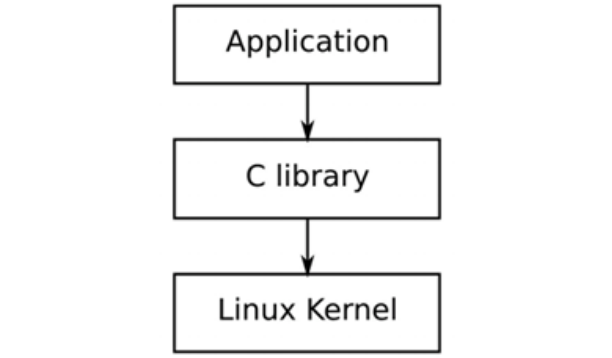
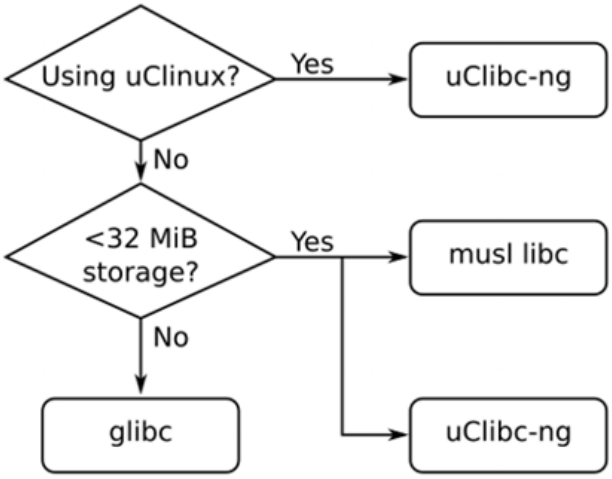
Chapter 1: Starting Out

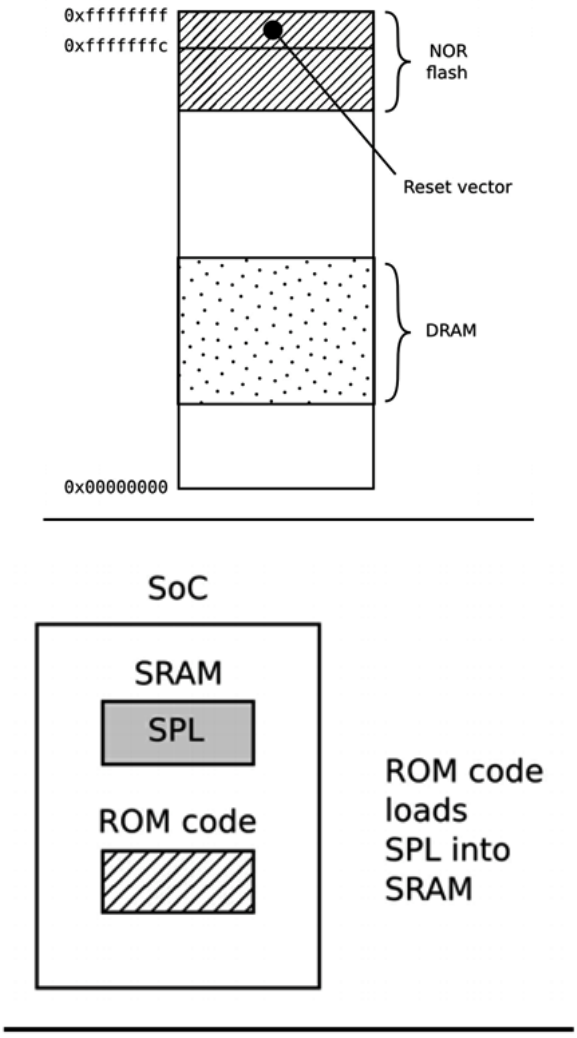
No Images

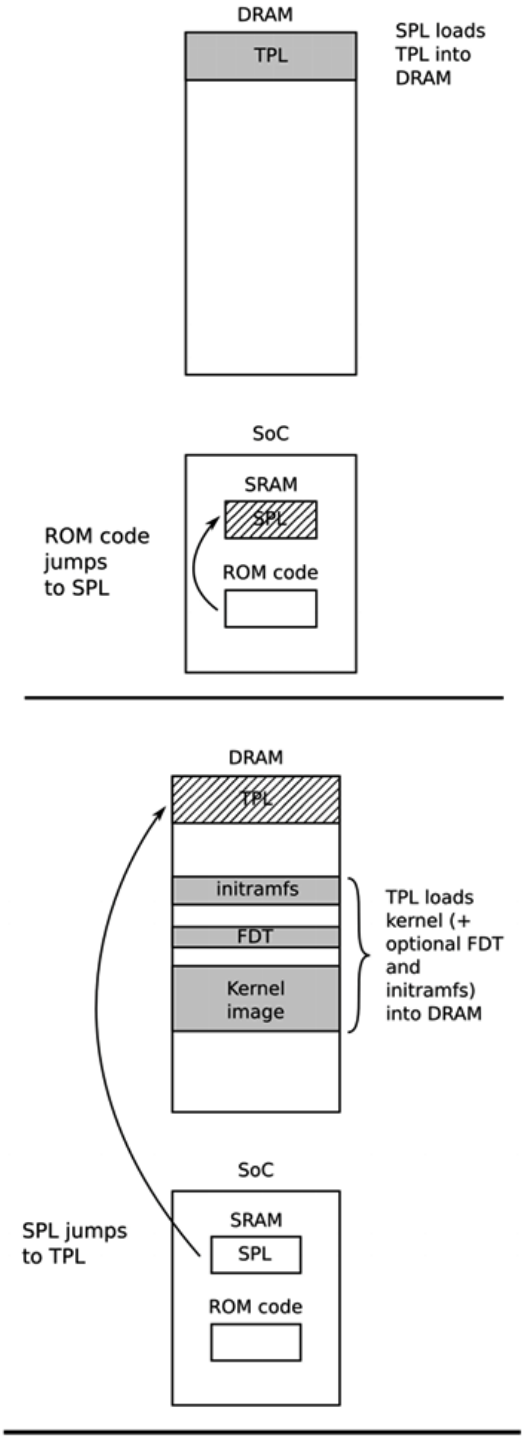
Chapter 2: Learning about Toolchains



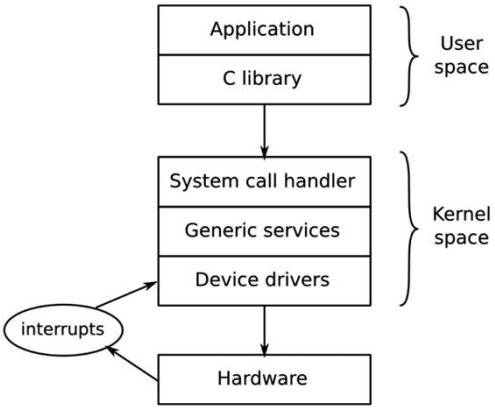


Chapter 3: All about Bootloaders

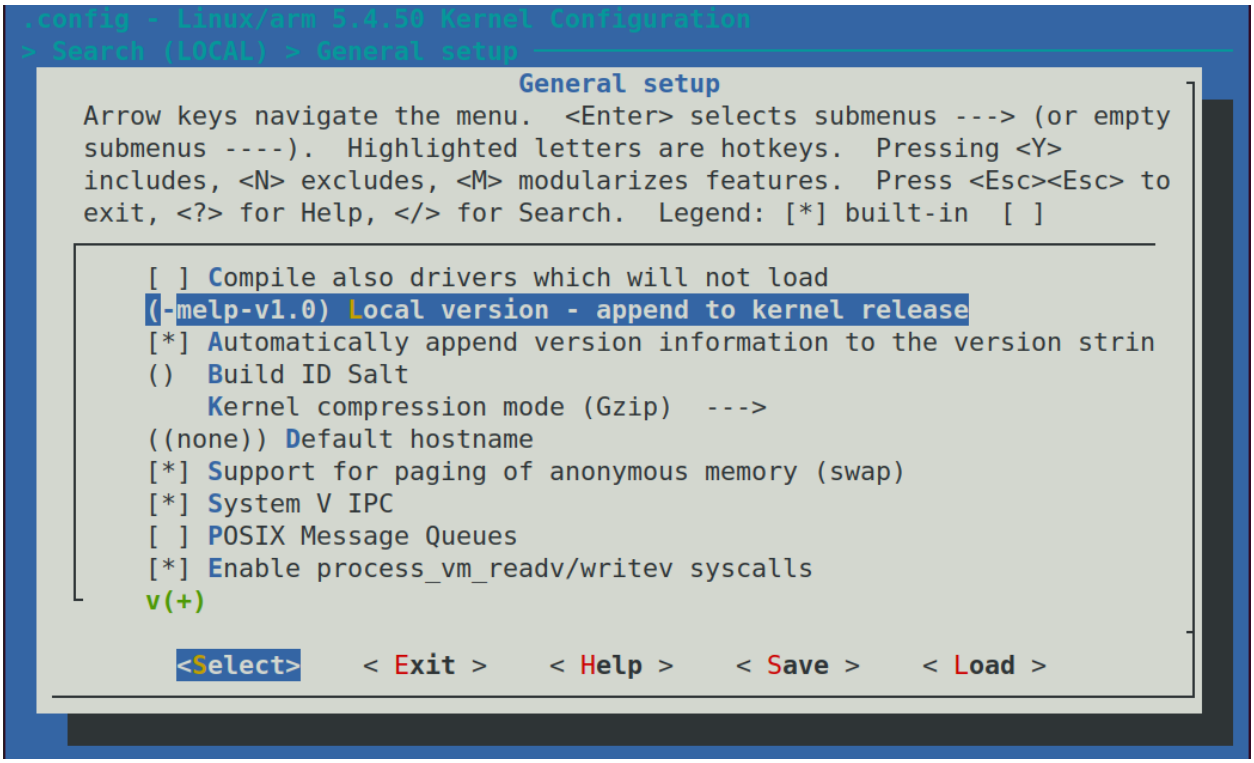



DRAM
TPL
SPL loads
TPL into
DRAM
SoC
SRAM
SPL
ROM code
ROM code
jumps
to SPL
DRAM
TPL
initramfs
FDT
Kernel
image
TPL loads
kernel (+
optional FDT
and
initramfs)
into DRAM
SoC
SRAM
SPL
ROM code
SPL jumps
to TPL

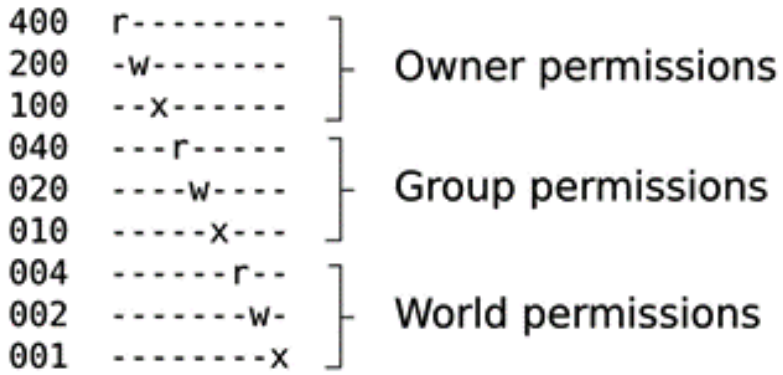
Chapter 4: Configuring and Building the Kernel



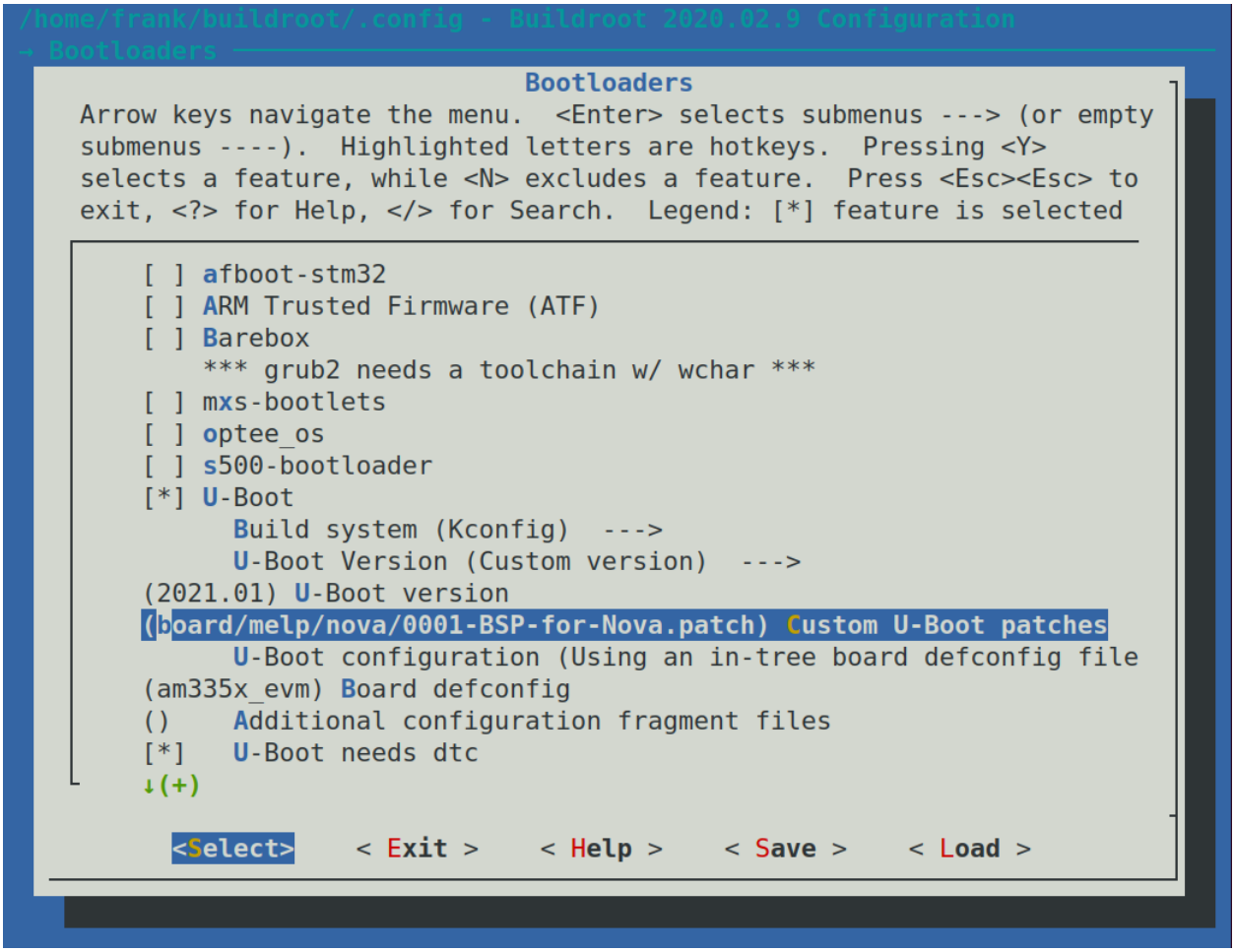

```
.config - Linux/arm 5.4.50 Kernel Configuration
> Search (DEVMEm) > Character devices
                        Character devices
  Arrow keys navigate the menu.  <Enter> selects submenus ---> (or empty
  submenus ----).  Highlighted letters are hotkeys.  Pressing <Y>
  includes, <N> excludes, <M> modularizes features.  Press <Esc><Esc> to
  exit, <?> for Help, </> for Search.  Legend: [*] built-in  [ ]
  ┌──^(-)──────────────────────────────────────────────────────────────┐
  │     [*]   Automatically load TTY Line Disciplines                  │
  │     [*] /dev/mem virtual device support                            │
  │     [ ] /dev/kmem virtual device support                           │
  │         Serial drivers  --->                                       │
  │     <*> Serial device bus  --->                                    │
  │     <*> TTY driver to output user messages via printk              │
  │     (6)   ttyprintk log level (1-7)                                │
  │     <M> Parallel printer support                                   │
  │     [ ]   Support for console on line printer                      │
  │     <M> Support for user-space parallel port device drivers        │
  │     v(+)                                                           │
  └────────────────────────────────────────────────────────────────────┘
        <Select>    < Exit >    < Help >    < Save >    < Load >
```

