD/MMC-cards inserted after the boot process, won't be detected.
If an MMC/SD-card was inserted before the boot process and mounted, it can be removed after unmounting: **umount /data.** After that it is not possible to insert the same, or any other card, again.

If it is essential for you to have a removable mass storage device, the best solution is to use an USB memory stick. It can be inserted after the boot process and mounted (mount /dev/sda1 /data). After unmounting (unmount /data) it can be removed and another USB-stick can be inserted.

4. Using the bootloader „U-Boot“

U-Boot is an open-source boot loader for embedded systems. U-Boot is well-documented, customizable, and loaded with functions. The U-Boot boot loader has been ported to more than 100 platforms. Wolfgang Denk (www.denx.de) maintains this project at www.sourceforge.de. The README in the U-Boot source code contains very detailed documentation of U-Boot.

Before you can start customizing the bootloader you will have to know the flash addresses of the installed software and flash partition sizes belonging to your product. These informations can be found in the appendix (Memory map).

4.1. Setting up a TFTP server under Linux

To transfer customized firmware a protocol for transferring data without the use of the operating system is needed.
The TFTP (Trivial File Transfer Protocol) implemented in the bootloader U-Boot is used for simple transfer of a Linux kernel image or a root file system image.
A corresponding TFTP server must be set up on the development system for this purpose. Use apt-get to install the required tftpd demon under Debian: **apt-get install tftpd** .
Usually tftpd is not started directly, but rather via the inetd Internet demon. An entry for TFTP must be on hand in the inetd configuration file after installation. Under Debian, the line **tftp dgram udp wait nobody /usr/sbin/tcpd /usr/sbin/in.tftpd /tftpboot** is automatically entered in the configuration file **/etc/inetd.conf** during packet installation. The server is given the base directory with **/tftpboot**. If no argument is given at start-up, the server uses **/tftpboot** as the base directory. This directory must exist, and must be readable by all users.

```
mkdir /tftpboot
chmod 777 /tftpboot
```

4.2. Description of the bootprocess

After resetting or turning on the power supply, an internal boot loader is started on the AT91RM9200. It searches the peripherals for a bootable program, in the following order:

1. Dataflash on NPCS0
2. EEPROM on TWI
3. 8-bit memory on NSC0

A bootable program can be identified by the eight exception vectors at the beginning of the program. If no valid sector sequence is found, the internal uploader is started. The uploader initializes the serial debug port and loads a program via DBGU for USART0 or using DFU (Device Firmware Upgrade) for USB into internal SRAM. It then starts the newly-loaded program.
If a valid vector sequence is found, the code is likewise loaded into the internal SRAM. (Information about the code length is stored in the sixth vector.) Then the *remap* command is carried out, and jumps to the first address of the internal SRAM.

The parallel flash is connected to NSC0 and is used as the boot medium.
In the first phase of the boot process the Atmel controller starts the bootloader U-Boot.
The U-Boot start code loads the boot loader at address 21 F00 000 (SDRAM).
U-Boot then initializes the memory.
In the second phase of the boot process the bootloader boots the Linux image found in flash memory.
The Linux image is decompressed to SDRAM. At last the root filesystem image is decompressed by Linux and stored in SDRAM.

You can interrupt the boot process by pressing any key during the first phase of the boot process (within 3 seconds). Then the U-Boot command line appears.

4.3. Reading and writing memory and flash memory

The Portux data bus for memory is 32-bit and for flash 16-bit wide. Therefore, we recommend using all variable memory commands with the **.l**, .**w** or **.b** option (long word, word or byte). Otherwise, side effects cannot be ruled out.

Example:
cmp - memory compare
cmp [.l, .w, .b] Addr1 Addr2 count

You can check the contents of two memory ranges with the **cmp** command. Extensions can be used to determine the size of the memory access:
cmp.l -> 32-bit long word (default), .w ->16-bit word or .b -> 8-bit byte.
The comparison runs until the number of units indicated by count have been compared, or until the first difference is found. The size of the memory compared is calculated by count * (l,w,b).

All commands that read memory can be used for both flash and SDRAM. Commands that modify memory (with the exception of **cp***,* which recognizes flash regions on its own) can be used only for SDRAM and are inappropriate for directly writing flash memory.
Please note, when performing memory write operations, that the area containing the U-Boot code is not modified; this will generally crash the system.
Before executing write operations on the flash memory you must ensure that the corresponding memory range has already been erased, using the **erase** command (described below). Note also that the memory area used for U-Boot and the environment variables is protected against accidental write operations. You can turn this write protection off and on using the **protect** command.

A complete list of all U-Boot commands can be found at the end of this document (chapter U-Boot commands).

4.4. Scripts with U-Boot

Some environment variables are used by U-Boot if they are set, such as IP parameters.

On the other hand, some are set by U-Boot, such as ***filesize*** and ***fileaddr*** when downloading a file.

Printenv outputs the current contents of the environment variables.
To show specific variables, you can add their names as arguments.

```
printenv [name[ name[ ...]]]
```

During runtime, changes to variables or new variables are stored in RAM and not saved permanently in flash memory. Saving is done explicitly with the **saveenv** command.

```
saveenv
```

Sets the environment variable ***name*** to the value *value*. If the variable already exists, its current value is overwritten; if it does not yet exist, it is created. If no value is given, the variable is erased (if it exists).

```
setenv name value
setenv name
```

The **run** command runs the environment variable ***name*** as if it were a command. This makes it possible to store commands in environment variables and create simple boot scripts.

```
run name
```

Using the **run** command, which makes it possible to run saved variables as a command sequence, you can create simple scripts to automate regularly occurring processes. In U-Boot, the characters **$()** are used to reference variables, **;** is for creating command sequences and **** is the escape character.
U-Boot generally interprets numerical arguments as hex values. In other words, 10000000 is 0x1000 0000 Hex.

For example: U-Boot> **echo $(*filesize*)**
U-Boot> 171a4
Entering this command outputs the contents of the ***filesize*** environment variable. The same command without parentheses would be interpreted as a simple string:

```
U-Boot> echo $filesize
U-Boot> $filesize
```

If the **$** character from the first example is marked with the escape character, the argument is also interpreted as a string:

```
U-Boot> echo \$(filesize)
U-Boot> $(filesize)
```

Similarly, you can use a semicolon to indicate a sequence of commands:

```
U-Boot> echo $(filesize); echo Hello
U-Boot> 171a4
U-Boot> Hello
```

Escape the semicolon with the backslash escape character, and the argument will be interpreted as a string:

U-Boot> **echo $(filesize)\; echo Hello**
U-Boot> 171a4; echo Hello

A list of all U-Boot environment variables can be found at the end of this document (chapter U-Boot environment variables).

4.5. Creating a bootscript

To demonstrate U-Boot's scripting capabilities, we will now describe the construction of a boot script step by step.
This script loads a RAM-disk image from the network via TFTP and starts a kernel found in flash memory with the appropriate boot arguments for size and RAM-disk address.
The following tasks must be carried out: The RAM-disk image needs to be loaded from the network via TFTP, the boot arguments need to be set, and the kernel needs to be booted.
The assumption is made that the following prerequisites have been satisfied: a bootloader and kernel images are stored in flash memory at the correct address and the network environment is configured correctly.

In the first step, the boot arguments are divided into logical sections and the environment variable ***basicargs,*** which contains the static boot arguments, is defined.

U-Boot> **setenv *basicargs* console=ttyS0,115200 mem=64M root=/dev/ram rw**
U-Boot> **printenv *basicargs***
U-Boot> *basicargs*=console=ttyS0,115200 mem=64M root=/dev/ram rw

Then the MTD (memory technology devices) partitions for the flash unit are defined in another variable: ***mtdparts***.
Be sure to note the backslash escape character (\) in front of the semicolon, which prevents the partitioning of the dataflash from being interpreted as a command.

U-Boot> **setenv *mtdparts* mtdparts=phys_mapped_flash:384k(boot)ro,**
1408k(linux)ro,2432k(initrd)ro,-(cfg)\;dataflash0:-(data)
U-Boot> **printenv mtdparts**
mtdparts=mtdparts=phys_mapped_flash:384k(boot)ro,1408k(linux)ro,
2432k(initrd) ro,-(cfg); dataflash0:-(data)

The size and address of the **initrd** can only be determined later, when the current image has been loaded from the network.

The address of the kernel is now stored in a variable and the environment variable ***bootcmd*** is created. ***bootcmd*** is automatically called by the *boot/bootd* command.

U-Boot> **setenv *kerneladdr* 10060000**
U-Boot> **setenv *bootcmd* run ramboot**
U-Boot> **printenv *kerneladdr bootcmd***
kerneladdr=10060000
bootcmd=run ramboot

In the variable ***ramboot,*** we will specify the actual command sequence necessary for booting the kernel.

U-Boot> **setenv *ramboot* tftpboot 21400000 initrd.bin\;setenv bootargs**

\$(basicargs) initrd=0x\$(fileaddr),0x\$(filesize) \$(mtdparts)\;bootm \$(kerneladdr)

U-Boot> **printenv *ramboot***

ramboot=tftpboot 21400000 initrd.bin;setenv bootargs $(basicargs) initrd=0x$(fileaddr),0x$(filesize) $(mtdparts);bootm $(kerneladdr)

Once again, note the escape characters before all special characters. Later, when ***ramboot*** is run, the variable names will be replaced with their contents. Here, however, when setting the variables, they need to be interpreted as strings.

The boot script is now almost done, but the new entries need to be saved by calling **saveenv**; otherwise everything needs to be entered again after the next boot.

U-Boot> **saveenv**

```
Saving Environment to Flash...
Un-Protected 1 sectors
Erasing Flash...flash_erase: first: 9 last: 9
. done
Erased 1 sectors
Writing to Flash... done
Protected 1 sectors
```

Now we can test the script:

U-Boot> **boot**

```
TFTP from server 192.168.2.238; our IP address is 192.168.2.171
Filename 'initrd.bin'.
Load address: 0x21100000
Loading:#################################################################
#################################
done
Bytes transferred = 1478664 (169008 hex)
## Booting image at 10060000 ...
Image Name: uImage
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 739208 Bytes = 721.9 kB
Load Address: 21000000
Entry Point: 21000000
Verifying Checksum ... OK
OK
Starting kernel ...
Uncompressing
Linux..... done, booting the kernel.
...
Kernel command line: console=ttyS0,115200 mem=64M root=/dev/ram rw
initrd=0x21100000,0x169008 mtdparts=phys:192k(boot)ro,832k(linux)ro,
2m(initrd)ro,-(cfg);dataflash0:-(data)
```

4.6. Updating U-Boot

To load a new version of U-Boot, you just need to interrupt the boot process of U-Boot and use the U-Boot running in SDRAM to re-load the U-Boot flash memory area.
Since the U-Boot flash range is write-protected, you must first remove the write protection. Then load the new image from the network via TFTP and copy it to flash.

The original U-Boot images can be found on the starter-kit CD in the directory /tftpboot:

u-boot.bin	contains the bootloader
boot.bin	contains the bootloader inclusive all environment variables excepting the MAC address, this address is worldwide unique and should be written down before updating U-Boot

```
U-Boot> tftpboot 21000000 u-boot.bin
        TFTP from server 192.168.2.238; our IP address is 192.168.2.171
        Filename 'u-boot.bin'.
        Load address: 0x21000000
        Loading: ####################
        done
        Bytes transferred = 94632 (171a8 hex)

U-Boot> protect off 10000000 1005FFFF
        Un-Protected 9 sectors

U-Boot> erase 10000000 1005FFFF
        flash_erase: first: 0 last: 8
        Erased 9 sectors

U-Boot> cp.b 21000000 10000000 171a8
        Copy to Flash... done

U-Boot> protect on 10000000 1005FFFF
        Protected 9 sectors

U-Boot> reset
```

5. Compiling and debugging applications

5.1. Setting up a development system

The development system described here assumes that the Portux is connected to a separate development computer, using either Ethernet or a serial cable. All transfers between the two systems occur exclusively over this connection.
The development system does not have any particular hardware demands; a standard PC is in most cases sufficient. To operate a graphical interface under Linux, a minimum of 64MB RAM and a corresponding graphic card are necessary.
A network card and serial interface are required for connecting to the Portux.
A Linux workstation is normally used as a development computer for an embedded Linux device such as the Portux.