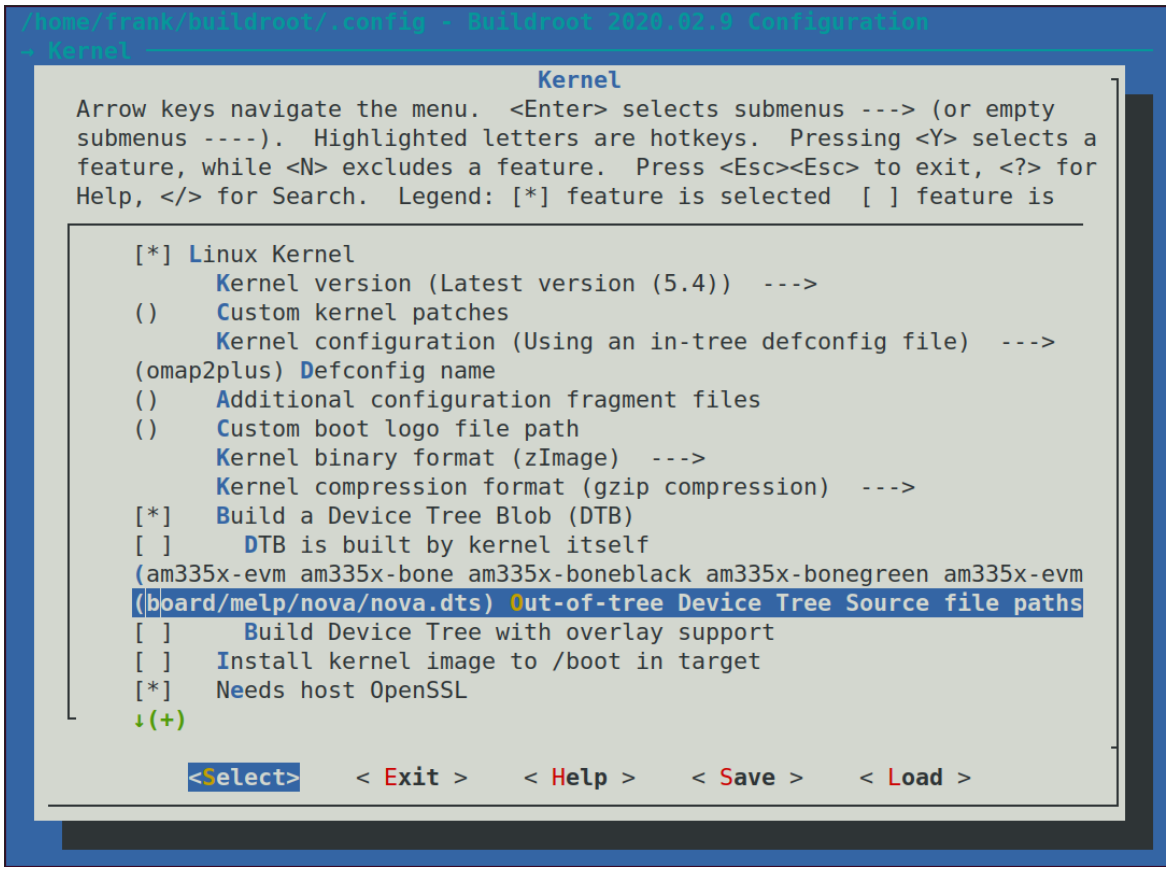

.config - Linux/arm 5.4.50 Kernel Configuration
> Search (LOCAL) > General setup
General setup
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
[ ] Compile also drivers which will not load
(-melp-v1.0) Local version - append to kernel release
[*] Automatically append version information to the version strin
() Build ID Salt
Kernel compression mode (Gzip) --->
((none)) Default hostname
[*] Support for paging of anonymous memory (swap)
[*] System V IPC
[ ] POSIX Message Queues
[*] Enable process_vm_readv/writev syscalls
v(+)
<Select> < Exit > < Help > < Save > < Load >

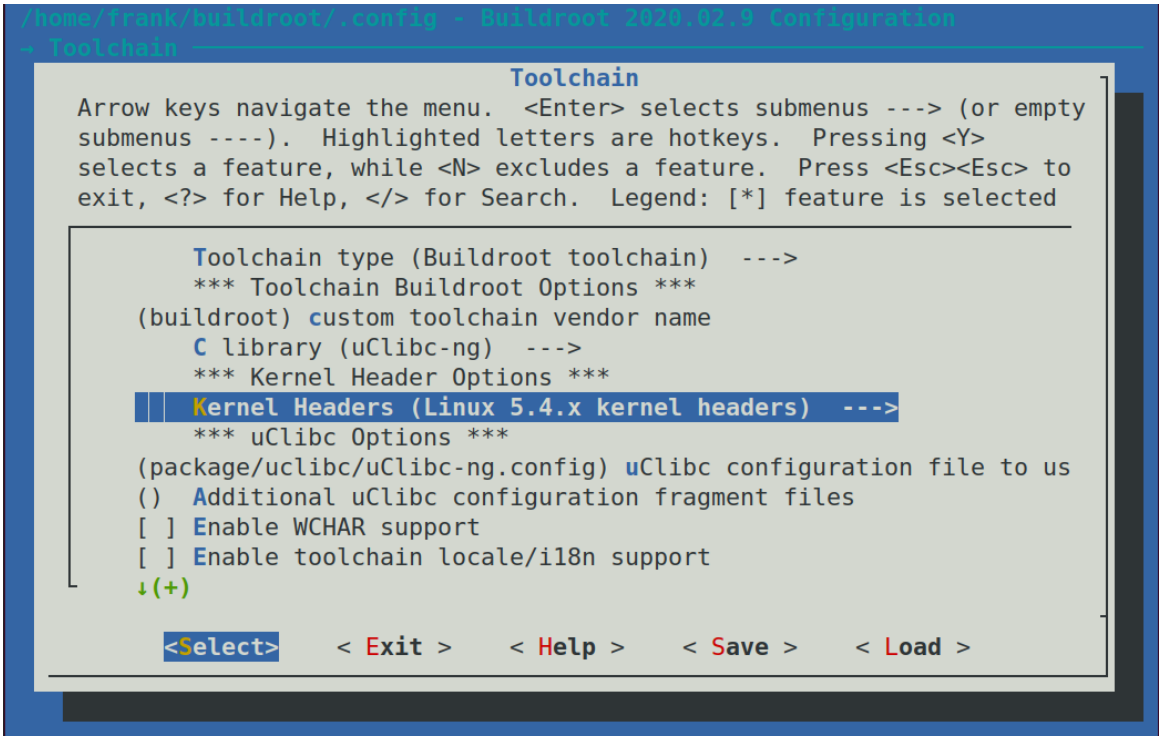
Chapter 5: Building a Root Filesystem

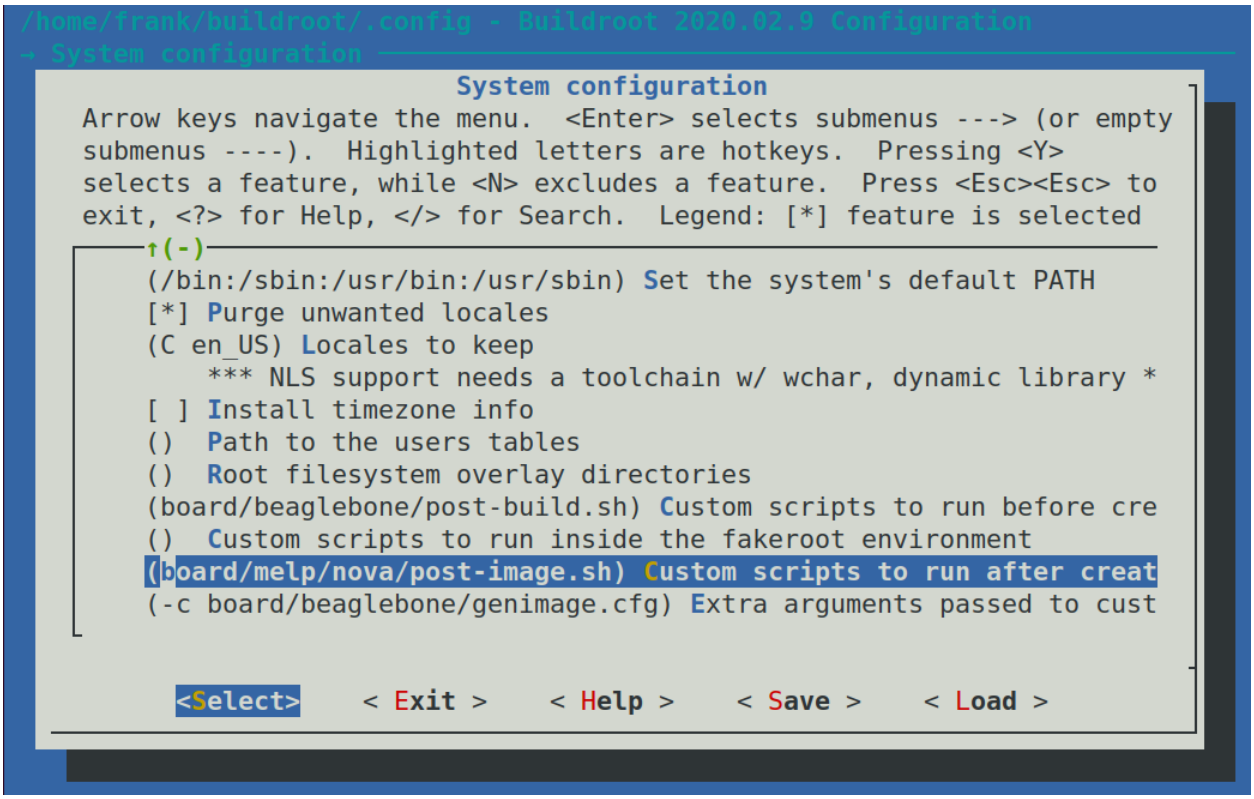


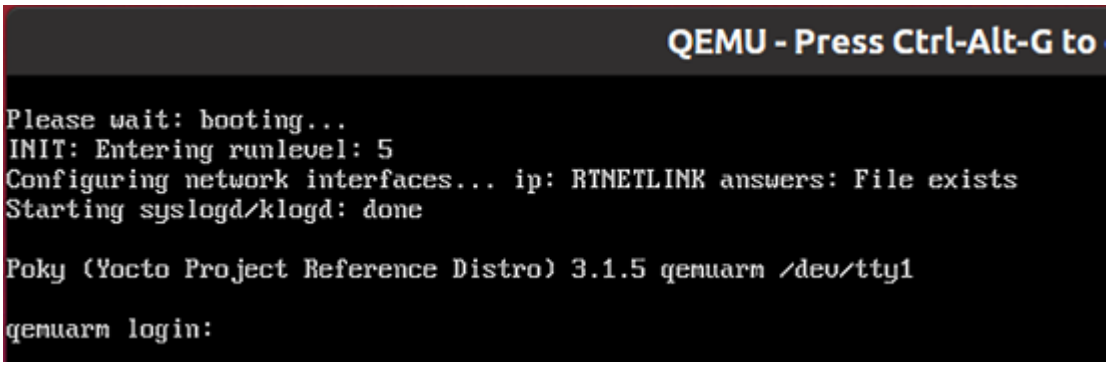
Chapter 6: Selecting a Build System



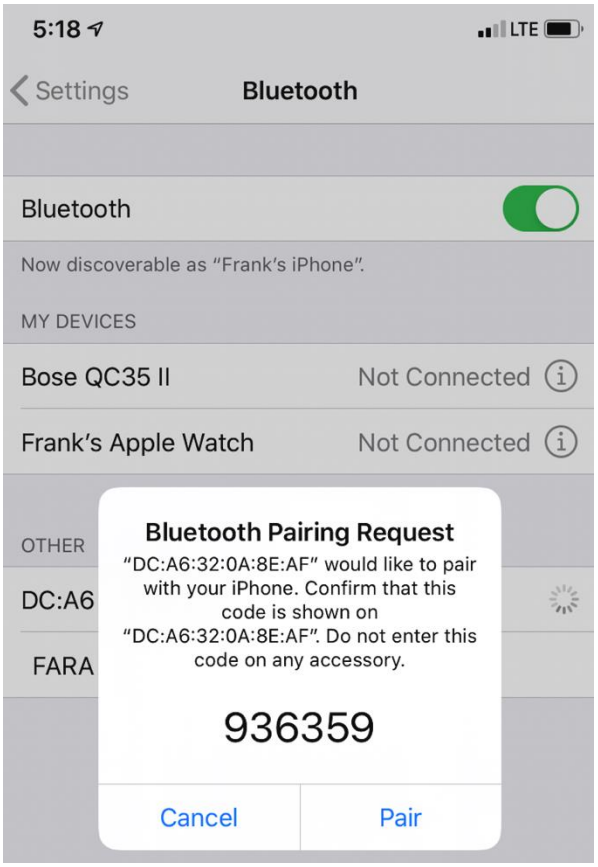

/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ Kernel
Kernel
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature is
[*] Linux Kernel
Kernel version (Latest version (5.4)) --->
() Custom kernel patches
Kernel configuration (Using an in-tree defconfig file) --->
(omap2plus) Defconfig name
() Additional configuration fragment files
() Custom boot logo file path
Kernel binary format (zImage) --->
Kernel compression format (gzip compression) --->
[*] Build a Device Tree Blob (DTB)
[ ] DTB is built by kernel itself
(am335x-evm am335x-bone am335x-boneblack am335x-bonegreen am335x-evm
(board/melp/nova/nova.dts) Out-of-tree Device Tree Source file paths
[ ] Build Device Tree with overlay support
[ ] Install kernel image to /boot in target
[*] Needs host OpenSSL
↓(+)
<Select> < Exit > < Help > < Save > < Load >