As a basis for such a host system, taskit recommends and supports the freely available Debian Linux distribution for Portux development. Debian stands out for its stability and good packet management. Both the current stable version „woody“ and the forthcoming „sarge“ version may be used. Several ways to acquire Debian are described at http://www.debian.org/distrib/. With a broadband Internet connection, you can download the current installation CD images using the jigdo tool or a BitTorrent client. The procedure for using jigdo is described at http://www.debian.org/CD/jigdo-cd/. The first of the seven CDs in the distribution is sufficient for installing a basic system.
If the development computer has a network connection, additional packages can be installed over the network. For complete installation instructions for the x86 architecture, see http://www.debian.org/releases/stable/i386/install.
The following descriptions relate to such a Debian system.

You could also run a Linux system in a virtual environment using a virtual machine such as VMWare or VirtualPC. This solution, however, severely limits performance and usability.

If the development PC uses Windows 2000 or XP, you can use the cross-platform tool chain under the Cygwin environment (http://www.cygwin.com/).
The installation process of the MS Windows toolchain is described in the appendix but taskit will not grant support for installing and developing on the Microsoft Windows platform.

5.1.1. Installing the toolchain on Debian

A tool chain for cross compiling is the most important element of the development system for the Portux. Precompiled binaries for the i386 architecture are on the starter-kit CD.
In the /toolchain directory on the started-kit CD an installation script can be found, this can only be done by the user root:

cd /dev/cdrom/toolchain
./install_toolchain.sh.

The compilation of a tool chain itself is labour intensive and will not be described here. The toolchain was made with Crosstools, which simplifies the compilation considerable. Have a

look at http://kegel.com/crosstool/ for further information.

After the installation, corresponding version of binutils, gcc and c++ are available for crosscompiling. Type **ls /usr/bin | grep arm-linux** to get a list of all available tools.

5.2. Mounting the working directory

After installing the tool chain, you can compile your own software for the Portux. In the early stages of development, it is convenient to mount the working directory on the development system with NFS (network file system), in order to make changes available quickly.

Installation of the NFS-server:

apt-get install nfs-common nfs-kernel-server

If an NFS server is already set up on the development system, you only need to add one line to the **/etc/exports** file:

/portux/develop *.local.domain(ro).

This line exports, for example, the /portux/develop directory for all clients on the local domain with read access. If this folder does not exist it has to be created:

mkdir /portux
mkdir /portux/develop
chmod 777 /portux/develop

The exported directory can then be mapped to a directory on the Portux with the mount command.

mkdir /mnt/develop
mount -t nfs -o nolock *nfs_servername*:/portux/develop /mnt/develop

5.3. Compiling the application sample

In the **/examples** directory on the starter kit CD you will find the **example1.c** file, which contains C sourcecode for a simple program for entering and printing text on the Portux. For editing, first copy the file to the /portux/develop directory on the development computer. Then you can use the cross-compiler to compile example1.c:

arm-linux-3.4.2-gcc -Wall example1.c -o example1 .

5.4. Starting the sample

If the execution rights for the newly created binary are set correctly, the program can now be called on the Portux:

cd /mnt/develop
./example1

5.5. Debugging the sample

The GNU debugger (GDB) is one of the most important debugging tools for Linux. To

debug an embedded system, set up a gdb server with the gdb package. The gdbserver itself is a small application that carries out commands from the gdb, which runs on the development system. You will find the gdbserver in the Linux starter kit's root file system, in the **/usr/bin** directory. Before debugging a program, you must compile it with the appropriate flags (-g or -ggdb for more information).

cd /portux/develop

arm-linux-3.4.2-gcc -g example1.c -o example1_debug

If you include in debugging information, the binary created is much larger. As long as you have the original version with the debugging information on the development system, however, you can simply copy the smaller, stripped-down version to the target system. You can strip down the debugger using the arm-linux-strip tool.

For remote debugging, you can set up communication between the gdbserver on the Portux and the gdb on the development system either over a serial null modem cable or over a TCP/IP connection. The connection via TCP/IP is described below. First you need to start the gdbserver on the Portux, and then create the connection from the gdb on the development computer:

gdbserver *development_computer_ip*:2345 example1_debug

The development computer is entered as host. As port, choose any available port. All command line parameters for the program (in this case, led is an integer indicating the number of repetitions) must be given in this call. Then you can start the gdb on the other system and create the connection to your Portux:

arm-linux-gdb example1_debug

(GDB) **target remote *portux_ip*:2345**

Now you are ready to start debugging with the usual gdb commands.

5.6. Downsizing the binary

After compiling the example the filesize of the binary can be noticeable reduce by removing unneeded informations generated by the compiler as well as debug informations (debugging wont be possible any more):

arm-linux-3.4.2-strip example1

6. Compiling a new linux kernel

If you work with Embedded Linux regularly, you will often face the need to create your own kernel. In most cases, this involves integrating new drivers, e.g. for USB devices, or additional file systems. Because memory space is limited on an embedded board, it does not make sense to set up a large number of drivers to start with (as is common for desktop PCs) unless you know for sure that you actually need them.

The kernel binaries and sources delivered with the Portux are made up of a standard kernel with ARM patches and some AT91-specific patches or drivers.
The process for creating your own kernel is broken down into three steps – configuring, compiling and installing.

6.1. Configuring the kernel

The source codes for the Linux kernel are on the starter-kit CD in the tarred GZIP archive **linux.tgz**. The kernel sources are configured in delivery form. You just need to append the drivers you want to use or deselect the drivers that you don't need.
Before you can configure the kernel the tarred archive has to be extracted to your development folder:

cd /portux
tar -xzvf *starter-kit-CD*/linux.tgz

Before creating a new configuration, we recommend making a backup of the old configuration:

cd /portux/linux/linux-X.X.XX
cp .config .configBAK

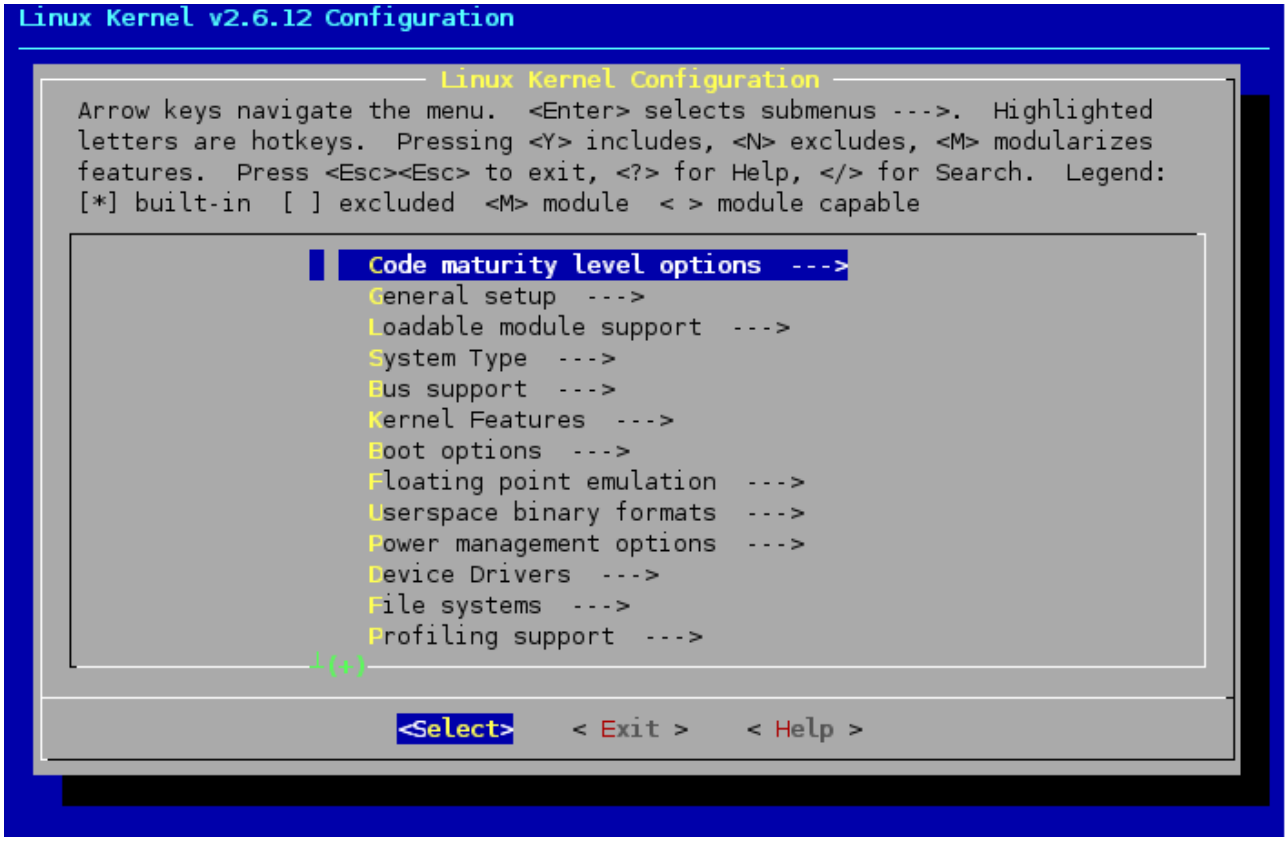
Note: X.X.XX is the version number of the linux kernel.

Various tools can be used for kernel configuration; the most well-known is menuconfig. Menuconfig is a Text User Interface (TUI), it offers a text-based interface, which allows for easy configuration and can also be used in terminal emulation mode. In order to use it you have to install the curses development package:

apt-get install ncurses-dev .

After that you can start the kernelconfiguration by typing:

make menuconfig.



The options can now be selected or deselected in the individual levels. The basic selection consists of „**empty**“, „*****“, „**M**“. Empty means that the driver will not be compiled with the kernel. * means that the driver will be included in the kernel binary. M means that the driver is configured as a module; in other words, it can be dynamically activated and deactivated at runtime. When you have set the configuration as you like, finish the process with Exit and Save. The kernel is now ready to compile.
The corresponding options for cross-compilation are already entered in the makefile.

6.2. Compiling the kernel

Compiling is simple: **make zImage**
If the compilation runs without errors, the compiled image is saved in **arch/arm/boot**.
If you configured drivers as modules, you still need to create these: **make modules** .
The kernel makefile provides a target for installing the modules – modules_install. By default, the modules are installed in the **/lib/modules** directory. For cross-environment development, the modules must be installed in a different directory. The example gives a module directory within the Linux source folder. When entering the path to the module directory, ensure that no relative paths are given; since the script goes through the kernel directories, relative paths can change.

make INSTALL_MOD_PATH=/portux/linux/modules modules_install

The modules are now copied to the /portux/linux/modules/lib/modules/modules/2.x.xx/ directory.

6.3. Preparing the kernel

To install the new kernel on the Portux, you now need to prepare the zipped kernel image for use by U-Boot. This is done using the **mkimage** tool. Mkimage is also included in the /scripts directory on the starter-kit CD.
Enter the following 3 lines as one line separated by a space character:

mkimage -A arm -T kernel -O linux -C none
-a 21000000 -e 21000000 -n plinux
-d arch/arm/boot/zImage uImage

Result:

Image Name: plinux
Created: Tue Dec 14 19:12:23 2004
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 738972 Bytes = 721.65 kB = 0.70 MB
Load Address: 0x21000000
Entry Point: 0x21000000

This script packs a 64 Kb header around the zipped image. This gives U-Boot important information for booting the kernel correctly.
Before you can install the kernel you need to copy the uImage into the tftp directory:

cp uImage /tftpboot

You can also carry out this process by running the simple shell script **install_portux.sh**, which you will find in the /scripts directory on the starter-kit CD.

6.4. Installing the kernel

Finally, load the finished image in U-Boot, program it into flash memory and start it:

U-Boot> **erase 10060000 101BFFFF**
U-Boot> **tftpboot 21000000 uImage**
-> TFTP from server 192.168.2.238; our IP address is 192.168.2.171
Filename 'uImage'.
Load address: 0x21000000
Loading: ##
##
################
done
*Bytes transferred = 739036 (**b46dc** hex)*

The last step is to copy the kernelimage into flash. To do that the copy-command needs the filesize of the kernelimage. The filesize is displayed after the transfer from the remote PC (marked red) and is also stored in the environment variable ***filesize***.

U-Boot> **cp.b 21000000 10060000 $(filesize)**
-> Copy to Flash... done
U-Boot> **boot**

Note: Keep in mind that the kernel image can not be bigger than the size of the corresponding flash disk partition (see appendix). In case it should be bigger you have to

change the flash disk partition sizes (phys_mapped_flash) and reinstall the root and config partition. But this is only necessary in rare cases.

During development, you can also start the image directly from RAM without copying it to flash memory: **bootm 21000000**.

If you have created drivers as modules, install the modules now. Unfortunately, you cannot avoid creating a new root file system (for further information see chapter “Creating a new root filesystem”).

cp -a /portux/linux/modules/* /portux/rootfs/
/portux/mkfsimage.sh
cp /portux/images/initrd.bin /tftpboot

6.5. Resetting to the original state

If the kernel has been configured incorrectly and no longer functions, the delivery state can be reinstated as long as no changes have been made to the source code itself.
In the root directory of the kernel enter the following lines:

cp ../configs/portux-x.x.x-defconfig
make oldconfig //much happens
make dep // much happens

The original configuration is now reinstated.
Entering **make zImage** generates the same kernel that was programmed in flash memory at the time of delivery.
At last repeat steps tree and four to install the kernel.

7. Creating a new root filesystem

7.1. Overview

The root filesystem is the place where system applications and libraries are stored. It is loaded from the flash disk and decompressed to an 8 MiB ram disk during the boot process. Thus all changes in the root filesystem on the Portux will be lost after the next reboot. In case there is the need to save files to flash memory (i.e.: log files) you will have to create and modify them on the root filesystem and copy them to the config partition at the end. This approach is dispositional because the ramdisk it is very fast and flash write cycles are limited.

When creating a new root filesystem image you have to keep in mind that it can not be bigger than the flash disk partition used for the root filesystem (the default size can be taken from the appendix). If it is bigger than the corresponding flash disk partition you will overwrite other partitions during the copy process.

The first steps when creating your own root file system are: creating a directory tree according to the File Hierarchy Standard (FHS), copying the cross-compiled C system libraries *glibc* or *uclibc* to the new file system, copying the kernel modules and creating device files (a.k.a. device nodes) under /dev. These steps are not covered here.

The root file system used on the Portux and found on the starter-kit CD as tarred archive can serve as a starting point for your own customized root file system.
Busybox and the MTD utilities are already integrated in these root file systems; re-compiling and re-installing is only necessary if the configuration needs to be changed.
In the end, we will describe creating an image of the changed root file system, booting it and copying it to flash memory.

7.2. Installing the busybox

The busybox contains the most important standard Linux commands in one binary, so that they do not need to be compiled individually for the target system.
You can download the newest version of the Busybox packages from the project website (www.BusyBox.net) and unpack it to the /portux/sysapps/ directory or use version from the starter-kit CD.

To unpack it from the starter-kit CD enter the following lines into the terminal:

cd /tmp
cp /dev/cdrom/sysapps.tgz /tmp (where /dev/cdrom is the starter-kit CD)
tar -xzvf sysapps.tar
mv sysapps/ /portux

It is also necessary to extract the rootfs.tgz(root file system) from the starter-kit CD:

cp /dev/cdrom/rootfs.tgz /tmp
tar -xzvf rootfs.tgz
mv rootfs/ /portux

Then go to the busybox directory: **cd /portux/sysapps/busybox-1.00 .**
You can configure the make options using a graphical interface by entering:

make menuconfig

You can select individual commands and features here.
Enter the path to the cross-compiler under „Build options1“ (normally /usr/bin). You also need to enter the path to the root file system (/portux/rootfs in this example) under „Installation options“.
Finish by compiling and installing:

make dep
make
make install

The functionality of the TinyLogin package has been integrated into newer versions of Busybox. If you select these functions (e.g., passwd etc.) in the configuration, the compiled Busybox binary must have setuid root permissions in order for these applets to work correctly.

chmod 4755 /portux/rootfs/bin/busybox

As an alternative, you can install TinyLogin separately and leave out the section Login/Password Management Utilities in the Busybox configuration.

7.3. Installing the MTD-utilities

The MTD (memory technology devices) utilities are required for partitioning, copying and erasing the flash memory.
To be able to install the MTD utilities on the target system, you need the compression library **zlib**.

Copy zlib from the software CD and unpack it:

cp /dev/cdrom/build-tools.tgz /tmp (where /dev/cdrom is the starter-kit CD)
tar -xzvf build-tools.tar
mv /tmp/build-tools /portux

Then go to the directory and set it up to compile:

cd /portux/build-tools/zlib-1.2.1/
CC=arm-linux-3.4.2-gcc LDSHARED=“arm-linux-3.4.2-gcc -shared“
./configure –shared

The variable ***CC*** sets the cross-compiler and zlib is compiled as a dynamic library by setting ***LDSHARED***.
Next, compile zlib and install it in the directory indicated by ***prefix***:

make
make prefix=/usr/arm-linux/lib install

After the library has been installed, you can copy it to the target system:

cd /usr/arm-linux/lib
cp -d libz.so* /portux/rootfs/lib

Now you can install the MTD utilities (skip these steps if you have already installed the busybox before):

cp /dev/cdrom/sysapps.tgz /tmp

tar -xzvf sysapps.tar
mv /tmp/sysapps /portux

After that go to the util directory: **cd /portux/sysapps/mtd/util**
Edit the makefile here. It is important to set the environment variable ***CROSS=arm-linux*** for indicating the cross-compiler and ***DESTDIR***, which gives the installation directory and must point to the directory with the root file system for the target system (in our example, **/portux/rootfs**).
Now type **make** to compile the MTD-utils.

7.4. Creating the initial ramdisk image

The easiest way to make a root file system available to the kernel when booting is to use an initial RAM disk (initrd). This initrd contains a compressed root file system which is decompressed by the kernel and saved in a RAM disk. Then it can be mounted by the kernel as the root file system.
A description follows for creating an initrd image with an ext2 file system on a development computer.
Pre-requisite: a corresponding root directory with content needs to have been created beforehand.
We assume in this example that a **/portux** directory exists, containing the root file system directory **/portux/rootfs**.

First, create a new directory for the image to be generated:

cd /portux
mkdir images

In the same directory, create the folder initrd, in which the image is be mounted:

mkdir /initrd

Now create a blank 8MiB file system image, which will take on the root file system later, and store it in the newly created images directory:

dd if=/dev/zero of=images/initrd.img bs=1k count=8192

Using **/dev/zero** initializes the image with nulls to start with, which leads to higher compression rates later.
Note: If you want to change the size of the 8MiB root filesystem image you also have to change the size of the initial ramdisk in the kernel by changing the value '*Device Drivers->Block Devices->Ram disk support->Default RAM disk size'* with menuconfig.

After initialising the file system image, add a file system to the image and mount it. Then write the contents of the root file system to the RAM disk and, finally, remove it from the file system with umount. Root permissions are required for these steps.

su -m
/sbin/mke2fs -F -v -m0 images/initrd.img
mount -o loop images/initrd.img initrd/
cp -av rootfs/* initrd/
umount initrd/
exit

Next, compress the image containing the root file system and set the correct access rights:

gzip -9 < images/initrd.img > images/initrd.bin
chmod 644 images/initrd.bin

The parameter -9 tells gzip to use the highest level of compression.

You can also carry out this process by running the simple shell script mkfsimage.sh, found in the folder scripts on the starter-kit CD:

cd /portux
cp /dev/cdrom/scripts/mkfsimage.sh /portux
./mkfsimage.sh

Now you can transfer the initrd.bin image to the Portux and configure the boot loader, in order to give the kernel the appropriate boot parameter for using the initrd.

7.5. Testing the new root filesystem

Before copying the image to flash memory, you should test whether it will be booted properly, without errors.
The initrd created in the previous step must first be transferred from the development computer to the Portux. You can use TFTP to do this.
If a TFTP server is running on the development system, move the compressed initrd.bin image file to the **/tftpboot** directory.

All further steps are undertaken on the Portux by means of a terminal program. After start-up and pressing a key within 3 seconds, the system shows the U-Boot prompt.
Now we can make use of the bootscript we have created in chapter “Creating a bootscript”:

run ramboot

7.6. Installing the new root filesystem permanently

If the kernel boots without any problems, you can reset the board and copy the root file system image again via TFTP and write it to the flash memory.

Use the tftpboot command to load the initrd.bin from the server and write it to RAM:

U-Boot> **tftpboot 21400000 initrd.bin**

After the TFTP transfer, the variable ***filesize*** contains the size of the image, this is needed for copying the file to flash memory.

Now copy the image to flash memory.
First erase the target flash memory range. The start and end addresses must point to exactly the beginning and end of a flash-sector:

U-Boot> **erase 101C0000 1041FFFF**

After clearing the memory, you can write the file system image to the flash memory.
Note: If the initrd is bigger then the flash partition that is used for storing it, the you will overwrite other flash partitions (i.e.: /config in our example).

U-Boot> **cp.b 21400000 101C0000 0x$(filesize)** .

8. Creating a new user data partition

8.1. Overview

As you can see in chapter the appendix the last (and biggest) part of the flash disk is used for a JFFS2 partition. The Journalling Flash File System version 2 or JFFS2 is a log-structured file system for use in flash memory devices. Unlike the ext2 filesystem, used for the root filesystem, with JFFS2 it is possible to create and modify files that are stored directly onto the flash disk.
This partition is mounted as the directory **/config** during the boot process and is used to store your applications as well as the file **rc.local.**

The file rc.local is executed by the linux kernel after the boot process to start services like DHCP and telnet. Furthermore it is possible to modify rc.local in that way that your application is started automatically after the boot process by inserting the following line:

/config/YourApplication

Because write / erase cycles on flash devices are limited, your application should not use the flash disk to store data that is changed or deleted very often during application runtime (i.e. temporary files, log files). Rather your application should use the ramdisk for such operations and copy the needed files to the flash partition in large time intervals or when the application has finished its work.

8.2. Archiving the JFFS2 partition

In case installing and configuring your application is very complex it may be useful to have a backup of the whole partition so that it can be restored quickly when deleting it accidental.
Making an exact copy of the JFFS2 partition is very simple. First you just have to create an new directory on the development system to store the archives and export it:

mkdir /portux/backup
chmod 777 /portux/backup
insert the line '/portux/backup *(rw)' into /etc/exports

Then mount it on the Portux and copy the whole JFFS2 partition (this is the 3rd flash partition: /dev/mtd/3 or /dev/mtd3) by directly accessing the mtd flash device. To save the archive on the development system using the filename 'archive2007.jffs2' you have to enter the following line in the Portux bash shell:

mount -t nfs -o nolock development_system_ip:/portux/backup /mnt
cat /dev/mtd/3 > /mnt/archive2007.jffs2
umount /mnt

8.3. Restoring the JFFS2 partition

Enter the following line on the Portux to restore the above created archive (the flash will automatically be deleted before copying):

flashcp -v /mnt/archive2007.jffs2 /dev/mtd/3

Note: See that the copied archive is not bigger the the flash partition it is copied to. In the case the copy process will fail.

8.4. Resetting to the original state

In case you accidentally deleted you JFFS2 partition you can reset it to the delivery state. First copy the image file **jffs2_r.bin** from **/tftpboot** directory on the starter-kit CD to your tftpboot directory.
All further steps are undertaken on the Portux by means of a terminal program. After start-up and pressing a key within 3 seconds, the system shows the U-Boot prompt.
Then enter the following lines:

tftpboot 20000000 jffs2.bin
erase 10420000 10FFFFFF
cp.b 20000000 10400000 $(filesize)

9. The Portux input driver

9.1. Overview

The Portux input driver controls each of the four input devices build in or connected to the Portux. This includes the touch panel, the matrix keyboard, a PS/2 keyboard and an infrared remote control.
The driver consists of five modules, one main module called portuxinput, and one module for each input device.
The main module must be loaded first or you get an error message while trying to load one of the other input device modules.