/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ Toolchain
Toolchain
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected
Toolchain type (Buildroot toolchain) --->
*** Toolchain Buildroot Options ***
(buildroot) custom toolchain vendor name
C library (uClibc-ng) --->
*** Kernel Header Options ***
Kernel Headers (Linux 5.4.x kernel headers) --->
*** uClibc Options ***
(package/uclibc/uClibc-ng.config) uClibc configuration file to us
() Additional uClibc configuration fragment files
[ ] Enable WCHAR support
[ ] Enable toolchain locale/i18n support
↓(+)
<Select> < Exit > < Help > < Save > < Load >

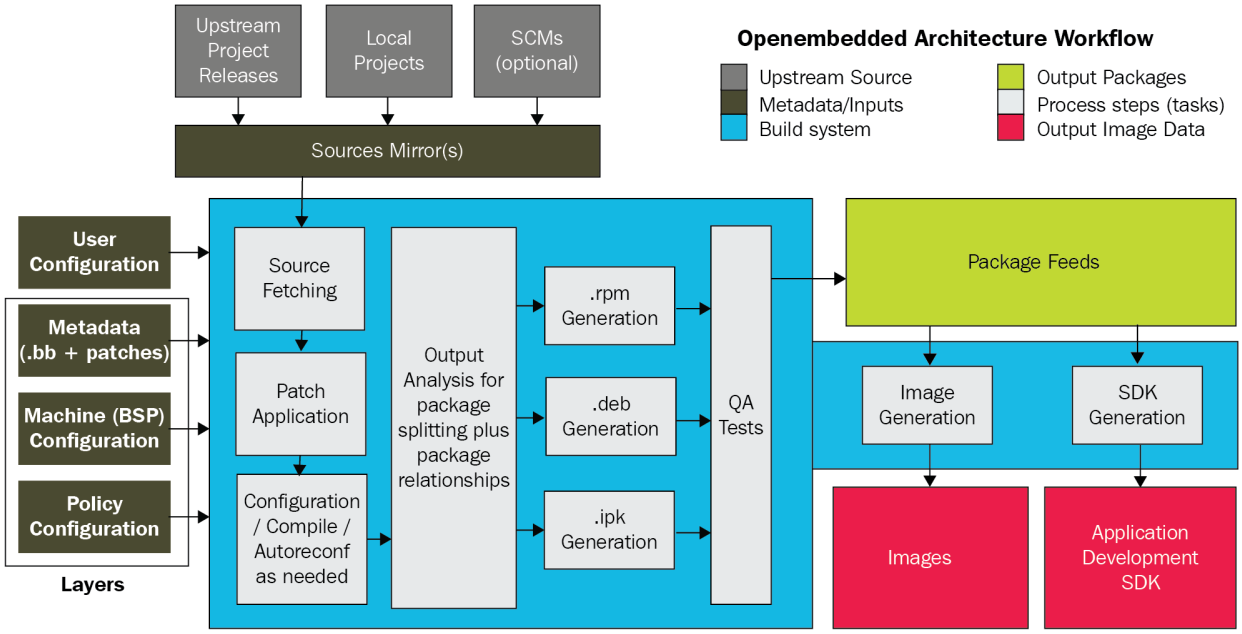

/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ System configuration
System configuration
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected
↑(-)
(/bin:/sbin:/usr/bin:/usr/sbin) Set the system's default PATH
[*] Purge unwanted locales
(C en_US) Locales to keep
*** NLS support needs a toolchain w/ wchar, dynamic library *
[ ] Install timezone info
() Path to the users tables
() Root filesystem overlay directories
(board/beaglebone/post-build.sh) Custom scripts to run before cre
() Custom scripts to run inside the fakeroot environment
(board/melp/nova/post-image.sh) Custom scripts to run after creat
(-c board/beaglebone/genimage.cfg) Extra arguments passed to cust
<Select> < Exit > < Help > < Save > < Load >

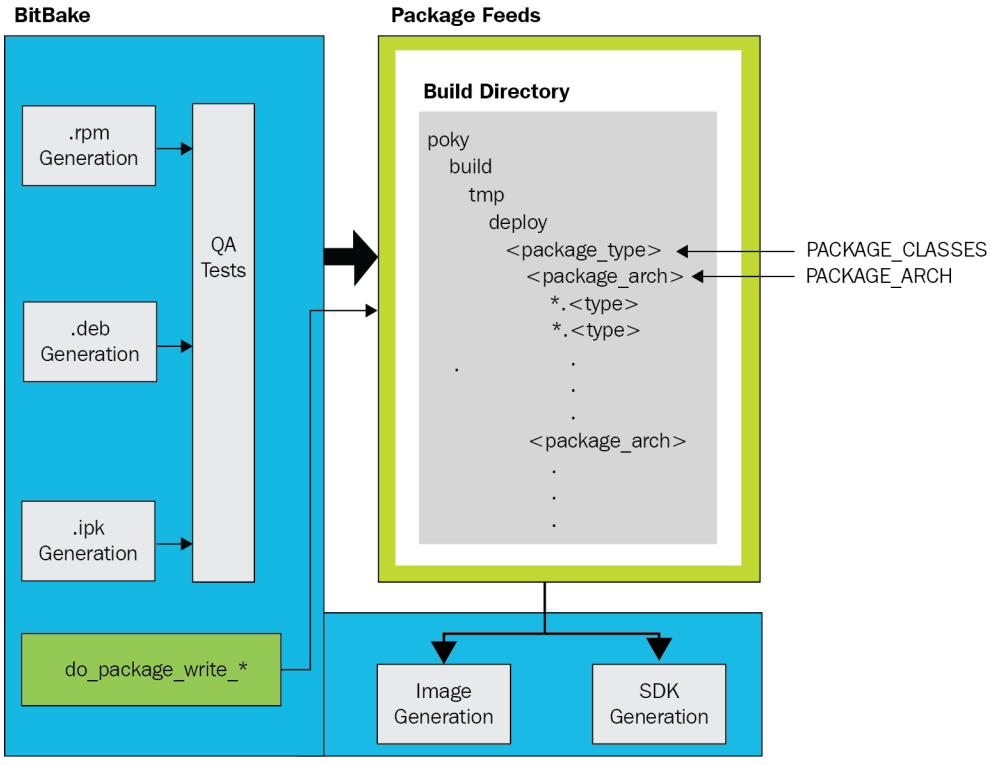

QEMU - Press Ctrl-Alt-G to
Please wait: booting...
INIT: Entering runlevel: 5
Configuring network interfaces... ip: RTNETLINK answers: File exists
Starting syslogd/klogd: done
Poky (Yocto Project Reference Distro) 3.1.5 qemuarm /dev/tty1
qemuarm login:

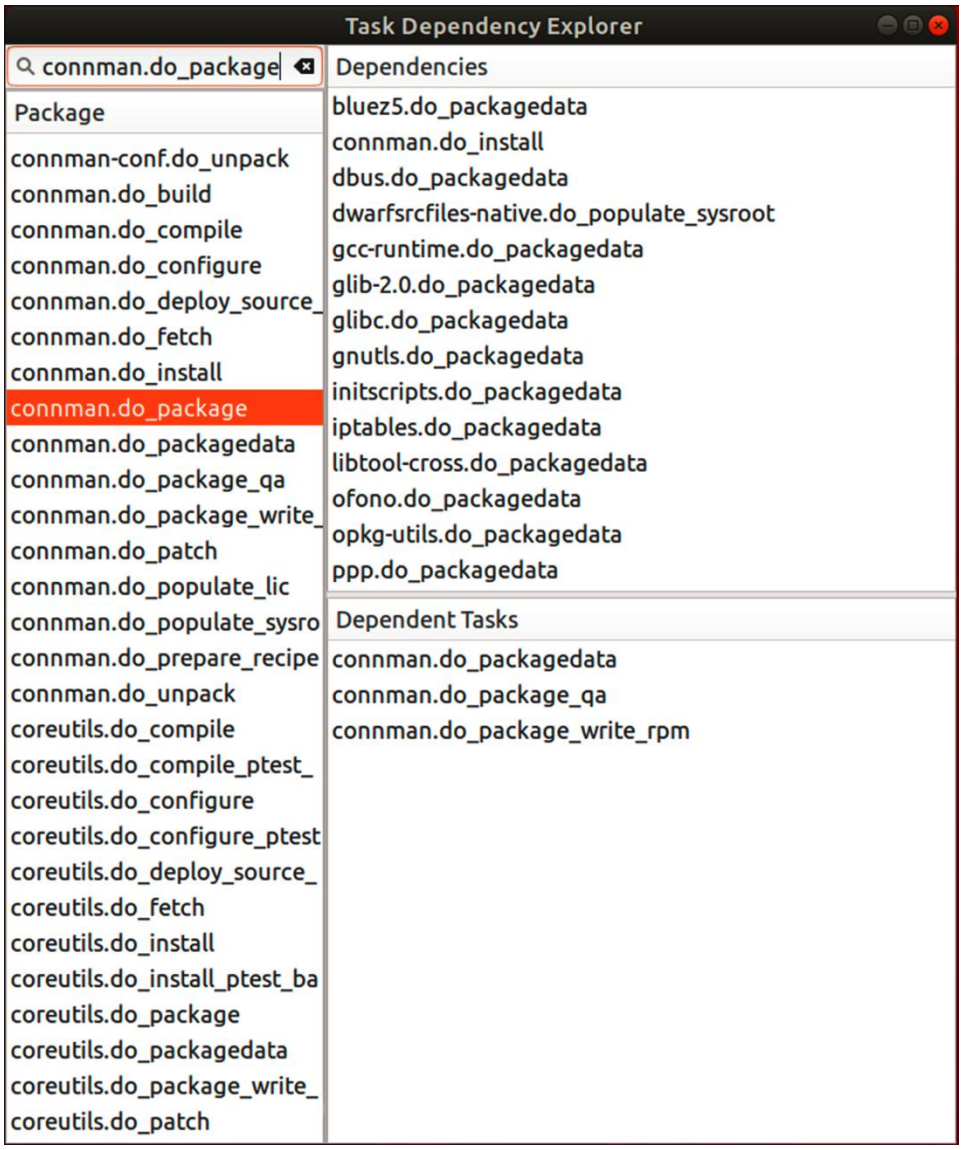
Chapter 7: Developing with Yocto



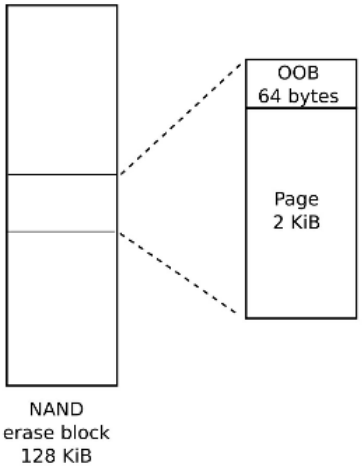
Chapter 8: Yocto Under the Hood

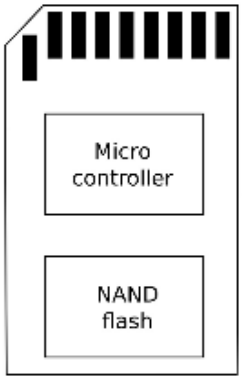


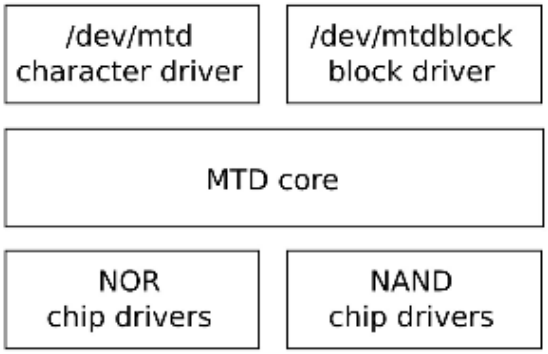


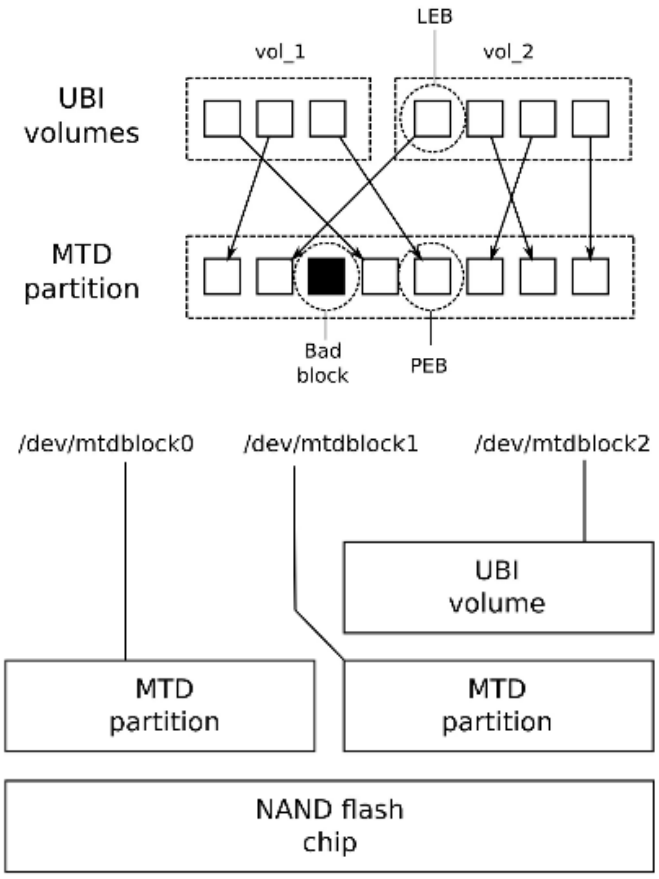

Task Dependency Explorer
connman.do_package
Package
connman-conf.do_unpack
connman.do_build
connman.do_compile
connman.do_configure
connman.do_deploy_source_
connman.do_fetch
connman.do_install
connman.do_package
connman.do_packagedata
connman.do_package_qa
connman.do_package_write_
connman.do_patch
connman.do_populate_lic
connman.do_populate_sysro
connman.do_prepare_recipe
connman.do_unpack
coreutils.do_compile
coreutils.do_compile_ptest_
coreutils.do_configure
coreutils.do_configure_ptest
coreutils.do_deploy_source_
coreutils.do_fetch
coreutils.do_install
coreutils.do_install_ptest_ba
coreutils.do_package
coreutils.do_packagedata
coreutils.do_package_write_
coreutils.do_patch
Dependencies
bluez5.do_packagedata
connman.do_install
dbus.do_packagedata
dwarfsrcfiles-native.do_populate_sysroot
gcc-runtime.do_packagedata
glib-2.0.do_packagedata
glibc.do_packagedata
gnutls.do_packagedata
initscripts.do_packagedata
iptables.do_packagedata
libtool-cross.do_packagedata
ofono.do_packagedata
opkg-utils.do_packagedata
ppp.do_packagedata
Dependent Tasks
connman.do_packagedata
connman.do_package_qa
connman.do_package_write_rpm