The matrix keyboard module (portuxmatrix) and the infrared remote control module (portuxir) additionally have a ***keymap*** which can be altered from user space through ioctl functions.
Furthermore it is possible to define different keymaps (***layer***) at the same time, that gives the possibility to change the keymap during application runtime by pressing the remap key that has to de assigned therefore.

The main module also includes a keymap which is called ***keyarray***. This used to clone mobile phone like keys, where one key can have several characters that are accessed by pressing one key several times. By pressing a key several times it cycles through an array of characters until another key is pressed or a timeout occurs.

A list of all constants and structures of the Portux input driver can be found in the appendix (input driver reference).

9.2. Un- / installing the drivers

If you power on the Portux and wait until linux has completed booting the drivers are already started.

To uninstall a driver simply stop it driver and then delete it. For example the matrix keyboard driver:

rmmod portuxmatrix
rm /config/modules/portuxmatrix.ko

If you now want to install the driver again, for example if you have a newer version, just copy it to the directory **/config/modules**.
The next time you start-up the Portux it will be loaded automatically.

You can also start it manually be entering:

insmod /config/modules/portuxmatrix

The main driver module **portuxinput.ko**, the matrix driver module **portuxmatrix.ko**, the PS/2 driver module **portuxkbd.ko**, the IR remote control driver module **portuxir.ko** and the touchscreen driver module **portuxtouch.ko** can be found on the starter-kit CD

(**/inputdriver/ir_keyb_matrix_touch/modules**) or in **/config/modules** on the Portux.

9.3. Customizing the keymap of the matrix keyboard

A whole list of assignable keys like KEY_B in the first example can be found in the Linux kernel header **/include/linux/input.h** of the Linux sources.
The macros and constants to modify the functioning of the input driver can be found on the software CD in the input driver header **portuxinput.h**.
You need to include the portuxinput.h every time an application has to modify the keymaps of functions of the Portux input driver. For example if you create your application in the /portux directory on the development system you will have to copy it from the starter-kit cd:

cd /portux
mkdir include
cp /dev/cdrom/inputdriver/ir_keyb_matrix_touch/include/* /portux/include.

Then you will have to include it in your application:

#include "/portux/include/portuxinput.h"

To customize the keymap of the matrix keyboard you have to open the portuxinput device (/dev/misc/portuxinput), change the content of the keymap struct and write it to the input device.

Every change in the keymap will be lost after the next reboot, so you have to include the sourcecode for changing the keymap in your application or compile it as an extra tool that is executed before you start you application.

Example 1: This code changes the third key in the first column of the matrixkeyboard to 'b':

```
/* This sample can be found on the starter-kit cd:
     /dev/cdrom/examples/input/matrixsample1.c            */
#include <sys/ioctl.h>
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <linux/input.h>
#include "/portux/include/portuxinput.h" // input driver header

int main(void)
{
     int fd = open("/dev/misc/portuxinput", O_RDWR);

     struct matrixentry entry = {
          .x         = 0,            // key at column 1
          .y         = 2,            // key at row 3
          .layer     = 0,            // first layer
          .value     = {
               .flags     = 0,
               .value     = KEY_B    // assign key 'b' (small b)
          }
     };
```

```
        if(ioctl(fd, PORTUXMATRIX_IOC_SETKEY, &entry))
              perror("Error changing key!");

        return 0;
}
```

Compiling: **arm-linux-3.4.2-gcc -Wall matrixsample1.c -o matrixsample1**

Example 2: To change the whole keymap and assign the key '(' (shifted '9') to every key you have to code:

```
/* This sample can be found on the starter-kit cd:
      /dev/cdrom/examples/input/matrixsample2.c            */
...
matrixmap map;
int x, y;

int fd = open("/dev/misc/portuxinput", O_RDWR);

for(x = 0; x < PORTUXMATRIX_MAX_X; x++)
      for(y = 0; y < PORTUXMATRIX_MAX_Y; y++) {
            // assign a shifted '9' -> '(' to the key
            map[0][y][x].flags = PORTUXINPUT_MASK_LSHIFT;
            map[0][y][x].value = KEY_9;
      }

if(ioctl(fd, PORTUXMATRIX_IOC_SETKEYMAP, &map))
      perror("Error changing keymap!");
```

Example 3: Change all keymaps(layer) and assign the character 'A' to every key of the first layer and 'B' to the second layer then assign the function for switching the keymaps to the first key (0x0) on every layer:

```
/* This sample can be found on the starter-kit cd:
      /dev/cdrom/examples/input/matrixsample3.c            */
...
matrixmap map;
int x, y, layer;

int fd = open("/dev/misc/portuxinput", O_RDWR);

// create 2 keymaps
// PORTUXMATRIX_MAX_LAYER = 2; defined in portuxinput.h
for(layer = 0; layer < PORTUXNIPUT_MAX_LAYER; layer++) {
      for(x = 0; x < PORTUXMATRIX_MAX_X; x++) {
            for(y = 0; y < PORTUXMATRIX_MAX_Y; y++) {
                  map[layer][y][x].flags = PORTUXINPUT_MASK_LSHIFT;
                  if(layer == 0) // if is first layer assign 'A'
                        map[layer][y][x].value = KEY_A;
                  else
```

```
                        map[layer][y][x].value = KEY_B;
                }
        }
        // assign the key for switching the keymap to the first key
        map[layer][0][0].flags = PORTUXINPUT_MASK_SETKEYMAP;
        if( layer  <  PORTUXMATRIX_MAX_LAYER - 1)
                // switch to next keymap
                map[layer][0][0].value = layer + 1;
        else
                // key on the last keymap switches to the first keymap
                map[layer][0][0].value = 0;
}

if(ioctl(fd, PORTUXMATRIX_IOC_SETKEYMAP, &map))
        perror("Error changing keymap!");
```

Example 4: Configure the keymap to clone mobile phone like keys. If you press a key on the matrixkeyboard several times it cycles through several characters (a->s->d->f->g->h->j->k->l). This function can also be used for IR remote controllers. The maximum number of characters that can be assigned to a key is 16 (PORTUX_MAX_KEYARRAYELEMENTS), and the maximum number of keys that can be used with a keyarray is 10 (PORTUX_MAX_KEYARRAYS) as defined in portuxinput.h.

```
/* This sample can be found on the starter-kit cd:
     /dev/cdrom/examples/input/matrixsample4.c            */

// note: if you don't want to use all 16 characters then the last
// character has to be 0 terminated
int arrayNR;
int charNR;
keyarray characters;
matrixmap map;

int fd = open("/dev/misc/portuxinput", O_RDWR);

for(arrayNR = 0; arrayNR < PORTUX_MAX_KEYARRAYS; arrayNR++) {
     for(charNR=0; charNR < PORTUX_MAX_KEYARRAYELEMENTS; charNR++)
     {
     // Note: PORTUX_MAX_KEYARRAYELEMENTS = 16 ~ 0 .. 15
          characters[arrayNR][charNR].flags = 0;
          characters[arrayNR][charNR].value = KEY_A + charNR;
     }
     // 0-termination of keyarray elements if needed
     if(characterNR < PORTUX_MAX_KEYARRAYELEMENTS - 1) {
          characters[arrayNR][characterNR + 1].flags = 0;
          characters[arrayNR][characterNR + 1].value = 0;
     }
}

// inform the input driver about the new keyarray
if(ioctl(fd, PORTUXINPUT_IOC_SETKEYARRAY, &characters)) {
```

```
        perror("Error changing keyarray!");
        return 1;
}

// assign the keyarray to the keys on row 1
for(arrayNR = 0; arrayNR < PORTUX_MAX_KEYARRAYS; arrayNR++) {
        map[0][0][arrayNR].flags = PORTUXINPUT_MASK_KEYARRAY;
        map[0][0][arrayNR].value = arrayNR;
}

if(ioctl(fd, PORTUXMATRIX_IOC_SETKEYMAP, &map))
        perror("Error changing keyarray!");
```

By default the keyarray function is configured to display a selected character after a timeout or after pressing another key (PORTUXINPUT_KEYARRAY_MODE_BLIND). But it is also possible to configure the keyarray function in that way that it delivers a backspace before every keypress (except the first keypress) in order to delete the last character (PORTUXINPUT_KEYARRAY_MODE_BACKSPACE).

Example 5: Changing the keyarray function mode from mode blind to mode backspace:

```
/* This sample can be found on the starter-kit cd:
        /dev/cdrom/examples/input/matrixsample5.c              */

int fd = open("/dev/misc/portuxinput", O_RDWR);

if(ioctl(fd, PORTUXINPUT_IOC_SETKEYARRAYMODE, \
                PORTUXINPUT_KEYARRAY_MODE_BACKSPACE))
        perror("Error changing keyarray mode.");
```

9.4. Customizing the keymap of the infrared interface (optional)

To customize the keymap of the IR remote control you have to open the portuxinput device (/dev/misc/portuxinput), change the content of the keymap struct and write it to the input device.
Every change in the keymap will be lost after the next reboot, so you have to include the sourcecode for changing the keymap in your application or compile it as an extra tool that is executed before you start you application.
The maximum number of IR-command codes is 256 (PORTUXIR_MAX_COMMANDCODES).

Example: Change all keymaps and assign the character 'a' to every key then assign the function to switch the keymaps to the first key (0x0):

```
/* This sample can be found on the starter-kit cd:
        /dev/cdrom/examples/inputirsample1.c              */
irmap map;
int IRcmd, mapNR;

int fd = open("/dev/misc/portuxinput", O_RDWR);
```

```
// create the keymaps
for(mapNR = 0; mapNR < PORTUXIR_MAX_LAYER; mapNR++) {
      // assign key 'a' to every key of the ir controller
      for(IRcmd = 0; IRcmd < PORTUXIR_MAX_COMMANDCODES; IRcmd++)
                  map[mapNR][IRcmd].flags = 0;     // no modifier
                  map[mapNR][IRcmd].value = KEY_A;// 'a'
            }
      // assign the key for switching the keymap to the first key
      map[mapNR][0].flags = PORTUXINPUT_MASK_SETKEYMAP;
      if(mapNR <  PORTUXIR_MAX_LAYER - 1)
            // switch to next keymap
            map[mapNR][0].value = mapNR + 1;
      else
            // the key of the last keymap switches to the first
            map[mapNR][0].value = 0;
}

if(ioctl(fd, PORTUXIR_IOC_SETKEYMAP, &map))
      perror("Error changing keymap!");
```

9.5. Getting the input

If you are using ***the Nano-X Window System*** *or* ***Trolltechs Qtopia Core*** the PS/2 keyboard, the matrix keyboard and the IR remote controller will be detected as input device automatically. If you are not using libraries that automatically detect these input devices, you will have to by-pass the them as STDIN to your application to get the input:

./yourApplication **< /dev/tty1**

Now you can use the getchar or scanf function to read the input:

```
/* This sample can be found on the starter-kit cd:
      /dev/cdrom/examples/input/inputsample1.c              */
char c;

printf("\nPlease press any key and confirm with enter (OKAY):");
c = getchar();
printf("\nInput:%c = %i\n", c, (int)c);
```

Note: To confirm the input it is necessary to press ENTER / RETURN on linux, so it is required to have assigned a key with that function. On the matrix keyboard by default the green key: OKAY is assigned to that function.

9.6. Using the touchscreen

The optional touchscreen can be used as pointer like a pc mouse in graphical applications. To build applications that use the touchscreen as input device you can use the class libraries of the *Nano-X Window System* or *Qtopia Core* from *Trolltech*.

The Nano-X Window System will detect the touchscreen as a standard input device

automatically.

When using *Qtopia Core* you will have to set an environment variable that is recognized by the *Qtopia* application:

export QWS_MOUSE_PROTO=LinuxTp:/dev/input/ts1

If ***QWS_MOUSE_PROTO*** is not defined *Qtopia Core* will try to detect an inputdevice automatically. This will fail and crash the system.
If you don't want to use a touchscreen in your Qtopia application you will have to pass the command line parameter **-nomouse**.