Chapter 9: Creating a Storage Strategy

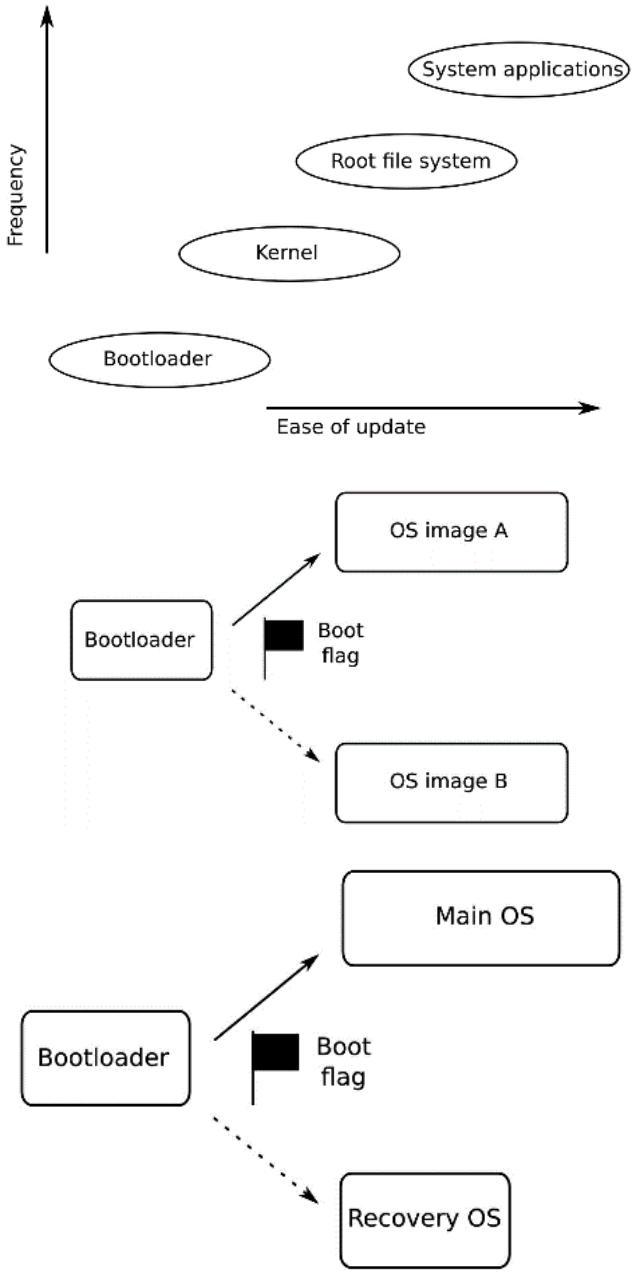


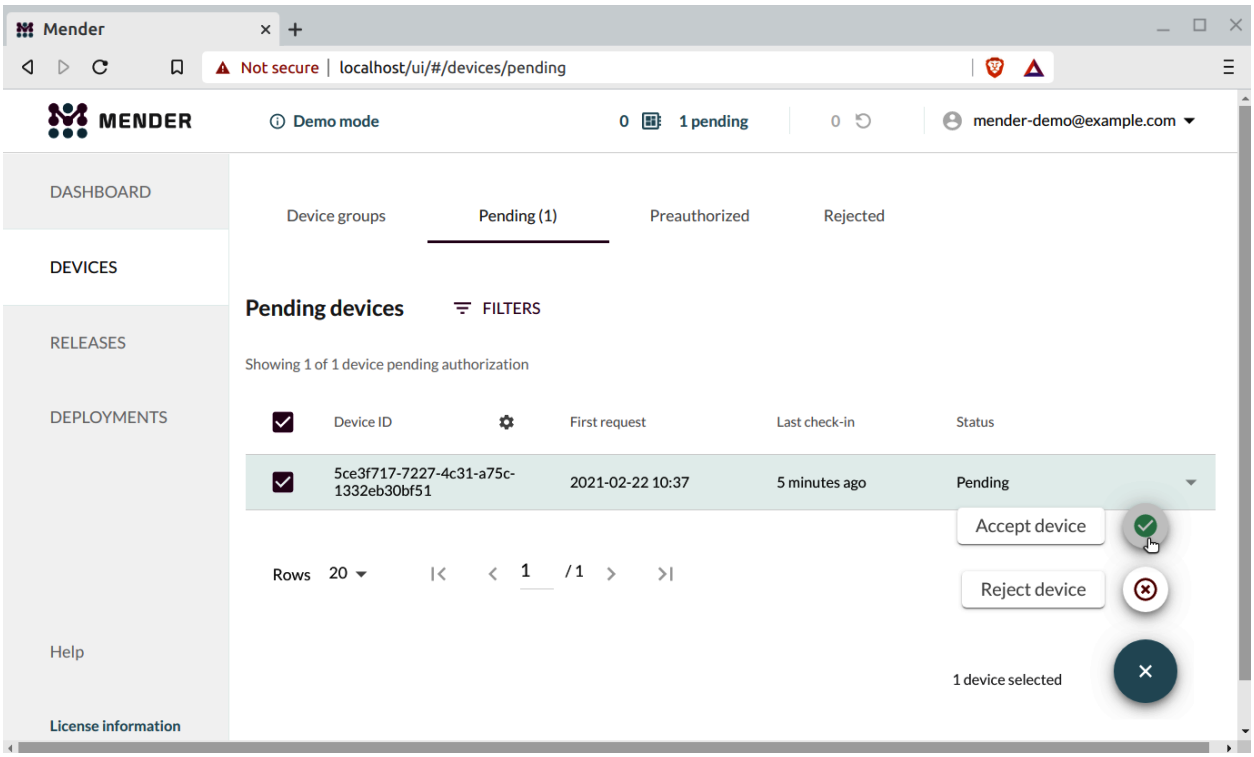


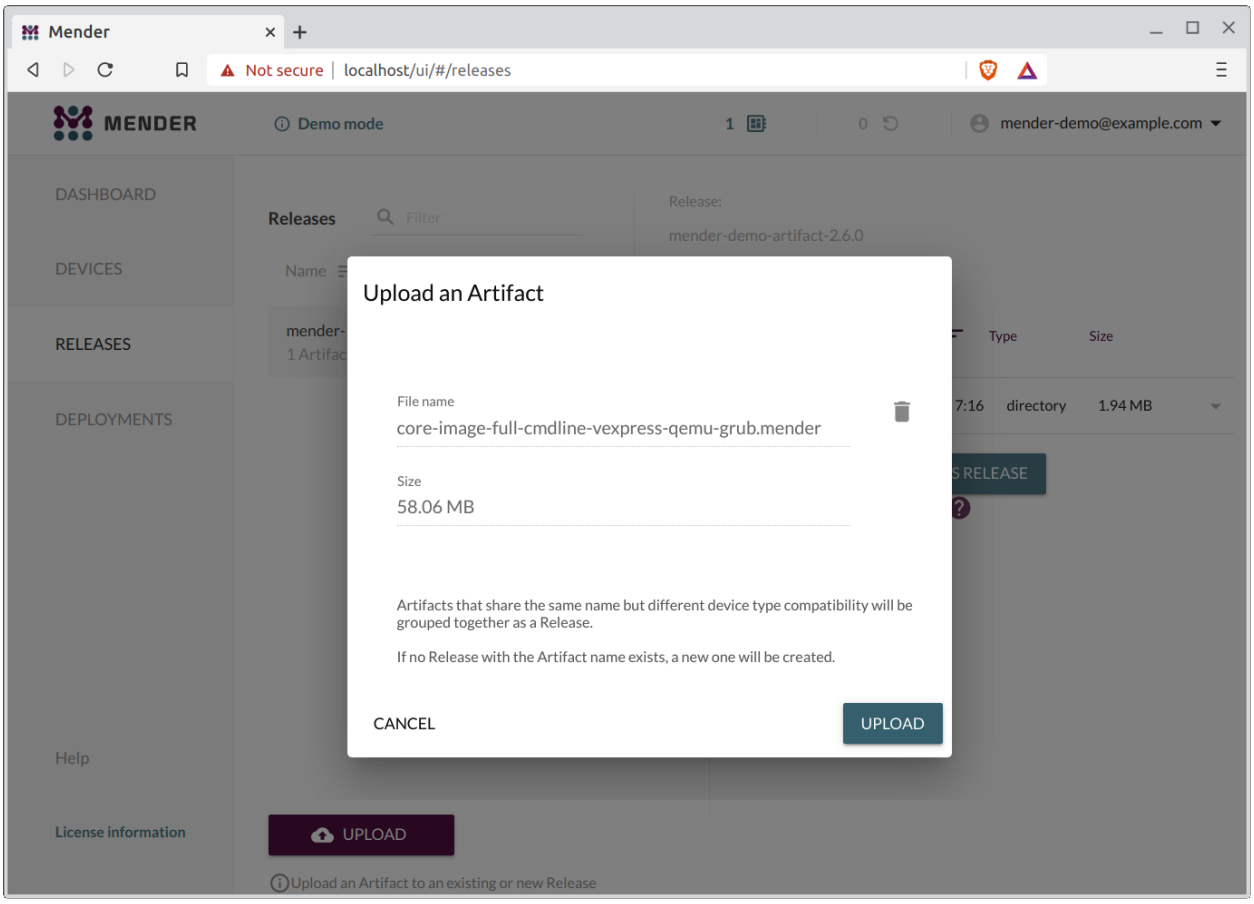


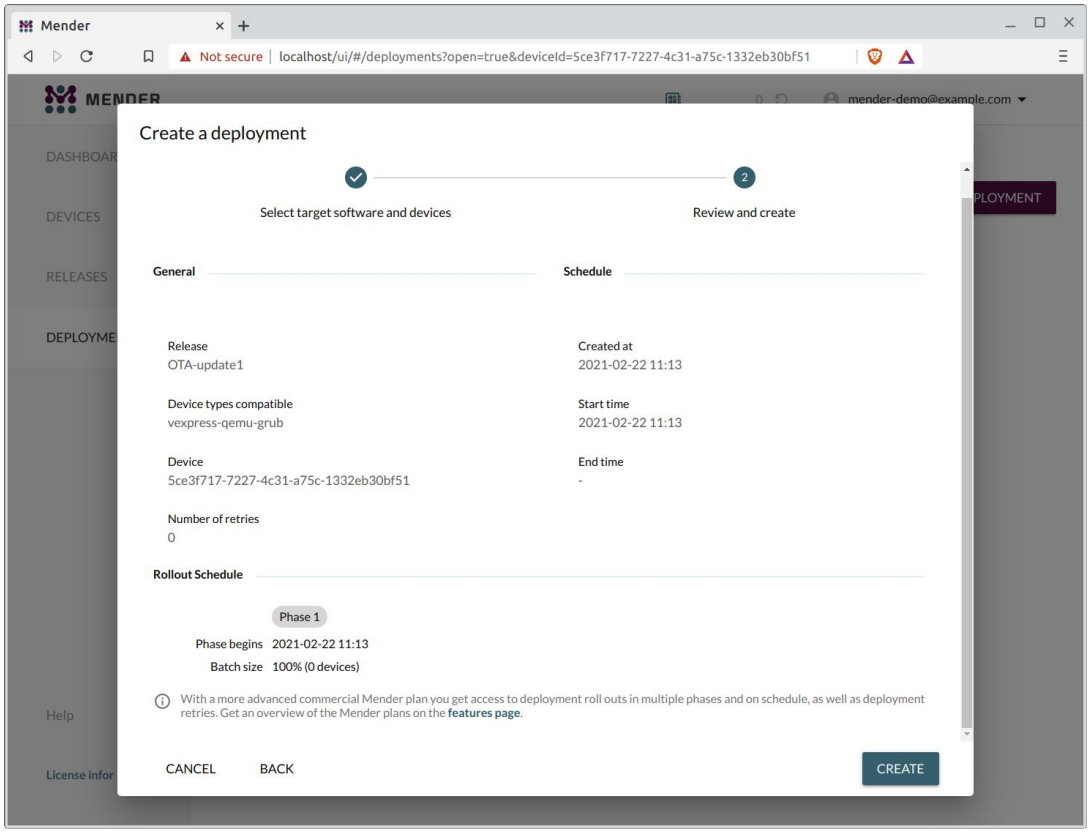

LEB
vol_1
vol_2
UBI
volumes
MTD
partition
Bad
block
PEB
/dev/mtdblock0
/dev/mtdblock1
/dev/mtdblock2
UBI
volume
MTD
partition
MTD
partition
NAND flash
chip

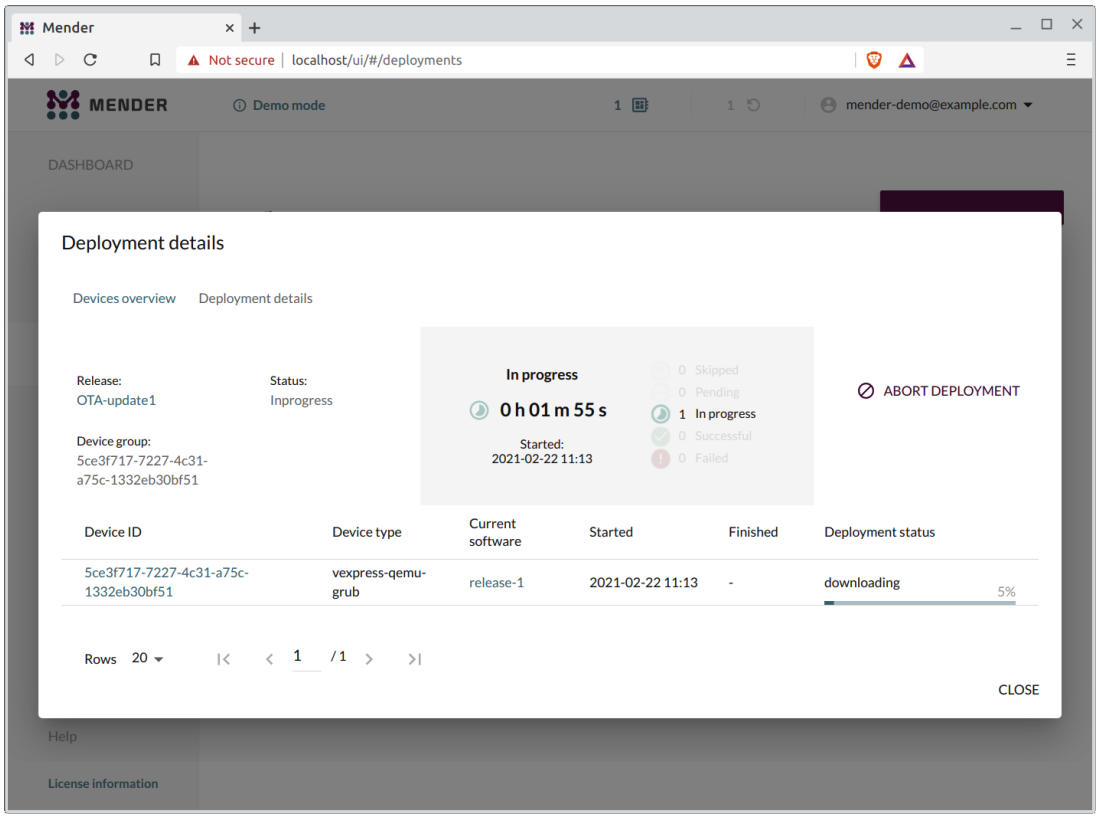
Chapter 10: Updating Software in the Field

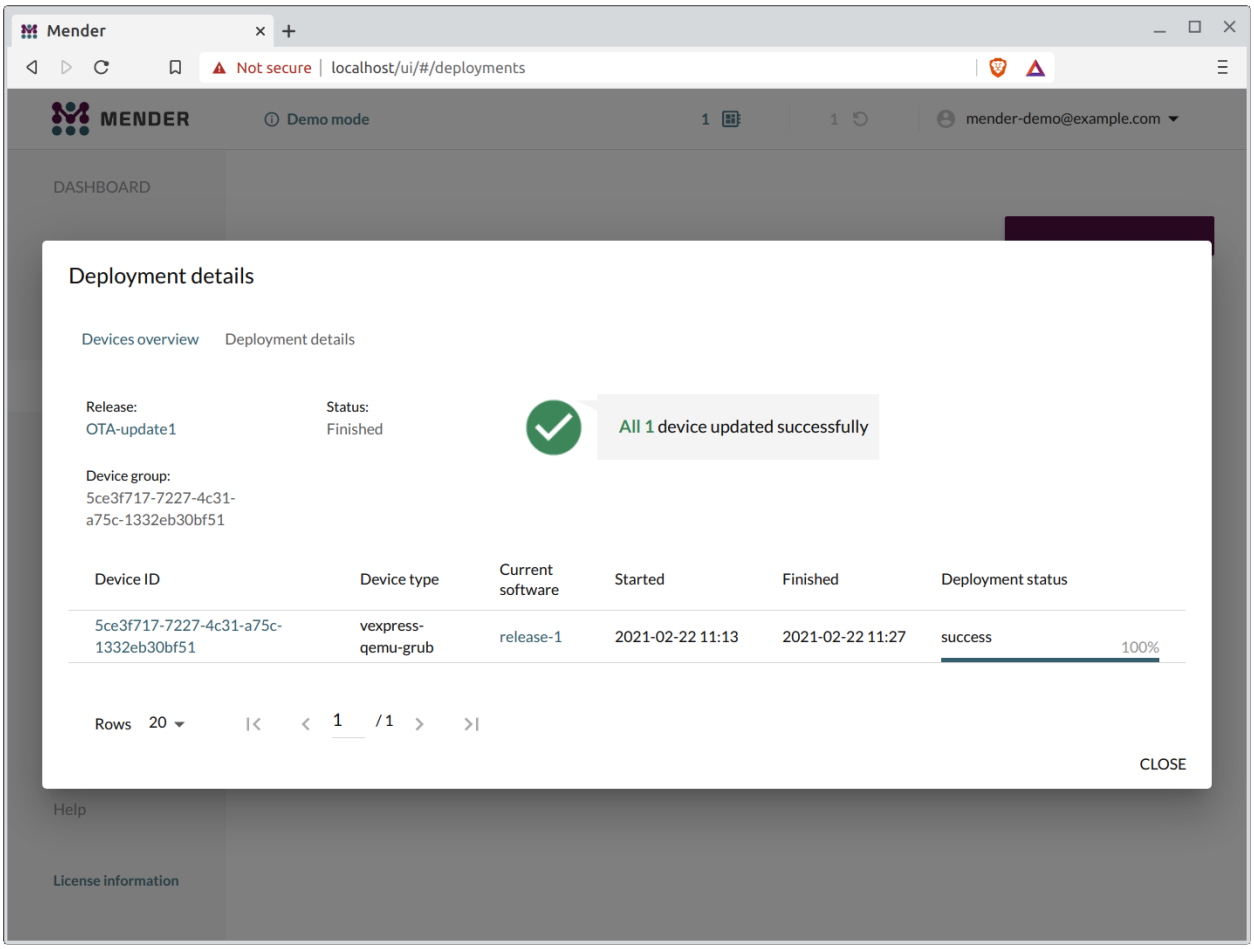



Mender
Not secure | localhost/ui/#/devices/pending
MENDER
Demo mode
0
1 pending
0
mender-demo@example.com
DASHBOARD
DEVICES
RELEASES
DEPLOYMENTS
Help
License information
Device groups
Pending (1)
Preauthorized
Rejected
Pending devices
FILTERS
Showing 1 of 1 device pending authorization
Device ID
First request
Last check-in
Status
5ce3f717-7227-4c31-a75c-1332eb30bf51
2021-02-22 10:37
5 minutes ago
Pending
Accept device
Reject device
Rows 20
1
/ 1
1 device selected


Mender
Not secure | localhost/ui/#/releases
MENDER
Demo mode
1
0
mender-demo@example.com
DASHBOARD
DEVICES
RELEASES
DEPLOYMENTS
Help
License information
Releases
Filter
Name
Release:
mender-demo-artifact-2.6.0
Type
Size
directory
1.94 MB
UPLOAD
Upload an Artifact to an existing or new Release
Upload an Artifact
File name
core-image-full-cmdline-vexpress-qemu-grub.mender
Size
58.06 MB
Artifacts that share the same name but different device type compatibility will be grouped together as a Release.
If no Release with the Artifact name exists, a new one will be created.
CANCEL
UPLOAD


Mender
Not secure | localhost/ui/#/deployments?open=true&deviceId=5ce3f717-7227-4c31-a75c-1332eb30bf51
MENDER
mender-demo@example.com
DASHBOARD
DEVICES
RELEASES
DEPLOYME
Help
License infor
Create a deployment
Select target software and devices
2
Review and create
General
Schedule
Release
OTA-update1
Created at
2021-02-22 11:13
Device types compatible
vexpress-qemu-grub
Start time
2021-02-22 11:13
Device
5ce3f717-7227-4c31-a75c-1332eb30bf51
End time
-
Number of retries
0
Rollout Schedule
Phase 1
Phase begins 2021-02-22 11:13
Batch size 100% (0 devices)
With a more advanced commercial Mender plan you get access to deployment roll outs in multiple phases and on schedule, as well as deployment retries. Get an overview of the Mender plans on the features page.
CANCEL
BACK
CREATE


Mender
Not secure | localhost/ui/#/deployments
MENDER
Demo mode
1
1
mender-demo@example.com
DASHBOARD
Help
License information
Deployment details
Devices overview
Deployment details
Release:
OTA-update1
Status:
Inprogress
Device group:
5ce3f717-7227-4c31-a75c-1332eb30bf51
In progress
0 h 01 m 55 s
Started:
2021-02-22 11:13
0 Skipped
0 Pending
1 In progress
0 Successful
0 Failed
ABORT DEPLOYMENT
Device ID
Device type
Current software
Started
Finished
Deployment status
5ce3f717-7227-4c31-a75c-1332eb30bf51
vexpress-qemu-grub
release-1
2021-02-22 11:13
-
downloading
5%
Rows 20
1
/ 1
CLOSE


Mender
Not secure | localhost/ui/#/deployments
MENDER
Demo mode
1
1
mender-demo@example.com
DASHBOARD
Deployment details
Devices overview
Deployment details
Release:
OTA-update1
Status:
Finished
All 1 device updated successfully
Device group:
5ce3f717-7227-4c31-a75c-1332eb30bf51
Device ID
Device type
Current software
Started
Finished
Deployment status
5ce3f717-7227-4c31-a75c-1332eb30bf51
vexpress-qemu-grub
release-1
2021-02-22 11:13
2021-02-22 11:27
success
100%
Rows 20
1
/ 1
CLOSE
Help
License information

balenaCloud

Your first 10 devices are always free

Upgrade anytime. Hassle free.

Sign up with GitHub

Sign up with Google

or sign up with

Email*

frank.vasquez@gmail.com

Password*

••••••••

Password strength: *Good*

Send me the balena monthly newsletter

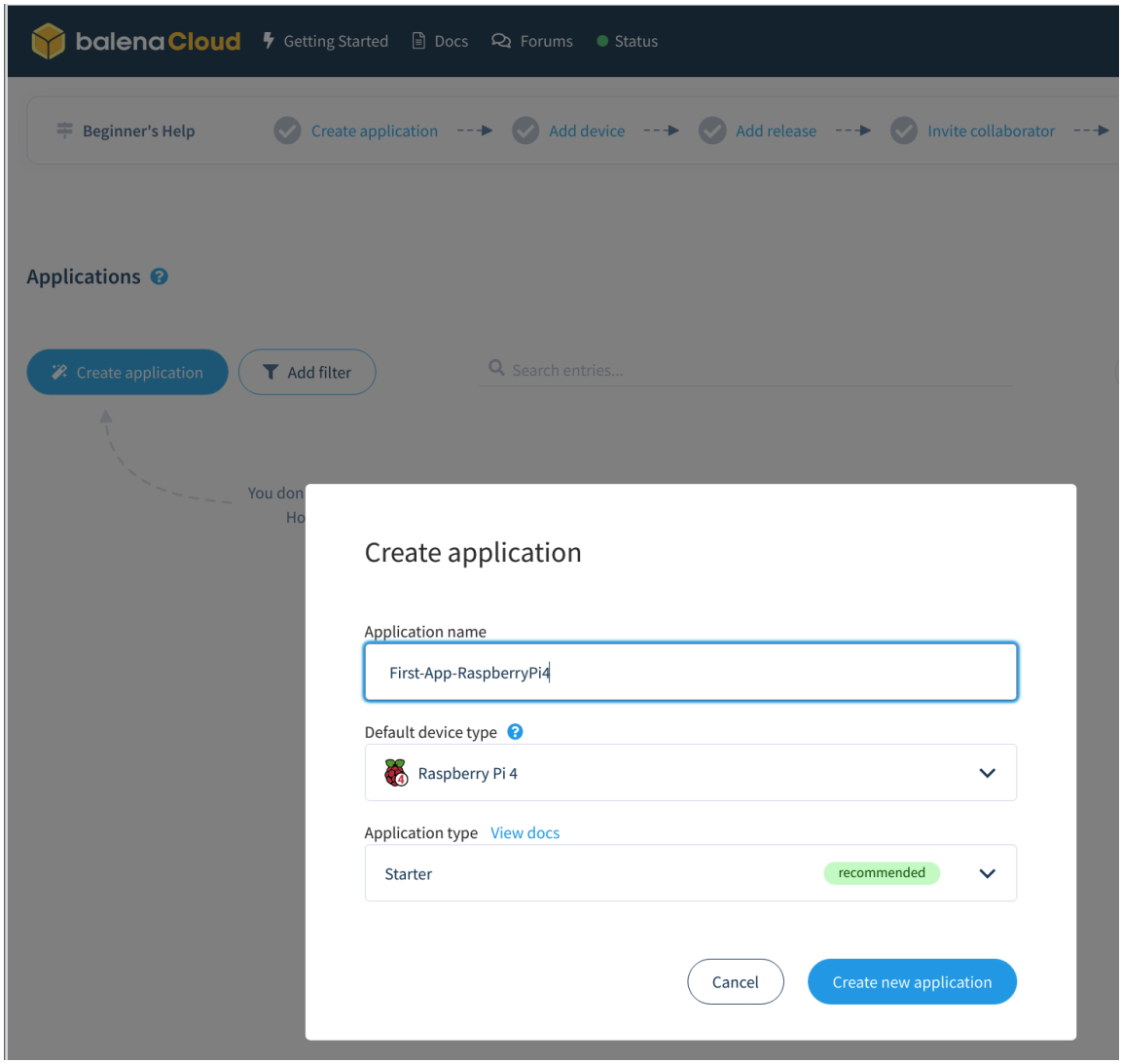
We send one newsletter a month, and do not share your e-mail with third parties

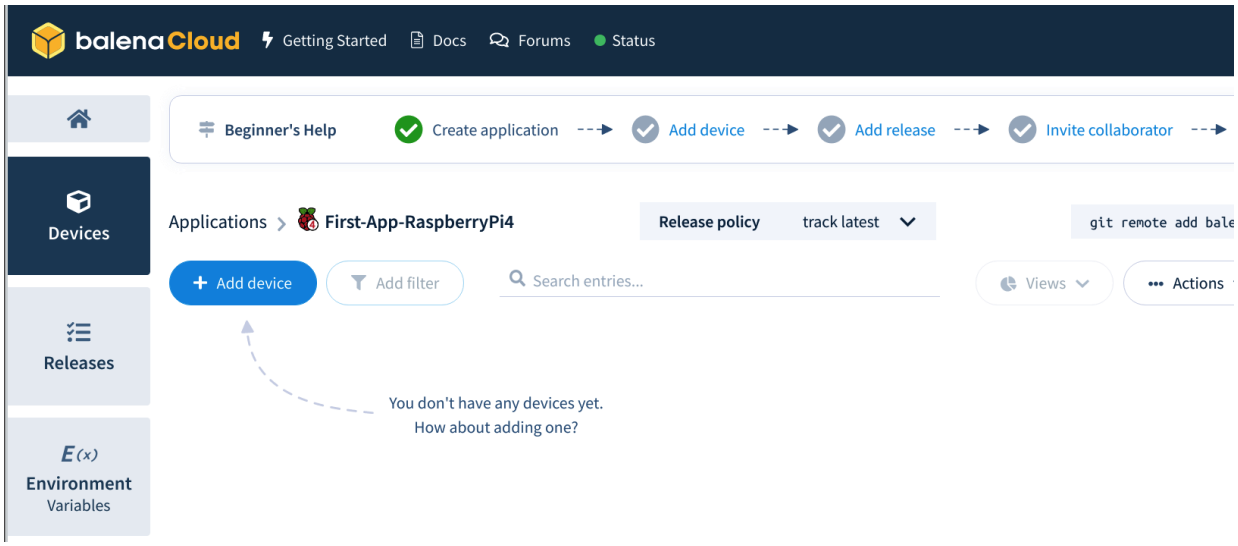
I'm not a robot

reCAPTCHA
Privacy - Terms

Sign up

Already have an account? Log in


balenaCloud
Getting Started
Docs
Forums
Status
Beginner's Help
Create application
Add device
Add release
Invite collaborator
Applications
Create application
Add filter
Search entries...
Create application
Application name
First-App-RaspberryPi4
Default device type
Raspberry Pi 4
Application type
View docs
Starter
recommended
Cancel
Create new application


balenaCloud
Getting Started
Docs
Forums
Status
Beginner's Help
Create application
Add device
Add release
Invite collaborator
Devices
Releases
Environment Variables
Applications
First-App-RaspberryPi4
Release policy
track latest
git remote add bale
Add device
Add filter
Search entries...
Views
Actions
You don't have any devices yet.
How about adding one?

Add new device

Select device type

Raspberry Pi 4

Select OS type View docs

balenaOS

Select version

v2.58.6+rev1 (recommended)

Show outdated versions

Select edition

Development Recommended for first time users

Development images should be used when you are developing an application and want to use the fast local mode workflow. **This variant should never be used in production.**

Production

Production images are ready for production deployments, but don't offer easy access for local development.