9.6.1. Calibrating the touchscreen

If you are using the touchscreen and the pointer does not follow you finger correctly you can calibrate it.
To adjust touchscreen coordinates to display coordinates the program **TouchTool** can be used. This tool can calibrate the touchscreen, save the measured data and reload saved calibration data.

First copy the TouchTool from /inputdriver/ir_keyb_matrix_touch/tools/touchtool on the starter-kit CD to /config on the Portux or integrate it into your root filesystem.
Then enter **/config/TouchTool -c** to start the calibration.
During the calibration process you will have to move your finger to the upper, lower, left and right side of the visible screen.
A 10 second countdown, indicating the end of the calibration process, is displayed on the terminal. This counter is restarted every time you touch the touchscreen.

The calibration values are stored in the eeprom of the touchscreen controller and can be loaded using the TouchTool: **/config/TouchTool -l**.

9.7. Using the knob

The rotary knob on the Portux Panel-Card starterkit board can be used as input device after the driver has been loaded.
This is done on startup by default (/config/rc.local). The driver module is located in /config/modules. The driver module and sources can be found on the starter-kit CD: /inputdriver/samknob

To check whether the driver is loaded or net type the following line: lsmod samknob
To remove the driver enter: rmmod samknob
To install the driver enter: insmod /config/modules/samknob.ko

If you are using *Trollech's* class library ***Qtopia Core*** or ***the Nano-X Window System*** the rotary knob will be detected as input device automatically. If you are not using libraries that automatically detect these input devices, you will have to by-pass the them as STDIN to your application to get the input:

./yourApplication **< /dev/tty1**

The following input events (keys) will be posted to the linux event system:

- the key left (KEY_LEFT) is posted when turning the knob against clockwise direction
- the key right (KEY_RIGHT) is posted when turning the knob in clockwise direction
- the key enter (KEY_ENTER, KEY_RETURN) is posted when the knob is pressed down

10. The display

10.1. Un- / Installing the driver

By default the driver for the display device is compiled into the linux kernel.
To activate or deactivate the driver you have to recompile and install the linux kernel.

The reconfiguration of the kernel can be done with menuconfig. After starting menuconfig the display driver can be found at: Device Drivers -> Graphics support -> Support for frame buffer devices (press SPACE until the ***** appears) -> XXX framebuffer support.

The recompilation process of the linux kernel is described in chapter “Compiling a new Linux kernel”.

10.2. Starting the driver

Because the driver is compiled into the kernel it is automatically started during the boot process.

10.2. Text based applications

To use the display for your text based applications you only have to by-pass the standard text output (STDOUT) and / or the standard error output (STDERR) to the display.
By-pass the STDOUT: ./YourApplication >/dev/tty1.
By-pass the STDERR: ./YourApplication 2>/dev/tty1.

Example 1: Printing 'Hello World' to the display (error messages are also displayed there).

```
echo Hello World >/dev/tty1 2>/dev/tty1
```

Example 2: Starting an application that gets input from a matrixkeyboard (or PS/2 keyboard or IR remote controller) and prints text and errors to the display

```
./YourApplication </dev/tty1 >/dev/tty1 2>/dev/tty1
```

10.3. Graphical applications

To use the display for graphical applications you can directly read and write into the framebuffer of the display.
For example to take a screenshot of the display and store it in /config enter:

```
cat /dev/fb0 > /config/ScreenShot
```

Then you can copy it back to the framebuffer:

```
cp /config/ScreenShot /dev/fb0
```

Another approach to create graphical applications is to use the open source *Nano-X Window System* or *Trolltech's Qtopia Core*. These class libraries will automatically detect

the display and use it.

The Nano-X Window System is installed in the root filesystem. To start your Nano-X application you have to start the Nano-X-server first and then your Nano-X application:

Nano-X &
./YourApplication

To know more about creating applications with *the Nano-X Window System* refer to the project homepage www.MicroWindows.org. There you can download the newest version of Nano-X Window System as well as the API-documentation and tutorials.

You can also use ***Trolltech***'s (www.trolltech.com) platform independent class library ***QT.*** *A*ccurately you will need the ***Qtopia Core*** libraries that are designed for ARM-processors with framebuffer devices. This library includes different display styles and other useful classes for creating graphical applications.

Because of incompatibilities, Qtopia only works properly on displays with 8-bit color depth.

But keep in mind that graphical *Qtopia* applications will need at least 5 megabytes of disk space whereas *Nano-X* applications including the *Nano-X* server need less than one megabyte.
You can download an evaluation Version from http://www.trolltech.com/products/qtopia. API-documentation and tutorials can be found at http://doc.trolltech.com/.

11. Appendix

11.1. Memory map

11.1.1. Memory map for Portux 920t EU + SW

First of all you need to know that there are 3 main memory regions:

- the 16 MiB onboard Flash is mapped to address 0x10000000 – 0x10FFFFFF
- the 64 MiB onboard SDRAM is mapped to address 0x20000000 – 0x23FFFFFF

Further on you need to know the memory addresses of the OS, the root filesystem and the bootloader including the used environment variables that are stored on the onboard flash.
To ensure not to accidentally overwrite or delete the installed software and to know where free space is available take a look at the following table:

Bootloader U-Boot (u-boot.bin)	0x10000000 - 0x1001FFFF
Bootloader environment variables	0x10020000 - 0x1003FFFF
Linux kernel image (uImage)	0x10040000 - 0x1017FFFF
Ramdisk image with root filesystem (initrd.bin)	0x10180000 - 0x102FFFFF
13 MB JFFS2 for user data (/config)	0x10300000 - 0x10FFFFFF

Table 1: Memory addresses of installed software

11.1.2. Memory map for Portux Panel-PC

First of all you need to know that there are 3 main memory regions:

- the 16 MiB onboard Flash is mapped to address 0x10000000 – 0x10FFFFFF
- the 64 MiB onboard SDRAM is mapped to address 0x20000000 – 0x23FFFFFF

Further on you need to know the memory addresses of the OS, the root filesystem and the bootloader including the used environment variables that are stored on the onboard flash.
To ensure not to accidentally overwrite or delete the installed software and to know where free space is available take a look at the following table:

Bootloader with environment variables	0x10000000 - 0x1005FFFF
Linux kernel image (uImage)	0x10060000 - 0x101BFFFF
Ramdisk image with root filesystem (initrd.bin)	0x101C0000 - 0x1041FFFF
12 MB JFFS2 for user data (/config)	0x10420000 - 0x10FFFFFF

Table 2: Memory addresses of installed software

11.1.3. Memory map for Panel-Card

First of all you need to know that there are 3 main memory regions:

- the 16 MiB onboard Flash is mapped to address 0x10000000 – 0x10FFFFFF
- the 64 MiB onboard SDRAM is mapped to address 0x20000000 – 0x23FFFFFF

Further on you need to know the memory addresses of the OS, the root filesystem and the bootloader including the used environment variables that are stored on the onboard flash.
To ensure not to accidentally overwrite or delete the installed software and to know where free space is available take a look at the following table:

Bootloader with environment variables	0x10000000 - 0x1005FFFF
Linux kernel image (uImage)	0x10060000 - 0x101BFFFF
Ramdisk image with root filesystem (initrd.bin)	0x101C0000 - 0x1047FFFF
11 MB JFFS2 for user data (/config)	0x10480000 - 0x10FFFFFF

Table 3: Memory addresses of installed software

11.2. U-Boot commands

U-Boot generally interprets numerical arguments as hex values. In other words, 10000000 is 0x10000000 Hex.

U-Boot has commands to

1. read and write memory and flash memory,
2. load programs and files via the serial interface or Ethernet,
3. start programs and boot Linux, and
4. set environment variables, as well as
5. additional commands.

As an overview of the available commands, here is the output of the Portux **help** command:

```
?        - alias for 'help'
base     - print or set address offset
boot     - boot default, i.e., run 'bootcmd'
bootd    - boot default, i.e., run 'bootcmd'
bootm    - boot application image from memory
bootp    - boot image via network using BootP/TFTP protocol
cmp      - memory compare
coninfo  - print console devices and information
cp       - memory copy
crc32    - checksum calculation
dhcp     - invoke DHCP client to obtain IP/boot params
echo     - echo args to console
erase    - erase FLASH memory
flinfo   - print FLASH memory information
go       - start application at address 'addr'
help     - print online help
imls     - list all images found in flash
itest    - return true/false on integer compare
loadb    - load binary file over serial line (kermit mode)
loop     - infinite loop on address range
md       - memory display
mm       - memory modify (auto-incrementing)
mtest    - simple RAM test
mw       - memory write (fill)
nfs      - boot image via network using NFS protocol
nm       - memory modify (constant address)
printenv - print environment variables
protect  - enable or disable FLASH write protection
rarpboot - boot image via network using RARP/TFTP protocol
reset    - Perform RESET of the CPU
run      - run commands in an environment variable
saveenv  - save environment variables to persistent storage
```

setenv - set environment variables
tftpboot - boot image via network using TFTP protocol
version - print monitor version

11.2.1. Read and write memory and flash memory

cmp - memory compare

cmp [.l, .w, .b] Addr1 Addr2 count

You can check the contents of two memory ranges with **cmp**. You can use extensions to determine the size of the memory access: cmp.l -> 32-bit long word (default), .w ->16-bit word or .b -> 8-bit byte. The comparison runs until the number of units indicated by ***count*** have been compared, or until the first difference is found. The size of the memory compared is calculated by count * (l,w,b)

For example:
A comparison of the U-Boot image in flash with an identical image in the SDRAM. The image in SDRAM is manipulated with an offset of 6 and compared anew:

```
U-Boot> cmp.w 10000000 20000000 100
Total of 256 halfwords were the same
U-Boot> mm.w 20000006
20000006: e59f ? aabb
20000008: f014 ? .
U-Boot> cmp.w 10000000 20000000 100
halfword at 0x10000006 (0xe59f) != halfword at 0x20000006 (0xaabb)
Total of 3 halfwords were the same
```

cp - memory copy

cp [.b, .w, .l] source target count

Copies ***count*** bytes (.b) or words (.w) from ***source*** to ***target***

For example:
Copying the U-Boot image from address 20000000 to address 21000000 of SDRAM:

```
U-Boot> cp.b 20000000 21000000 171a4
```

md - memory display

md [.b, .w, .l] address [count]

Displays ***count*** bytes (words) starting at ***address*** in hexadecimal, with an ASCII interpretation.

For example:

```
U-Boot> md.w 10000000 20
10000000: 0012 ea00 f014 e59f f014 e59f f014 e59f ................
10000010: f014 e59f f014 e59f f014 e59f f014 e59f ................
10000020: 0140 21f0 01a0 21f0 0200 21f0 0260 21f0 @..!...!...!`..!
```

```
10000030: 02c0 21f0 0320 21f0 0380 21f0 beef dead ...! ..!...!....
```

base - print or set address offset

base [base address]

Outputs or sets the current base address. Offsets for all memory commands are calculated from the base address. This option can be helpful when you need to access a certain memory region repeatedly.

For example:

```
U-Boot> base
Base Address: 0x00000000
U-Boot> md 40 4
00000040: 21f00000 21f00000 21f171a4 21f1b85c ...!...!.q.!\..!
U-Boot> base 20800000
Base Address: 0x20800000
U-Boot> md 40 4
20800040: 33cc316c 52ccbbdc 73ccb3c6 7bcc269e l1.3...R...s.&.{
```

mm - memory modify (auto-incrementing)

md [.b, .w, .l] address

This command enables interactive modification of memory addresses. It shows the address and its contents, and waits for user input. If you enter a hexadecimal number, this value will be written to the corresponding memory address and the next address will display. If you simply press the Enter key, no change is stored and the next address displays. If you enter an invalid hexadecimal value (such as q), the command ends. This command cannot be used to modify flash memory!

For example: Modifying SDRAM memory:

```
U-Boot> md 20000000
20000000: eeffeeff aabbf014 e59ff014 e59ff014 ................
U-Boot> mm.b 20000000
20000000: ff      ? ab
20000001: ee      ? ef
20000002: ff      ? cd
20000003: ee      ? ab
20000004: 14      ?
20000005: f0      ?
20000006: bb      ? ef
20000007: aa      ? cd
20000008: 14      ? q
U-Boot> md 20000000
20000000: abcdefab cdeff014 e59ff014 e59ff014 ................
```

mw - memory write (fill)

mw [.b, .w, .l] address value [count]

Writes ***value*** for ***count*** bytes (words) starting at ***address***. You can use this command to

initialize a memory range with a value.
This command cannot be used to modify flash memory!

For example: Writing 0xff ten times to SDRAM address 20 000 000:

```
U-Boot> md 20000000
20000000: abcdefab cdeff014 e59ff014 e59ff014 ................
20000010: e59ff014 e59ff014 e59ff014 e59ff014 ................
U-Boot> mw.b 20000000 ff 10
U-Boot> md 20000000 20
20000000: ffffffff ffffffff ffffffff ffffffff ................
20000010: e59ff014 e59ff014 e59ff014 e59ff014 ................
```

mtest - simple RAM test

mtest [start [end [pattern]]]

This simple RAM test writes to memory. The test was designed only for RAM memory, and fails if used for flash or ROM memory. The system will crash if this test is run on the memory range containing the U-Boot code, stack or heap (internal SRAM or SDRAM from 0x21 f00 000 to 21 ffffff).

For example: Testing the SDRAM from 20 000 000 to 20 100 000:

```
U-Boot> mtest 20000000 20100000
Pattern 0000000A Writing... Reading...
```

nm - memory modify (constant address)

nm [.b, .w, .l] address

The **nm** command writes different data records to the same address, interactively.
For example:

```
U-Boot> nm.b 20000000
20000000: 0a ? aa
20000000: aa ? bb
20000000: bb ? q
```

loop - infinite loop on address range

loop [.b, .w, .l] address count

The **loop** command reads in the contents of a memory range (from ***address*** to ***address*** + ***count***) in an endless loop. It is intended as a special memory test, since it tries to read out the memory as quickly as possible.
This command does not end; it can be stopped only by a reset!

For example:

```
U-Boot> loop.b 20000000 10
```

crc32 - checksum calculation

crc32 addr1 count [addr2]

The **crc32** command calculates the check sum for a memory range (from ***addr1*** to ***addr1***+***count***). You can optionally indicate ***addr2*** to save the calculated check sum there.

For example:

```
U-Boot> crc32 21000000 100 20000000
CRC32 for 21000000 ... 210000ff ==> e8d6cfbc
U-Boot> md 20000000 10
20000000: e8d6cfbc 0000000b 0000000c 0000000d ................
```

flinfo - print FLASH memory information

flinfo (fli for short)

Outputs information about the known flash module. *flinfo* outputs the start addresses of all sectors, as well as information about write protection on individual sectors.

For example:

```
U-Boot> fli
DataFlash:AT45DB321
Nb pages: 8192
Page Size: 528
Size= 4325376 bytes
Logical address: 0xC0000000
Area 0: C0000000 to C0007FFF (RO)
Area 1: C0008000 to C001FFFF (RO)
Area 2: C0020000 to C0027FFF
Area 3: C0028000 to C041FFFF
Bank # 1: AMD Chip: LV320B 32 Mbit
Size: 4 MB in 71 Sectors
Sector Start Addresses:
10000000 (RO) 10002000 (RO) 10004000 (RO) 10006000 (RO) 10008000 (RO)
1000A000 (RO) 1000C000 (RO) 1000E000 (RO) 10010000 (RO) 10020000 (RO)
10030000 10040000 10050000 10060000 10070000
      . . .
103A0000 103B0000 103C0000 103D0000 103E0000
103F0000
```

imls - list all images found in flash

imls

Lists all images stored in flash memory.

For example:

```
U-Boot> imls
Image at 10030000:
Image Name: plinux
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 739208 Bytes = 721.9 kB
Load Address: 21000000
Entry Point: 21000000
Verifying Checksum ... OK
```

protect - enable or disable FLASH write protection

protect on|off addr1 addr2
protect on|off all

Use the **protect** command to protect individual flash sectors from unintentional write accesses. This is purely a software protection on the U-Boot level. The protection prevents the **cp** and **erase** commands from being carried out on the correspondingly marked sectors. This protection is easy to remove and other programs (e.g. Linux) know nothing about this „protection“ and will erase the corresponding range. On the Portux, the range used for U-Boot and its environment variables is write protected. You can request a list of write-protected sectors using the **flinfo** command.

Example 1:
Display the standard configuration, remove all write protection, set write protection for all sectors.

```
U-Boot> flinfo
Bank # 1: AMD Chip: LV320B 32 Mbit
Size: 4 MB in 71 Sectors
Sector Start Addresses:
10000000 (RO) 10002000 (RO) 10004000 (RO) 10006000 (RO) 10008000 (RO)
1000A000 (RO) 1000C000 (RO) 1000E000 (RO) 10010000 (RO) 10020000 (RO)
10030000 10040000 10050000 10060000 10070000
      . . .
103A0000 103B0000 103C0000 103D0000 103E0000
103F0000
U-Boot> protect off all
Un-Protect Flash Bank # 1
U-Boot> flinfo
Bank # 1: AMD Chip: LV320B 32 Mbit
Size: 4 MB in 71 Sectors
Sector Start Addresses:
10000000 10002000 10004000 10006000 10008000
1000A000 1000C000 1000E000 10010000 10020000
10030000 10040000 10050000 10060000 10070000
      . . .
103A0000 103B0000 103C0000 103D0000 103E0000
103F0000
U-Boot> protect on all
Protect Flash Bank # 1
U-Boot> flinfo
Bank # 1: AMD Chip: LV320B 32 Mbit
Size: 4 MB in 71 Sectors
Sector Start Addresses:
10000000 (RO) 10002000 (RO) 10004000 (RO) 10006000 (RO) 10008000 (RO)
1000A000 (RO) 1000C000 (RO) 1000E000 (RO) 10010000 (RO) 10020000 (RO)
10030000 (RO) 10040000 (RO) 10050000 (RO) 10060000 (RO) 10070000 (RO)
      . . .
103A0000 (RO) 103B0000 (RO) 103C0000 (RO) 103D0000 (RO) 103E0000 (RO)
103F0000 (RO)
```

Example 2:

Address-based removal of write protection, recreation of starting configuration. When using address-based **protect** commands, please note that the beginning and ending address are exactly on the sector border.

```
U-Boot> protect off 10000000 103fffff
Un-Protected 71 sectors
U-Boot> flinfo
Bank # 1: AMD Chip: LV320B 32 Mbit
Size: 4 MB in 71 Sectors
Sector Start Addresses:
10000000 10002000 10004000 10006000 10008000
1000A000 1000C000 1000E000 10010000 10020000
10030000 10040000 10050000 10060000 10070000
      . . .
103A0000 103B0000 103C0000 103D0000 103E0000
103F0000
U-Boot> protect on 10000000 1002ffff
Protected 10 sectors
U-Boot> flinfo
Bank # 1: AMD Chip: LV320B 32 Mbit
Sector Start Addresses:
Size: 4 MB in 71 Sectors
10000000 (RO) 10002000 (RO) 10004000 (RO) 10006000 (RO) 10008000 (RO)
1000A000 (RO) 1000C000 (RO) 1000E000 (RO) 10010000 (RO) 10020000 (RO)
10030000 10040000 10050000 10060000 10070000
      . . .
103A0000 103B0000 103C0000 103D0000 103E0000
103F0000
```

erase - erase FLASH memory

erase addr1 addr2
erase all

You can delete flash sectors using the **erase** command. Write-protected sectors are not erased. As with the **protect** command, the sector borders must be observed exactly. Call *erase all* to erase all known flash modules.

For example: Deleting the 3rd MB of the flash module

```
U-Boot> erase 10200000 102FFFFF
flash_erase: first: 39 last: 54
Erased 16 sectors
```

11.2.2. Load programs and files via the serial interface or Ethernet

The commands **bootp**, **dhcp** and **rarpboot** all work according to an identical principal. They attempt to get valid IP parameters via the corresponding protocol (DHCP, BOOTP or RARP), in order to load a specified file from the network to an address, using TFTP. **tftpboot** and **nfs** expect that the IP parameters are already set; **loadb** loads a file via the serial interface using Kermit. In order to be able to use the commands for dynamic address assignment, the DHCP server must be configured properly in the network in order to deliver the IP address of the TFTP server, for example. If no specific IP address is returned, the DHCP server sends its own IP address instead. Here is a host statement for

the ISC DHCP server, version 3.0.1rc9:

```
host Portux
{
      hardware ethernet 00:50:C2:3A:B0:01;
      fixed-address 192.168.2.171;
      next-server 192.168.2.238; //Address of TFTP server
      filename u-boot.bin;
}
```

dhcp - invoke DHCP client to obtain IP/boot params

dhcp

Loads an image via BOOTP. The name of the image to be loaded must be entered either in the environment variable ***bootfile*** or in the DHCPD server configuration. The address to load to must be set in the environment variable ***loadaddr***; otherwise, the default load address is used (21 000 000).

For example:

```
U-Boot> dhcp
BOOTP broadcast 1
DHCP client bound to address 192.168.2.171
TFTP from server 192.168.2.238; our IP address is 192.168.2.171
Filename 'u-boot.bin'.
Load address: 0x21000000
Loading: ###################
done
Bytes transferred = 94628 (171a4 hex)
```

nfs - boot image via network using NFS protocol

nfs [addr] [serverip:filename]

Loads a file from the network via NFS. The IP parameters must already be set.

For example:

```
U-Boot> nfs 21000000 192.168.2.238:/develop/portux/u-boot.bin
File transfer via NFS from server 192.168.2.238; our IP address is
192.168.2.171
Filename '/develop/portux/u-boot.bin'.
Load address: 0x21000000
Loading: ###################
done
Bytes transferred = 94628 (171a4 hex)
```

rarpboot- boot image via network using RARP/TFTP protocol

rarpboot [addr] [filename]

Sets an IP address via RARP and loads the specified file from the network. If no address is indicated, the load address is taken from the ***loadaddr*** environment variable. If no filename is entered, the filename is taken from the ***bootfile*** environment variable.

For example:

```
U-Boot> rarpboot 21000000 u-boot.bin
RARP broadcast 1
TFTP from server 192.168.2.238; our IP address is 192.168.2.239
Filename 'u-boot.bin'.
Load address: 0x21000000
Loading: ###################
done
Bytes transferred = 94628 (171a4 hex)
```

tftpboot- boot image via network using TFTP protocol

tftpboot [addr] [filename]

Loads a file from the network via TFTP. The IP parameters must already be set.

For example:

```
U-Boot> tftpboot 21000000 u-boot.bin
TFTP from server 192.168.2.238; our IP address is 192.168.2.239
Filename 'u-boot.bin'.
Load address: 0x21000000
Loading: ###################
done
Bytes transferred = 94628 (171a4 hex)
```

bootp - boot image via network using BootP/TFTP protocol

bootp [addr] [filename]

Loads an image using BOOTP. The name of the image to be loaded must be specified either in the ***bootfile*** environment variable or in the configuration of the DHCPD server. The loading address must be set in the ***loadaddr*** environment variable or the default loading address (21 000 000) will be used.

For example:

```
U-Boot> bootp 21000000 u-boot.bin
BOOTP broadcast 1
DHCP client bound to address 192.168.2.171
TFTP from server 192.168.2.238; our IP address is 192.168.2.171
Filename 'u-boot.bin'.
Load address: 0x21000000
Loading: ###################
done
Bytes transferred = 94628 (171a4 hex)
```

loadb - load binary file over serial line (kermit mode)

loadb [addr] [baud]

Loads a file over the serial interface to the address ***addr***. Kermit is the protocol used, and it can be served by various clients (Windows: HyperTerminal, VTerm; Linux: cKermit)

For example:

```
U-Boot> loadb 21000000 115200
## Ready for binary (kermit) download to 0x21000000 at 115200 bps...
## Total Size = 0x000171a4 = 94628 Bytes
## Start Addr = 0x21000000
```

11.2.3. Start programs and boot Linux

boot - boot default, i.e., run 'bootcmd'
bootd - boot default, i.e., run 'bootcmd'

boot
bootd

Both commands run the boot script stored in the ***bootcmd*** environment variable. See chapter 3.5. for information about creating scripts.