Network Connection

Ethernet only

Wifi + Ethernet

Wifi SSID

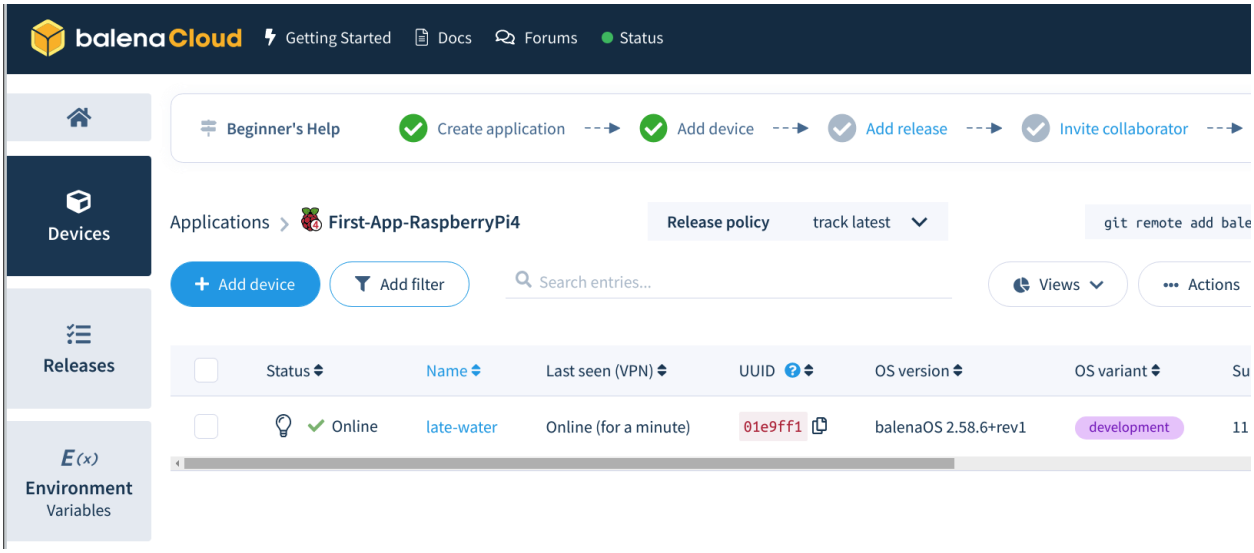
RT-AC66U_B1_38_2G

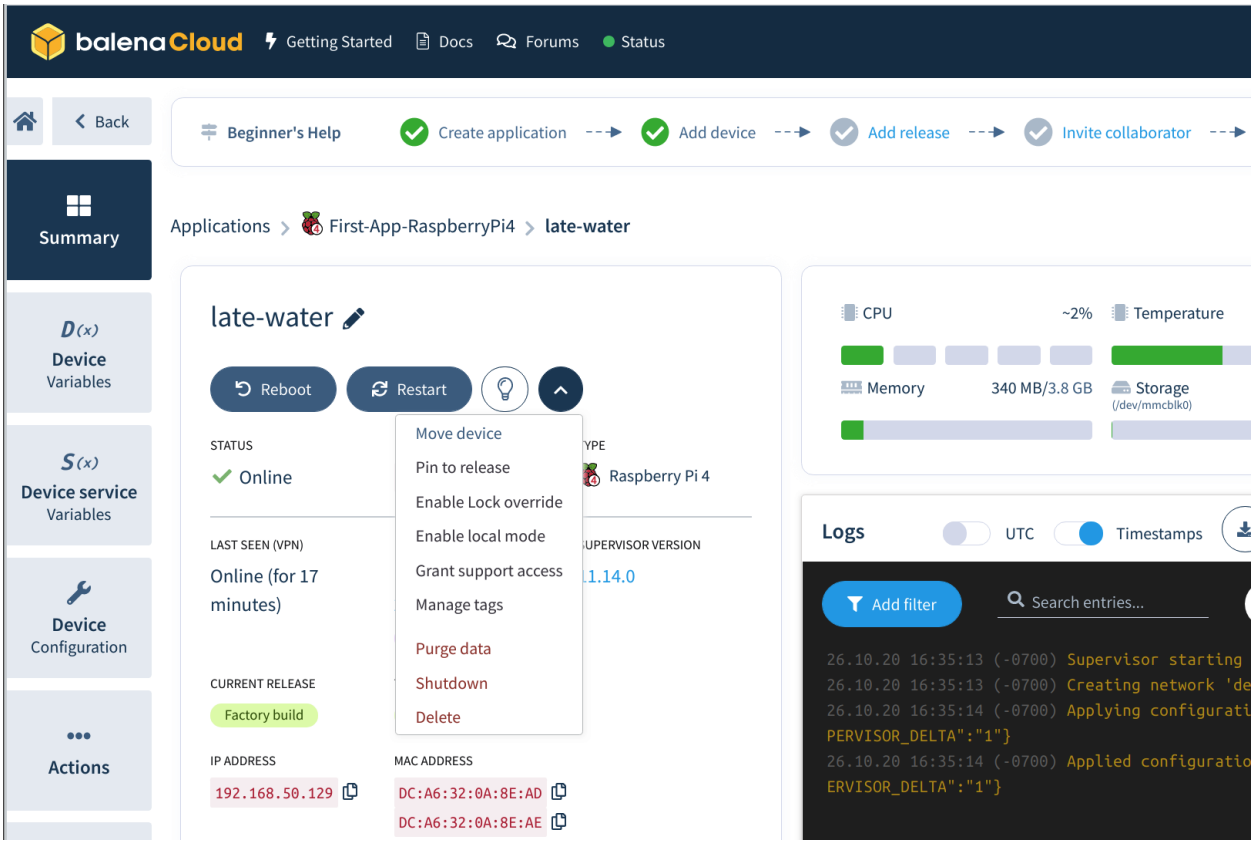
Wifi Passphrase

••••••••••••

+ Advanced

Download balenaOS (~158 MB)


balenaCloud
Getting Started
Docs
Forums
Status
Beginner's Help
Create application
Add device
Add release
Invite collaborator
Devices
Releases
Environment Variables
Applications
First-App-RaspberryPi4
Release policy
track latest
git remote add bale
Add device
Add filter
Search entries...
Views
Actions
Status
Name
Last seen (VPN)
UUID
OS version
OS variant
Online
late-water
Online (for a minute)
01e9ff1
balenaOS 2.58.6+rev1
development


balenaCloud
Getting Started
Docs
Forums
Status
Back
Beginner's Help
Create application
Add device
Add release
Invite collaborator
Summary
Device Variables
Device service Variables
Device Configuration
Actions
Applications
First-App-RaspberryPi4
late-water
late-water
Reboot
Restart
Move device
Pin to release
Enable Lock override
Enable local mode
Grant support access
Manage tags
Purge data
Shutdown
Delete
STATUS
Online
Raspberry Pi 4
LAST SEEN (VPN)
Online (for 17 minutes)
CURRENT RELEASE
Factory build
IP ADDRESS
192.168.50.129
MAC ADDRESS
DC:A6:32:0A:8E:AD
DC:A6:32:0A:8E:AE
CPU
~2%
Temperature
Memory
340 MB/3.8 GB
Storage
(/dev/mmcblk0)
Logs
UTC
Timestamps
Add filter
Search entries...
26.10.20 16:35:13 (-0700) Supervisor starting
26.10.20 16:35:13 (-0700) Creating network
26.10.20 16:35:14 (-0700) Applying configurati
PERVISOR_DELTA":"1"}
26.10.20 16:35:14 (-0700) Applied configuratio
ERVISOR_DELTA":"1"}

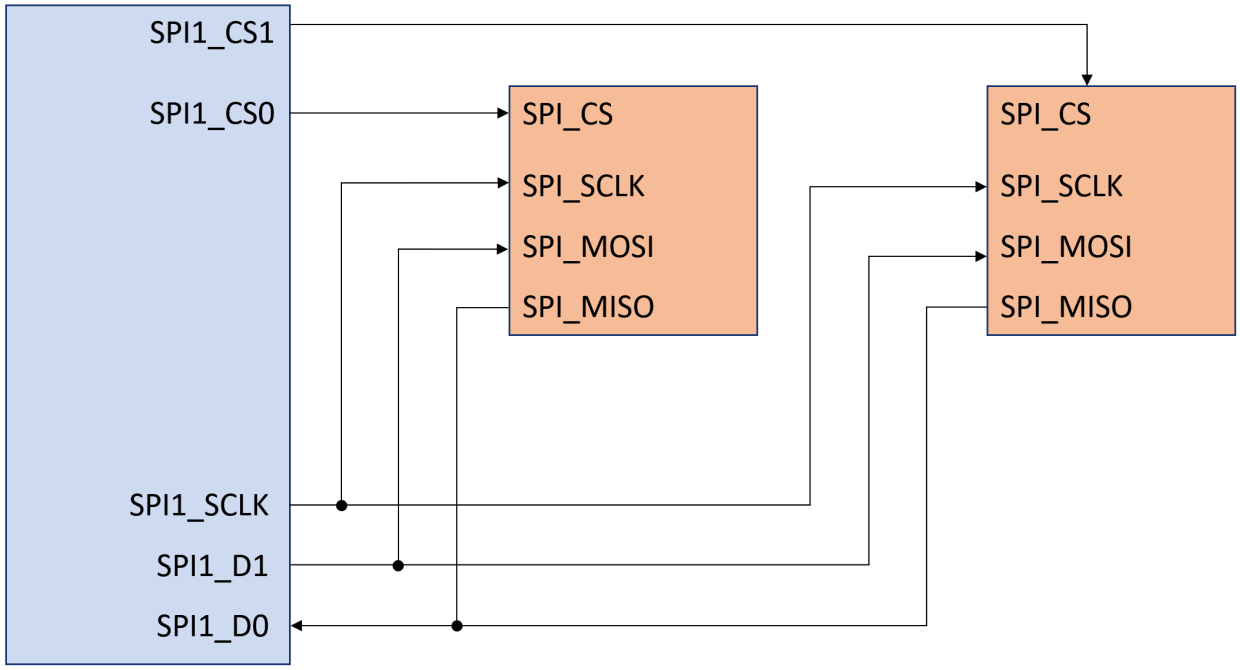
Chapter 11: Interfacing with Device Drivers

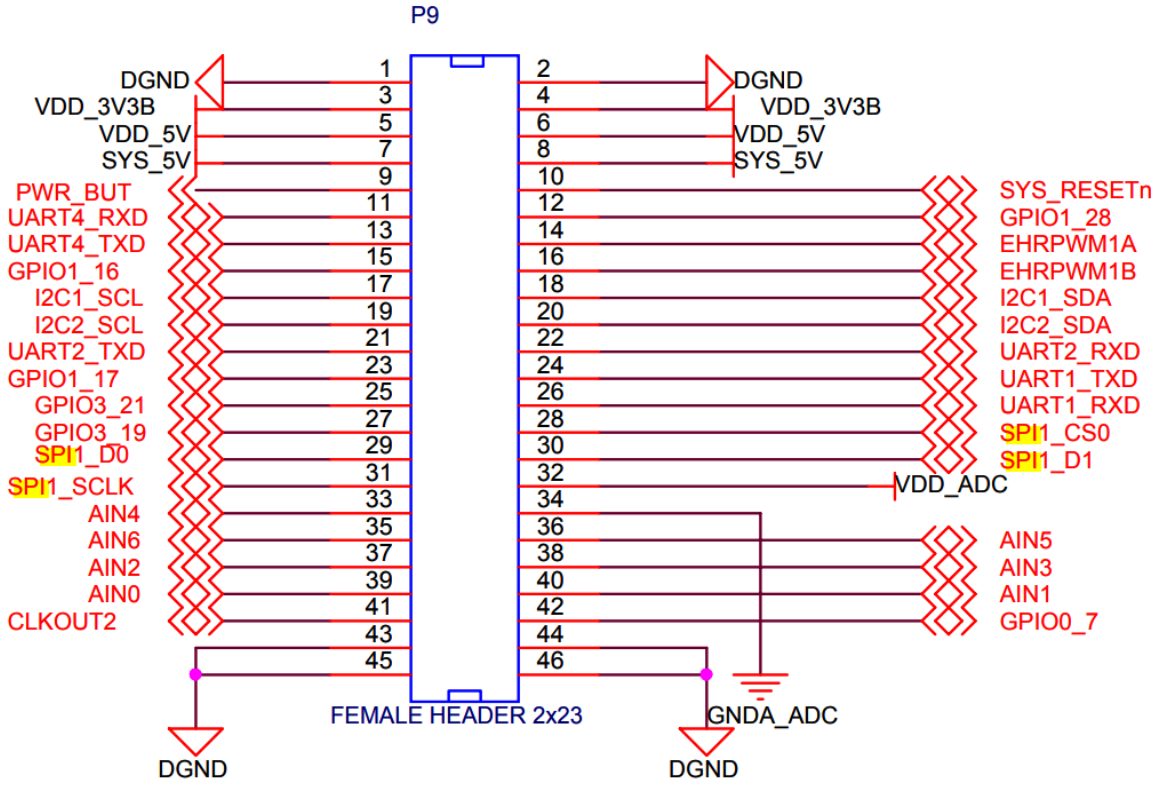
No Images

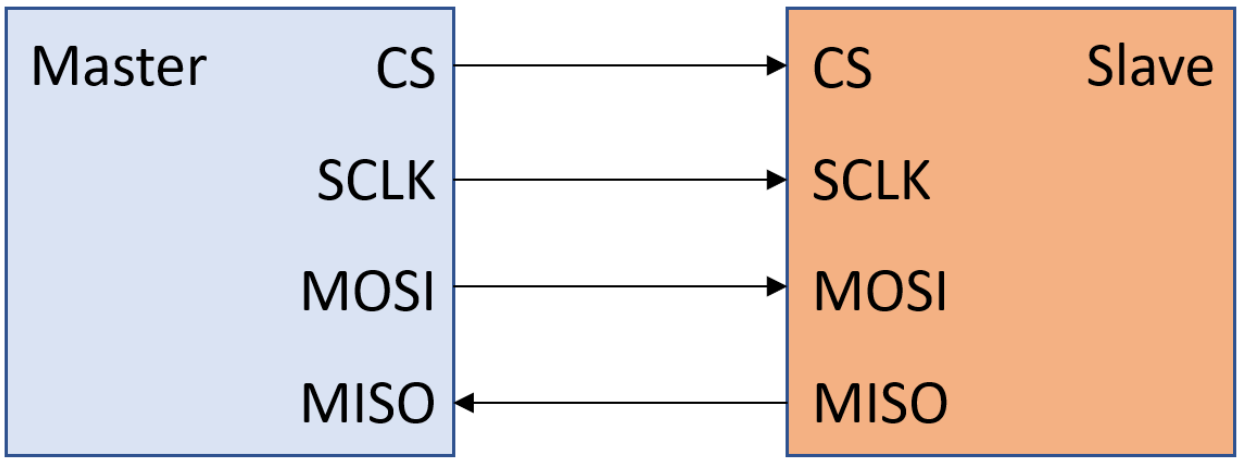
Chapter 12: Prototyping with Breakout Boards