For example:

```
U-Boot> boot
## Booting image at 10030000 ...
Image Name: plinux
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 739208 Bytes = 721.9 kB
Load Address: 21000000
Entry Point: 21000000
Verifying Checksum ... OK
OK
Starting kernel ...
```

bootm - boot application image from memory

bootm addr

Loads an image stored at the address ***addr***. The image must have a U-Boot header. To create a U-Boot header, see Chapter 5.3.

For example:

```
U-Boot> bootm 10030000
## Booting image at 10030000 ...
Image Name: plinux
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 739208 Bytes = 721.9 kB
Load Address: 21000000
Entry Point: 21000000
Verifying Checksum ... OK
OK
Starting kernel ...
```

go - start application at address 'addr'

go addr

Starts an application stored at address ***addr***. This command is not suitable for starting from Linux, since r0, r1 and r2 are not set. It is designed for stand-alone applications written specifically for the AT91RM9200.

For example:

```
U-Boot> go 21100000
## Starting application at 0x21100000 ...
```

11.2.4. Set environment variables

printenv- print environment variables

printenv [name[name[...]]]

printenv outputs the current contents of the environment variables. To show specific variables, you can add their names as arguments.

Example 1: Outputting all environment variables

```
U-Boot> printenv
bootdelay=3
baudrate=115200
ethaddr=00:50:C2:3A:B0:01
basicargs=console=ttyS0,115200 mem=64M root=/dev/ram rw
kerneladdr=10030000
      . . .
ipaddr=192.168.2.171
serverip=192.168.2.238
Environment size: 552/65532 bytes
```

Example 2: Outputting two variables

```
U-Boot> printenv netmask ipaddr
netmask=255.255.255.0
ipaddr=192.168.2.171
```

saveenv - save environment variables to persistent storage

saveenv

During runtime, changes to variables or new variables are stored in RAM and not saved permanently in flash memory. Saving is done explicitly with the *saveenv* command.

For example:

```
U-Boot> saveenv
Saving Environment to Flash...
Un-Protected 1 sectors
Erasing Flash...flash_erase: first: 9 last: 9
. done
Erased 1 sectors
Writing to Flash... done
Protected 1 sectors
```

setenv - set environment variables

setenv name value
setenv name

Sets the environment variable ***name*** to the value ***value***. If the variable already exists, its current value is overwritten; if it does not yet exist, it is created. If no value is given, the variable is erased (if it exists).

For example: Setting and deleting a new variable

```
U-Boot> printenv test
## Error: "test" not defined
U-Boot> setenv test Hello
U-Boot> printenv test
test=Hello
U-Boot> setenv test
U-Boot> printenv test
## Error: "test" not defined
```

run - run commands in an environment variable

run name

The **run** command runs the environment variable ***name*** as if it were a command. This makes it possible to store commands in environment variables and create simple boot scripts.

For example:

```
U-Boot> printenv ramcmd
ramcmd=setenv bootargs $(basicargs) initrd=0x$(fileaddr),0x$(filesize)
$(mtdparts);bootm $(kerneladdr)
U-Boot> run ramcmd
## Booting image at 10030000 ...
Image Name: plinux
Image Type: ARM Linux Kernel Image (uncompressed)
Data Size: 739208 Bytes = 721.9 kB
Load Address: 21000000
Entry Point: 21000000
Verifying Checksum ... OK
OK
Starting kernel ...
```

11.2.5. Additional commands

reset - Perform RESET of the CPU

reset

Resets the CPU

coninfo - print console devices and information

coninfo

Outputs informations about the current console.

For example:

```
U-Boot> coninfo
List of available devices:
serial 80000003 SIO stdin stdout stderr
```

version - print monitor version

Indicates the U-Boot version being used

For example:

```
U-Boot> version
U-Boot 1.1.2 (Nov 30 2004 - 12:03:10)
```

itest - return true/false on integer compare

itest[.b,.w,.l,.s] [*]arg1 op [*]arg2

Returns true/false when comparing two integers. You can specify the data size with .b (byte), .w (word) or .l (long word). .s defines a string in ***arg1*** or ***arg2***. arg1 or arg2 are the arguments to be compared. If the optional * is set, the argument is interpreted as address containing the content to be compared. The operator *op* is one of the following: == > >= < <=. *itest* gives no output to the console.

For example: Comparing the contents of the address 20 000 000 with 0xFFFF

```
U-Boot> itest.w *20000000 == 0xffff
```

echo - echo args to console

echo arg

Output the argument ***arg*** to the console

For example:

```
U-Boot> echo Hello
Hello
```

help - print online help

help

Outputs the help listing (see the beginning of this chapter)

11.3. U-Boot environment variables

A description of all important environment variables used by U-Boot follows.

11.3.1. Environment variables for Portux 920t EU + SW

basicargs contains the static boot arguments
default: console=ttyS0,115200 mem=64MB root=/dev/ram rw

baudrate defines the baudrate of the serial interface
default: 115200

bootcmd is automatically called by the **boot/bootd** command (which can be executed manually or is executed automatically when the Portux Panel-PC is started-up)
default: run flashboot

bootdelay time in seconds to interrupt the boot process / before **bootd** is carried out
default: 3

ethaddr Ethernet MAC address
sample: 00:50:D2:FA:B0:01

ipaddr IP address of the Portux Panel-PC
sample: 192.168.4.240

stdin standard input interface
default: serial

stdout standard output interface
default: serial

stderr standard error output interface
default: serial

serverip IP address of the TFTP server
sample: 192.168.4.238

inaddr destination address of the initial ramdisk with root filesystem
default: 21400000

insize size of the initial ramdisk with root filesystem
sample: 1733CB

kerneladdr address of the linux kernel image
default: 10040000

mtdparts the MTD partitions for the flash unit are defined here
default: mtdparts=phys_mapped_flash:256k(boot),1280k(linux),1536k(initrd),-(cfg)

flashboot command sequence necessary for booting the kernel; loading the root filesystem from onboard flash memory
default: cp.b 10180000 $(inaddr) $(insize);setenv bootargs $(basicargs)

initrd=0x$(inaddr),0x$(insize) $(mtdparts);bootm $(kerneladdr)

11.3.2. Environment variables for Portux Panel-PC

basicargs contains the static boot arguments
default: console=ttyS0,115200 mem=64M root=/dev/ram rw

baudrate defines the baudrate of the serial interface
default: 115200

bootargs parameters / settings passed to the kernel when booting
default: \$(basicargs) initrd=0x\$(fileaddr),0x\$(filesize) \$(mtdparts)\;bootm \$(kerneladdr)

bootcmd is automatically called by the **boot/bootd** command (which can be executed manually or is executed automatically when the Portux Panel-PC is started-up)
default: run flashboot

bootdelay time in seconds to interrupt the boot process / before **bootd** is carried out
default: 3

ethaddr Portux Panel-PC Ethernet MAC address
sample: 00:50:D2:FA:B0:01

flashboot command sequence necessary for booting the kernel; loading the root filesystem from onboard flash memory
default: cp.b $(initrdaddr) $(inaddr) $(insize);setenv bootargs $(basicargs) initrd=0x$(inaddr),0x$(insize) $(mtdparts);bootm $(kerneladdr)

kerneladdr address of the linux kernel image
default: 10060000

initrdaddr address of the linux root filesystem image
default: 101C0000

ipaddr IP address of the Portux Panel-PC
sample: 192.168.4.240

inaddr destination address of the initial ramdisk with root filesystem
default: 21400000

insize size of the initial ramdisk with root filesystem
sample: 1F9B4D

mtdparts the MTD partitions for the flash unit are defined here
default: mtdparts=phys_mapped_flash:384k(boot),1408k(linux),2432k(initrd),-(cfg)

stdin standard input interface
default: serial

stdout standard output interface
default: serial

stderr standard error output interface
default: serial

serverip IP address of the TFTP server
sample: 192.168.4.238

11.3.3. Environment variables for Panel-Card

basicargs contains the static boot arguments
default: console=ttyS0,115200 mem=32M root=/dev/ram rw

baudrate defines the baudrate of the serial interface
default: 115200

bootargs parameters / settings passed to the kernel when booting
default: $(basicargs) initrd=0x$(inaddr),0x$(insize) $(mtdparts)

bootcmd is automatically called by the **boot/bootd** command (which can be executed manually or is executed automatically when the Portux Panel-PC is started-up)
default: run flashboot

bootdelay time in seconds to interrupt the boot process / before **bootd** is carried out
default: 3

ethaddr Portux Panel-PC Ethernet MAC address
sample: 00:50:D2:FA:B0:01

flashboot command sequence necessary for booting the kernel; loading the root filesystem from onboard flash memory
default: cp.b $(initrdaddr) $(inaddr) $(insize);setenv bootargs $(basicargs) initrd=0x$(inaddr),0x$(insize) $(mtdparts);bootm $(kerneladdr)

kerneladdr address of the linux kernel image
default: 10060000

initrdaddr address of the linux root filesystem image
default: 101C0000

ipaddr IP address of the Portux Panel-PC
sample: 192.168.4.240

inaddr destination address of the initial ramdisk with root filesystem
default: 21400000

insize size of the initial ramdisk with root filesystem
sample: 282EA0

mtdparts the MTD partitions for the flash unit are defined here
default: mtdparts=phys_mapped_flash:384k(boot),1408k(linux),2816k(initrd),-(cfg)

stdin standard input interface
default: serial

stdout standard output interface
default: serial

stderr standard error output interface
default: serial

serverip IP address of the TFTP server
sample: 192.168.4.238

11.4. Input driver reference

11.4.1. struct portuxinputevent

Name
struct portuxinputevent— describes an input event

Synopsis
```
struct portuxinputevent {
        unsigned short flags;
        unsigned int value;
};
```

Members
flags - some additional flags to change the handling of the event
value - distance of a mouse movement or one of the key/button values, that can be reported to the input system, refer to include/linux/input.h for more information

Description
This structure is used by portuxinput_report_event to report events to the input system. With *flags* member you can decide, how *value* is treated.

11.4.2. struct matrixentry

Name
struct matrixentry— used in PORTUXMATRIX_IOC_GETKEY and PORTUXMATRIX_IOC_SETKEY ioctl

Synopsis
```
struct matrixentry {
        unsigned char x;
        unsigned char y;
        unsigned char layer;
        struct portuxinputevent value;
};
```

Members
x - column on the matrix keyboard
y - row on the matrix keyboard
layer - number of the layer which the event *value* ought to happen in
value - the event that should happen, if key in (*x*,*y*) is pressed

11.4.3. struct irentry

Name
struct irentry— used in PORTUXIR_IOC_GETKEY and PORTUXIR_IOC_SETKEY ioctl

Synopsis
```
struct irentry {
        unsigned char code;
        struct portuxinputevent value;
};
```

Members
code - code for which the event *value* ought to happen
value - event that ought to happen

11.4.4. struct calibration

Name
struct calibration— used in PORTUXTOUCH_IOC_CALIBRATIONSTATUS to monitor touch panel calibration

Synopsis
```
struct calibration {
        unsigned short minx;
        unsigned short maxx;
        unsigned short miny;
        unsigned short maxy;
        unsigned char active;
        unsigned char timeout;
        unsigned char remaining;
};
```

Members
minx - current minimum x value
maxx - current maximum x value
miny - current minimum y value
maxy - current maximum y value
active - shows if calibration is currently executed
timeout - the timeout used
remaining - number of seconds until calibration is finished

11.4.5. struct eeprom_t

Name
struct eeprom_t — used in PORTUXINPUT_IOC_WRITEEEPROM and PORTUXINPUT_IOC_READEEPROM to store data and EEPROM address.