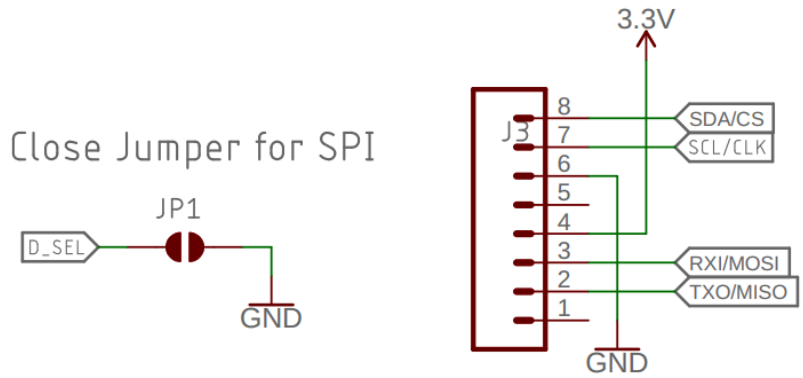
P9

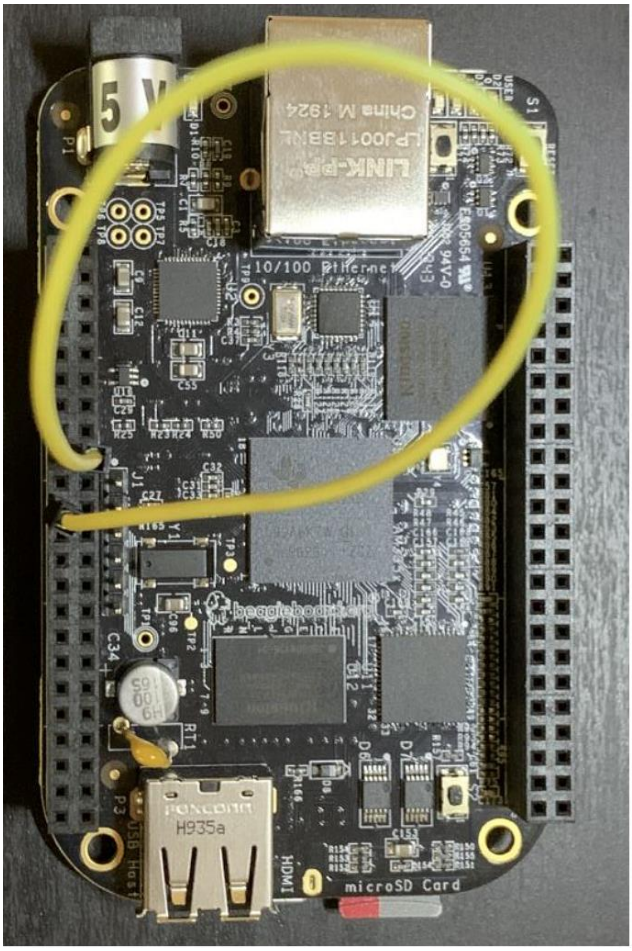
DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
GPIO_30	11	12	GPIO_60
GPIO_31	13	14	GPIO_40
GPIO_48	15	16	GPIO_51
SPI0_CS0	17	18	SPI0_D1
SPI1_CS1	19	20	SPI1_CS0
SPI0_D0	21	22	SPI0_SCLK
GPIO_49	23	24	GPIO_15
GPIO_117	25	26	GPIO_14
GPIO_125	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	SPI1_CS1
DGND	43	44	DGND
DGND	45	46	DGND




P9
DGND
VDD_3V3B
VDD_5V
SYS_5V
PWR_BUT
UART4_RXD
UART4_TXD
GPIO1_16
I2C1_SCL
I2C2_SCL
UART2_TXD
GPIO1_17
GPIO3_21
GPIO3_19
SPI1_D0
SPI1_SCLK
AIN4
AIN6
AIN2
AIN0
CLKOUT2
1 2
3 4
5 6
7 8
9 10
11 12
13 14
15 16
17 18
19 20
21 22
23 24
25 26
27 28
29 30
31 32
33 34
35 36
37 38
39 40
41 42
43 44
45 46
DGND
VDD_3V3B
VDD_5V
SYS_5V
SYS_RESETn
GPIO1_28
EHRPWM1A
EHRPWM1B
I2C1_SDA
I2C2_SDA
UART2_RXD
UART1_TXD
UART1_RXD
SPI1_CS0
SPI1_D1
VDD_ADC
AIN5
AIN3
AIN1
GPIO0_7
FEMALE HEADER 2x23
GNDA_ADC
DGND
DGND

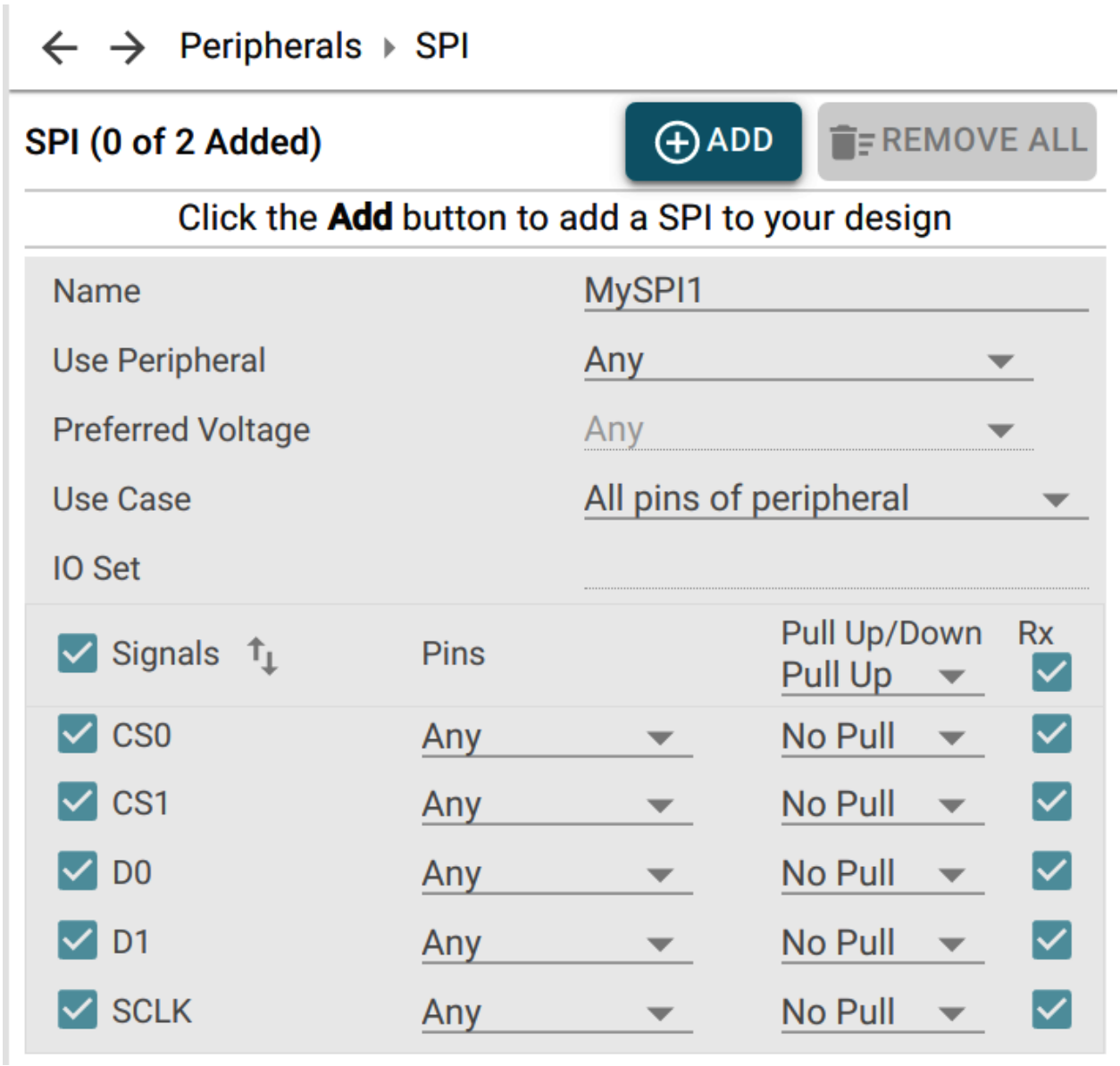

Master
CS
SCLK
MOSI
MISO
CS
SCLK
MOSI
MISO
Slave

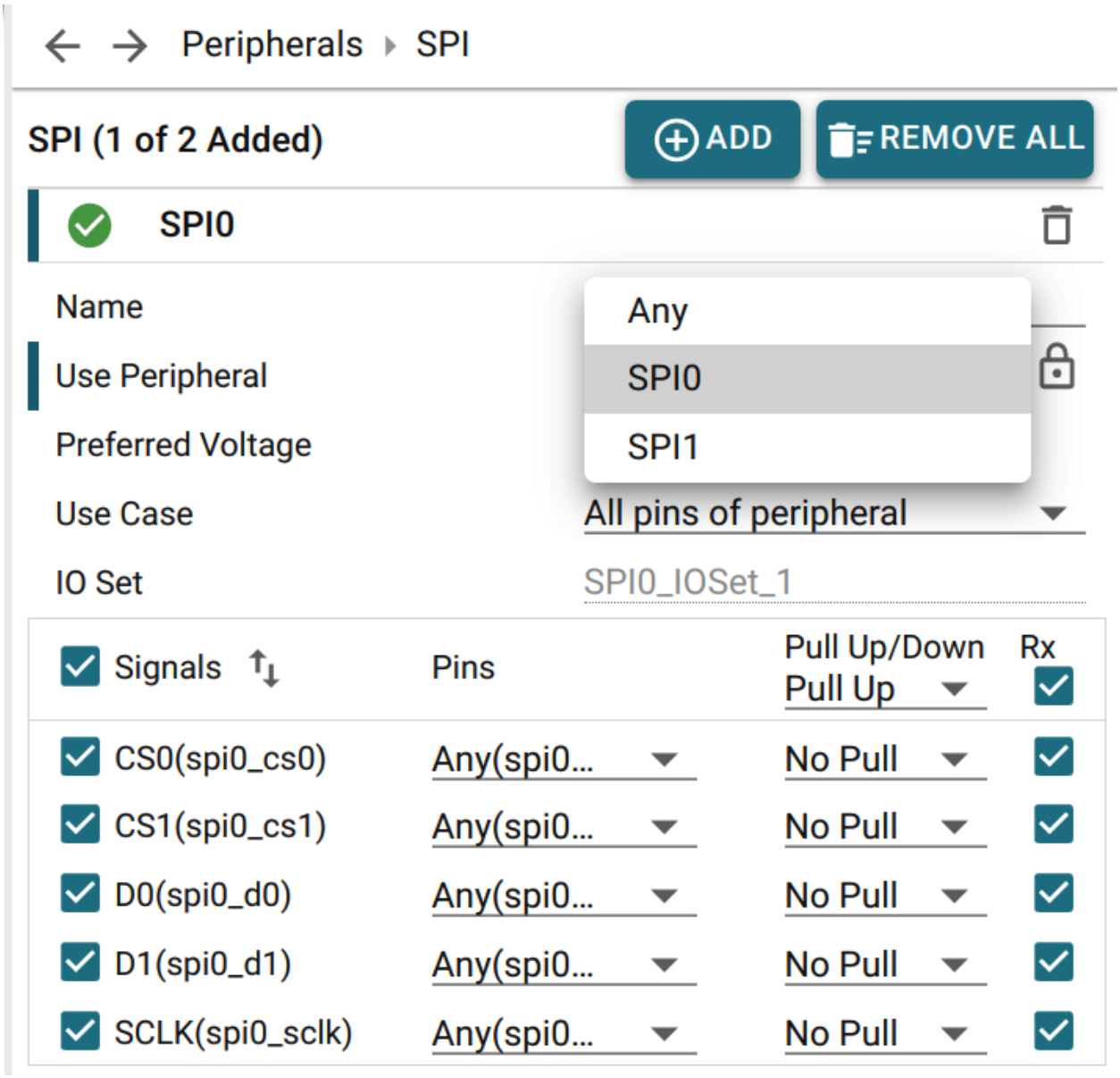

Close Jumper for SPI
JP1
D_SEL
GND
3.3V
J3
8
7
6
5
4
3
2
1
SDA/CS
SCL/CLK
RXI/MOSI
TXO/MISO
GND