Synopsis
```
struct calibration {
   unsigned short address;
   unsigned char data;
};
```

Members
address – EEPROM address for read/write operation
data – received data or data to store

11.4.6. Defines / Constants

These constants define the maximum size of the arrays used by the io-controll functions. They can be modified in the **portuxinput.h** but then you have to recompile the modules.

Constants for the matrix keyboard

PORTUXMATRIX_MAX_X 8: the maximum of 8 rows can be used

PORTUXMATRIX_MAX_Y 8: the maximum of 8 columns can be used

PORTUXMATRIX_MAX_LAYER 2: 2 different keymaps can be created

Constants for the IR-remote controller

PORTUXIR_MAX_LAYER 2: 2 different keymaps can be created

PORTUXIR_MAX_COMMANDCODES 256: 256 different IR-scancodes can be used

Constants for the PS/2 and matrix keyboard keyarray function

PORTUX_MAX_KEYARRAYS 10: 10 keyarrays can be created

PORTUX_MAX_KEYARRAYELEMENTS 16: every keyarray can have 16 keys (characters)

Flags for portuxinputevent

PORTUXINPUT_MASK_SETKEYMAP: Switches to the layer stored in value.

PORTUXINPUT_MASK_SETKEYMAPRET: Switches to the layer stored in value only for the next key press. After that it returns to the last used layer.

PORTUXINPUT_MASK_KEYARRAY: Simulates keys like on mobile phones where one key cycles through a number of keys. Value determines which array is used.

PORTUXINPUT_MASK_REPEAT: Normally, one key press generates more than one event. All events after the first are repeated ones. This flag determines, if they will be processed. In most cases you do not want this behaviour, so you will not set this flag. (An possible exception is mouse movement.)

PORTUXINPUT_MASK_MOUSEMOVE: If this flag is set, value is not treated as a key but

as a relative movement of the mouse cursor. The next two flags describe the direction. They should not be used, if this flag is not set. If this flag and all of the above are not set, than value is treated as a key/button code.

PORTUXINPUT_MASK_REL_X: Mouse movement in x direction

PORTUXINPUT_MASK_REL_Y: Mouse movement in y direction

PORTUXINPUT_MASK_LSHIFT: Left shift key is simulated while sending the key event.

PORTUXINPUT_MASK_RSHIFT: Right shift key is simulated while sending the key event

PORTUXINPUT_MASK_LALT: Left alt key is simulated while sending the key event.

PORTUXINPUT_MASK_RALT: Right alt key is simulated while sending the key event.

PORTUXINPUT_MASK_LCTRL: Left ctrl key is simulated while sending the key event.

PORTUXINPUT_MASK_RCTRL: Right ctrl key is simulated while sending the key event.

11.4.7. Ioctl functions

Every module except for portuxkbd provides ioctl functions to change its settings or execute commands. This section describes the usage of these functions. Ioctl functions where no argument is mentioned ignore it. These functions will return -1 on failure and the specific error is reported via the global variable errno as ioctl functions of all normal device files would do.

ioctl functions provided by the main module portuxinput:

Ioctl function	**description**
PORTUXINPUT_IOC_SETKEYARRAYMODE	Sets the mode, how the mobile phone like keys work. There are three modes to be passed as a char. PORTUXINPUT_KEYARRAY_MODE_BLIND - a key press is only delivered to the input system if a timeout occurs. PORTUXINPUT_KEYARRAY_MODE_BACKSPACE - every key is delivered to the input system, but before every one except the first a backspace is send to delete the last key. PORTUXINPUT_KEYARRAY_MODE_EVERY - like PORTUXINPUT_KEYARRAY_MODE_BACKSPACE, but without backspaces
PORTUXINPUT_IOC_SETKEYARRAY	Sets the key array map. It takes a pointer as an argument defined as typedef *struct portuxinputevent* keyarray[PORTUX_MAX_KEYARRAYS][PORTUX_MAX_KEYARRAYELEMENTS]. So you can define 10 key arrays, where each consists of at most 16 entries. If not all 16 entries are used, the array must

	be null terminated (value=0).
PORTUXINPUT_IOC_WRITEEEPROM	This function requires a pointer of type *struct eeprom_t* as argument and stores one byte at the selected address in input controller's EEPROM. Note : The EEPROM's size is 1024 bytes where the last 16 bytes are used by the calibration tool of touchpad (TouchTool) to store calibration data.
PORTUXINPUT_IOC_READEEPROM	Reads one byte from input controller's EEPROM. This function needs a pointer of type *struct eeprom_t* to determine the address and to store data after read.

ioctl functions provided by the portuxmatrix module:

Ioctl function	**description**
PORTUXMATRIX_IOC_SETKEY	It sets one entry in the matrix keyboard keymap. It takes a pointer to *struct matrixentry* as the argument. All members of the struct have to be set before invoking the ioctl.
PORTUXMATRIX_IOC_GETKEY	It retrieves one entry from the matrix keyboard keymap. It takes a pointer to *struct matrixentry* as the argument. The members x, y and layer have to be set before invoking the ioctl. The result is stored in value.
PORTUXMATRIX_IOC_SETKEYMAP	It sets the complete keymap. It takes a pointer to matrixmap as the argument, which is defined as typedef *struct portuxinputevent* matrixmap[PORTUXMATRIX_MAX_LAYER] [PORTUXMATRIX_MAX_Y] [PORTUXMATRIX_MAX_X].
PORTUXMATRIX_IOC_SETLAYER	Set the current keymap layer. Argument of type unsigned char must me smaller than or equal to the maximum layer number.
PORTUXMATRIX_IOC_SETMAXLAYER	Set the maximum keymap layer number. Argument of type unsigned char must me smaller than or equal to PORTUXMATRIX_MAX_LAYER

ioctl functions provided by the portuxtouch module

Ioctl function	**description**
PORTUXTOUCH_IOC_CALIBRATESTART	It starts the calibration process. It can be stopped PORTUXTOUCH_IOC_CALIBRATEFINISH and PORTUXTOUCH_IOC_CALIBRATIONABORT
PORTUXTOUCH_IOC_CALIBRATEFINISH	It stops an already running calibration process and stores the determined calibration values.

PORTUXTOUCH_IOC_CALIBRATEABORT	It stops an already running calibration process and but discards the current calibration values.
PORTUXTOUCH_IOC_CALIBRATE	It starts a self finishing calibration process. It takes an int as an argument which determines the timeout in seconds. That means that when you stopped touching the touch panel it waits as many seconds as given for new input from the touch panel until it finally stops calibration. At the start of the calibration, the minimum and maximum values initialized to only reflect the exact centre. When the calibration finishes, they are only stored, if all of them have changed.
PORTUXTOUCH_IOC_CALIBRATIONSTATUS	With this function you can determine the current minimum and maximum values during normal calibration and additionally the remaining time during the self finishing calibration. It takes a pointer to *struct calibration* as an argument.

ioctl functions provided by the portuxir module

Ioctl function	**description**
PORTUXIR_IOC_SETKEY	It sets one entry in the IR remote control keymap. It takes a pointer to *struct irentry* as an argument. All members of the struct have to be set before invoking the ioctl.
PORTUXIR_IOC_GETKEY	It sets one entry in the IR remote control keymap. It takes a pointer to *struct irentry* as an argument. The member code must be set before invoking the ioctl.
PORTUXIR_IOC_SETKEYMAP	It sets the complete keymap. It takes a pointer to irmap as the argument, which is defined as typedef *struct portuxinputevent* irmap[PORTUXIR_MAX_LAYER][PORTUXIR_MAX_COMMANDCODES].
PORTUXIR_IOC_SETFILTER	Each IR remote control does not only send a command code but additionally a device code. With this ioctl you can set the device code, which is the only accepted one or set, that every device code is accepted. This ioctl takes an integer as the argument which has to be between 0x00 and 0xff as the acceptable code or 0x100 to accept all codes.
PORTUXIR_IOC_SETLAYER	Set the current keymap layer. Argument of type unsigned char must me smaller than or equal to the maximum layer number.
PORTUXIR_IOC_SETMAXLAYER	Set the maximum keymap layer number. Argument of type unsigned char must be smaller than or equal to PORTUXIR_MAX_LAYER

11.5. Important linux shell commands

List files
    ls [-la]
Find a file
    find -type f -name “filename”
Copy a file
    cp /source/file.ext /target
Delete a file
    rm /folder/file.name
Move a file
    mv /source/file.ext /target
Rename a file
    mv /file.ext /newname.ext
Create a directory
    mkdir /myDir
Delete a directory
    rmdir /myDir
Start an application or script
    ./applicationname
Decompress a .PK file
    gunzip filename.pk
Get files from .TAR archive
    tar xvf filename.tar
Create a text file
    cat > file.txt
    this is a test
    CTRL + d (finish), CTRL + c (cancel)
Get ethernet configuration
    ifconfig eth0 [eth1; eth2 ...]
Configure ethernet
    ifconfig eth0 192.168.100.10
Show shared folders
    showmount -e
List running processes
    ps
Stop a process
    kill 123
List modules
    lsmod
Start module (driver)
    insmod xxx
Stop module (driver)
    rmmod xxx

11.6. Installing the toolchain on Microsoft Windows

Before you can install the toolchain it is necessary to install **Cygwin**. Cygwin is a Linux-like environment for MS Windows 2000 / XP.

11.6.1. Installing Cygwin

Perform the following steps to install Cygwin:

1. Execute the Cygwin setup.exe (http://www.cygwin.com/setup.exe) and click on the “Next” button
2. Choose “Install from the Internet” and click on the “Next” button
3. Select the installation directory (by default c:\programs\Cygwin) and click on the “Next” button
4. Select a directory for downloaded packages and click on the “Next” button
5. Select your internet connection and after that a download mirror an click on the “Next” button in each case
6. Now select the following packages to be installed and click on the “Next” button
   - admin: cygrunsvr
   - devel: make
   - net: nfs-server

11.6.2. Installing the toolchain

Now you can install the toolchain:

1. Copy the following files from the starter-kid CD to c:\programs\Cygwin\tmp
   - arm-linux-gdb
   - crosstool.tgz
   - install_toolchain.sh
2. Start the cygwin bash shell.
3. Create the directory /opt: **mkdir /opt**
4. Change to the directory /tmp: **cd /tmp**
5. Start the install script: **./install_toolchain.sh**
6. Remove the installation files: **rm /tmp/***

After the installation, corresponding version of binutils, gcc and c++ are available for crosscompiling. Type **ls /usr/bin | grep arm-linux** to get a list of all available tools.

11.6.3. Mounting the working directory

To transfer your applications to the Portux or to start them directly from the development system a network connection via NFS has to be set-up:

1. Start your Cygwin shell (Start -> Programs -> Cygwin -> Cygwin Bash Shell)
2. Start the NFS configuration: **/usr/bin/nfs-server-config**
3. Answer the first and the second question with 'yes' and enter new account informations for the NFS server (further informations about configuring the NFS server can be found at: http://www.csparks.com/CygwinNFS/index.xhtml).
4. Now you have to edit (create) the file ***c:\programs*\Cygwin\etc\exports** to tell

Cygwin which folder(s) shall be exported. For example if you want to export the directory '\develop' on hard disk c: with read access to host 192.168.1.10 you have to add the following line: **/cygdrive/c/develop 192.168.1.10(ro)**

5. After finishing the configuration of the NFS server, the system services '**Cygwin portmap**', '**Cygwin nfsd**' and '**Cygwin mountd**' have to be restarted in the Windows control panel (management -> services).
6. Then you have to open the following ports at your firewall (On Windows XP open the firewall properties, go to tab 'Exceptions' and click on the button 'Add Port...')
   - 2049 TCP
   - 2049 UDP
   - 111 TCP
   - 111 UDP
7. The last step is to give network access to **c:\programs\Cygwin\usr\sbin\rpc.mountd.exe** (on the Windows XP firewall go to tab 'Exceptions' and click 'Add Program ...').

To mount the above mentioned directory enter the following line in the command shell of the Portux (assuming that the ip address of the development system is 192.168.1.5 and the ip address of the Portux is 192.168.1.10):

mount -t nfs -o nolock 192.168.1.5:/cygdrive/c/develop /mnt

Now you can copy your application to c:\develop and start it on the Portux:

cd /mnt
./YourApplication