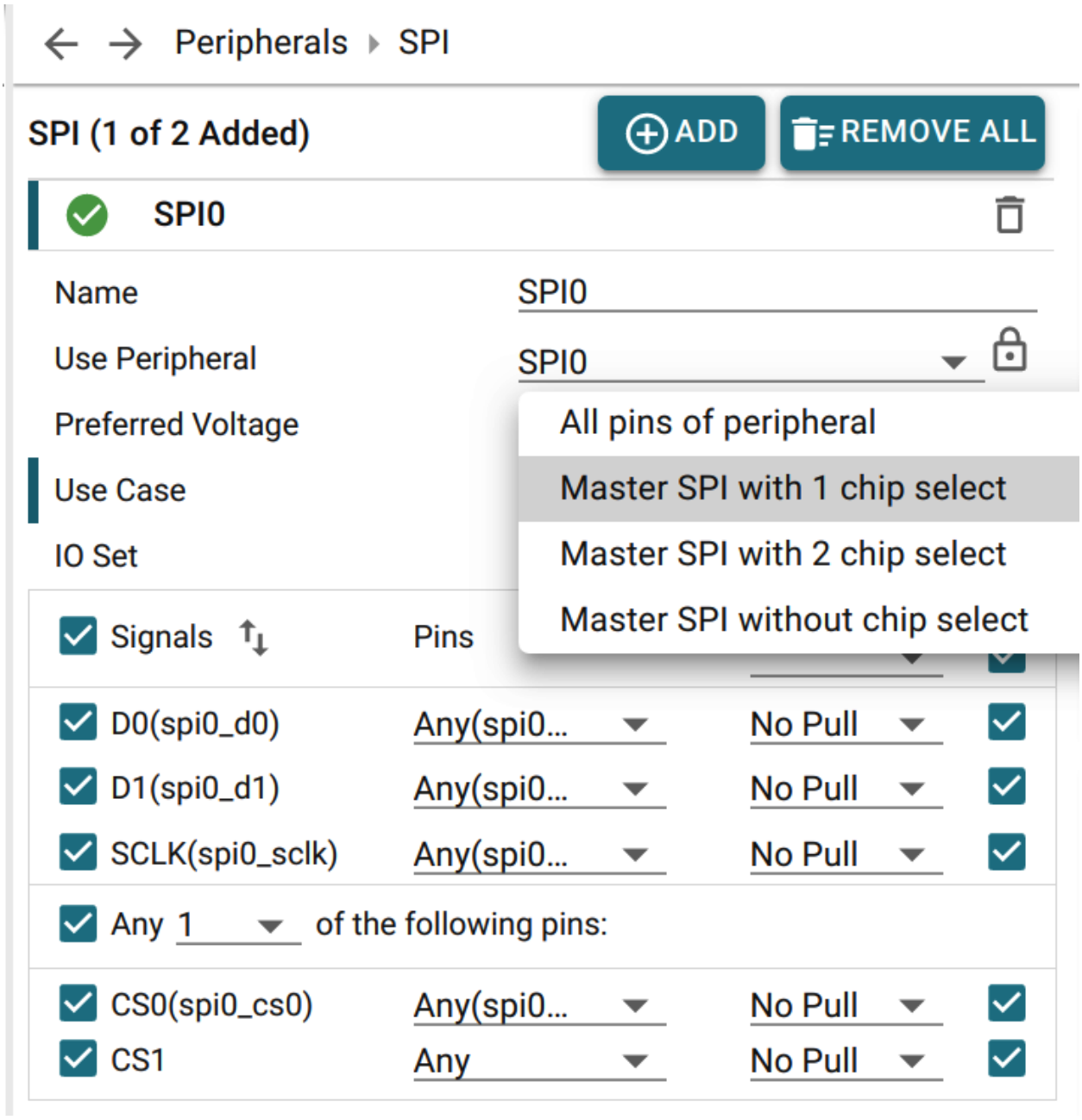


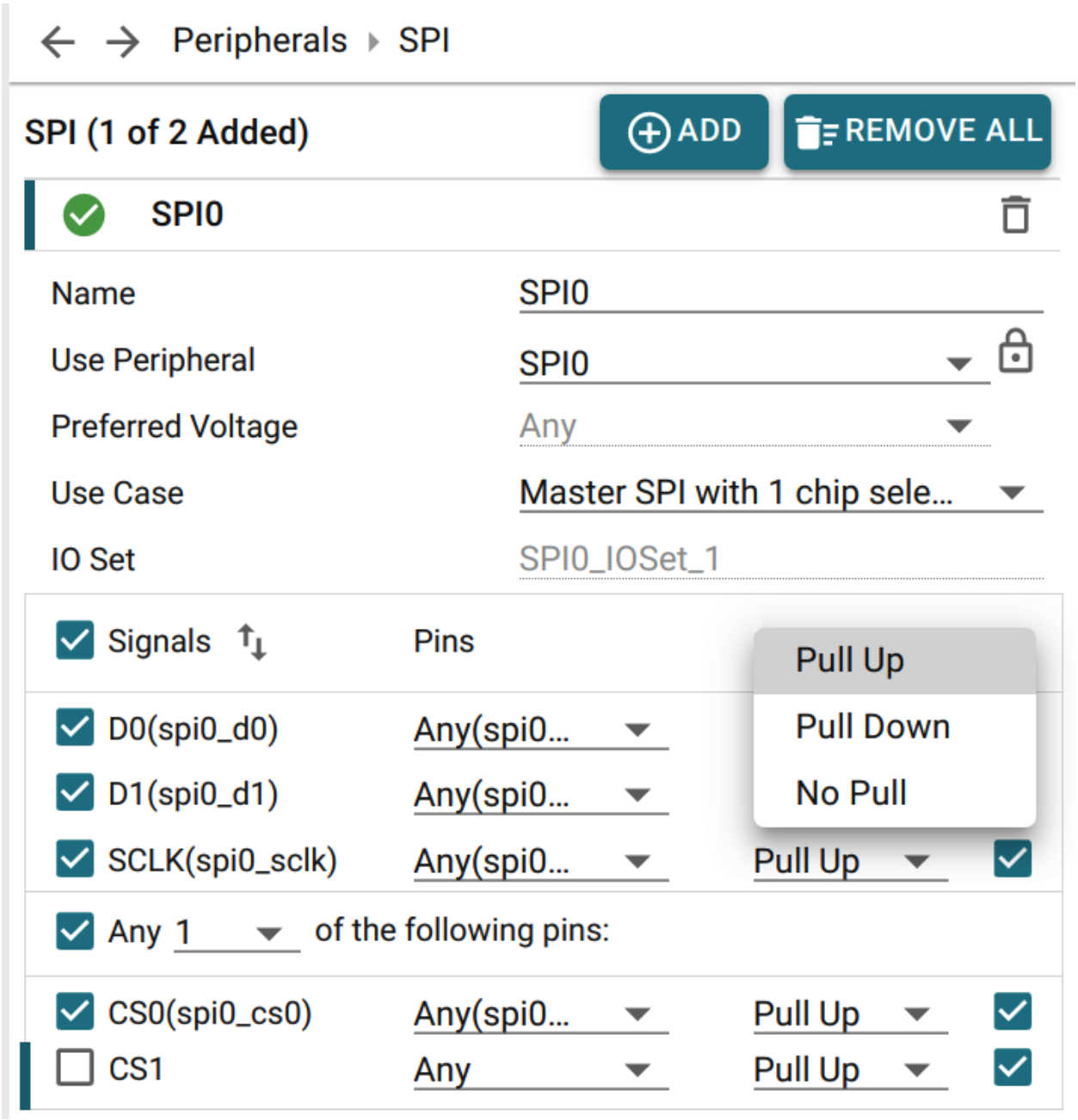
P9

DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETN
GPIO_30	11	12	GPIO_60
GPIO_31	13	14	GPIO_40
GPIO_48	15	16	GPIO_51
SPI0_CS0	17	18	SPI0_D1
SPI1_CS1	19	20	SPI1_CS0
SPI0_D0	21	22	SPI0_SCLK
GPIO_49	23	24	GPIO_15
GPIO_117	25	26	GPIO_14
GPIO_125	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	SPI1_CS1
DGND	43	44	DGND
DGND	45	46	DGND


Peripherals
SPI
SPI (0 of 2 Added)
ADD
REMOVE ALL
Click the Add button to add a SPI to your design
Name
MySPI1
Use Peripheral
Any
Preferred Voltage
Any
Use Case
All pins of peripheral
IO Set
Signals
Pins
Pull Up/Down
Pull Up
Rx
CS0
Any
No Pull
CS1
Any
No Pull
D0
Any
No Pull
D1
Any
No Pull
SCLK
Any
No Pull


Peripherals
SPI
SPI (1 of 2 Added)
ADD
REMOVE ALL
SPI0
Name
Use Peripheral
Preferred Voltage
Use Case
IO Set
Any
SPI0
SPI1
All pins of peripheral
SPI0_IOSet_1
Signals
Pins
Pull Up/Down
Pull Up
Rx
CS0(spi0_cs0)
CS1(spi0_cs1)
D0(spi0_d0)
D1(spi0_d1)
SCLK(spi0_sclk)
Any(spi0...
No Pull


Peripherals
SPI
SPI (1 of 2 Added)
ADD
REMOVE ALL
SPI0
Name
SPI0
Use Peripheral
SPI0
Preferred Voltage
Use Case
IO Set
All pins of peripheral
Master SPI with 1 chip select
Master SPI with 2 chip select
Master SPI without chip select
Signals
Pins
D0(spi0_d0)
Any(spi0...
No Pull
D1(spi0_d1)
Any(spi0...
No Pull
SCLK(spi0_sclk)
Any(spi0...
No Pull
Any 1 of the following pins:
CS0(spi0_cs0)
Any(spi0...
No Pull
CS1
Any
No Pull


Peripherals
SPI
SPI (1 of 2 Added)
ADD
REMOVE ALL
SPI0
Name
SPI0
Use Peripheral
SPI0
Preferred Voltage
Any
Use Case
Master SPI with 1 chip sele...
IO Set
SPI0_IOSet_1
Signals
Pins
Pull Up
Pull Down
No Pull
D0(spi0_d0)
Any(spi0...
D1(spi0_d1)
Any(spi0...
SCLK(spi0_sclk)
Any(spi0...
Pull Up
Any 1 of the following pins:
CS0(spi0_cs0)
Any(spi0...
Pull Up
CS1
Any
Pull Up

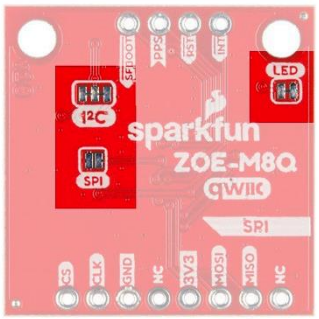
Peripherals ▸ SPI

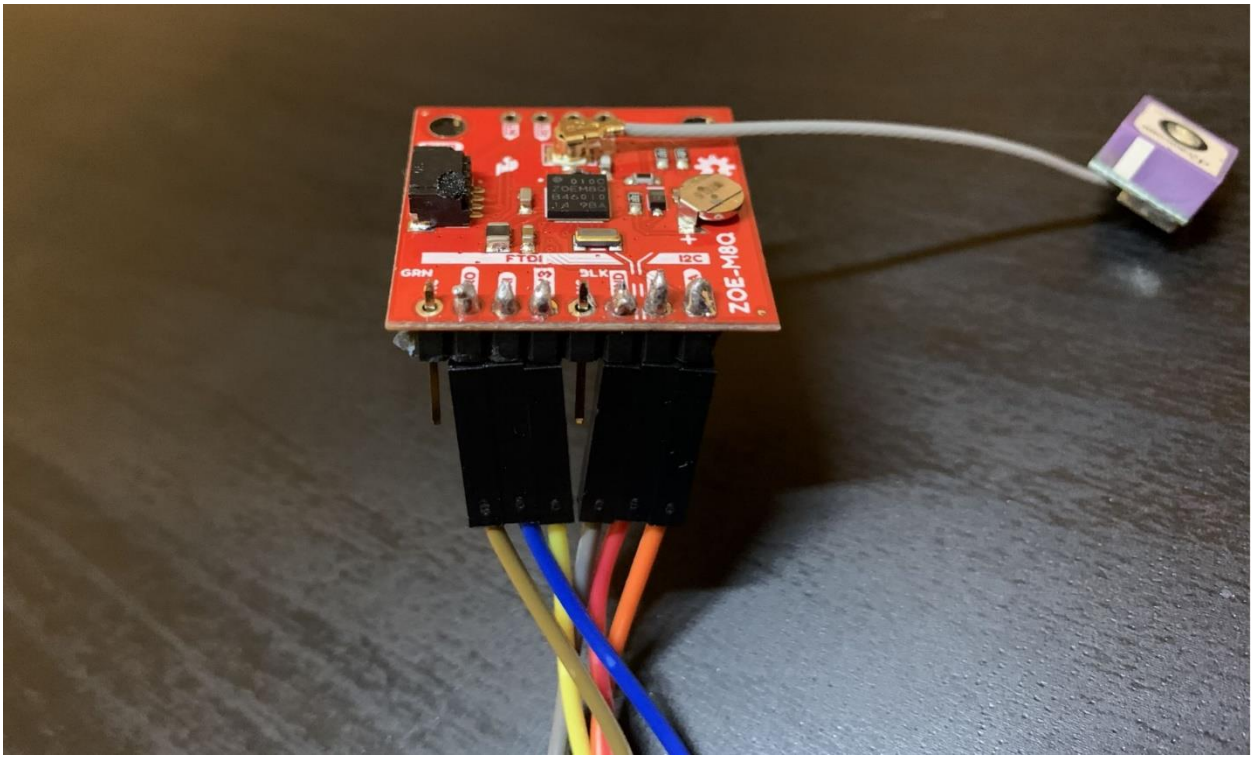
SPI (1 of 2 Added) ADD REMOVE ALL

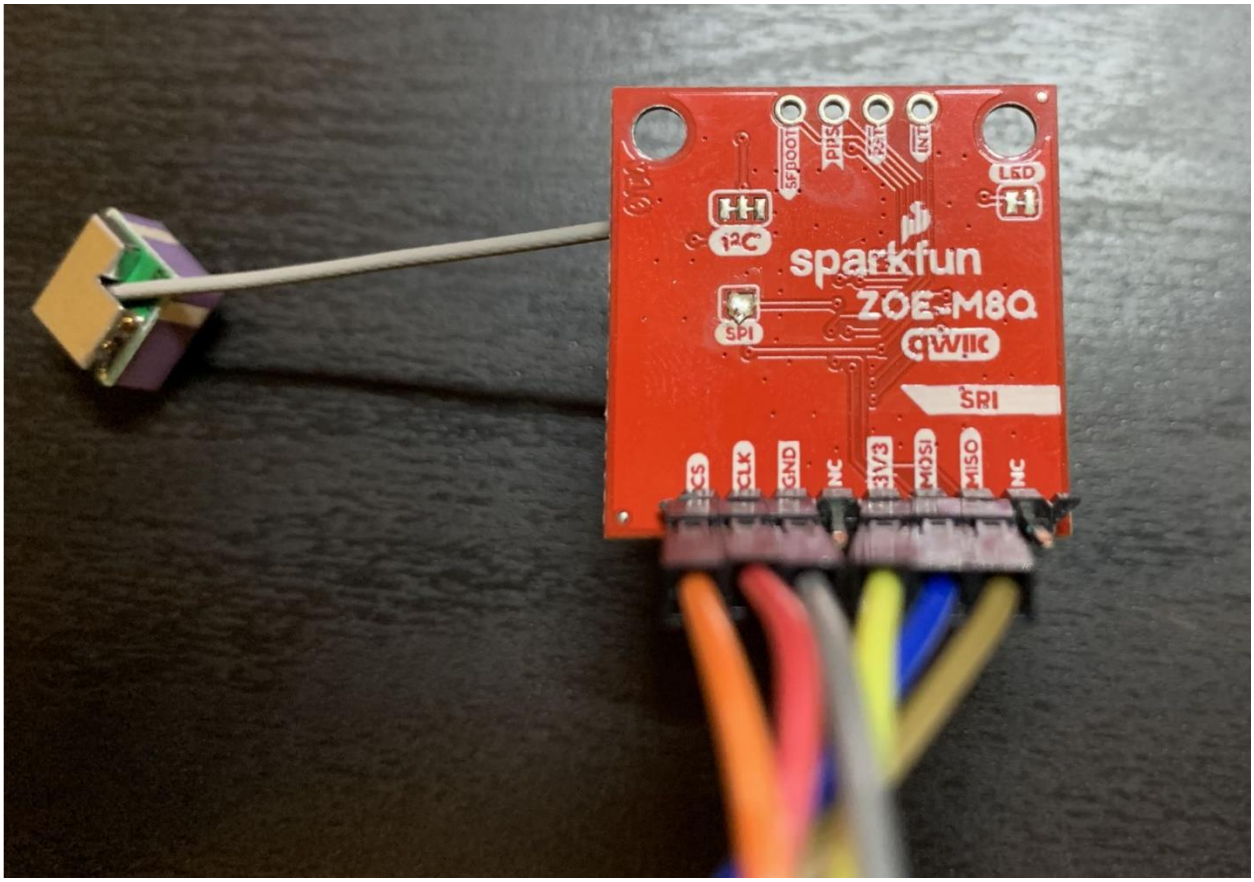
SPI0

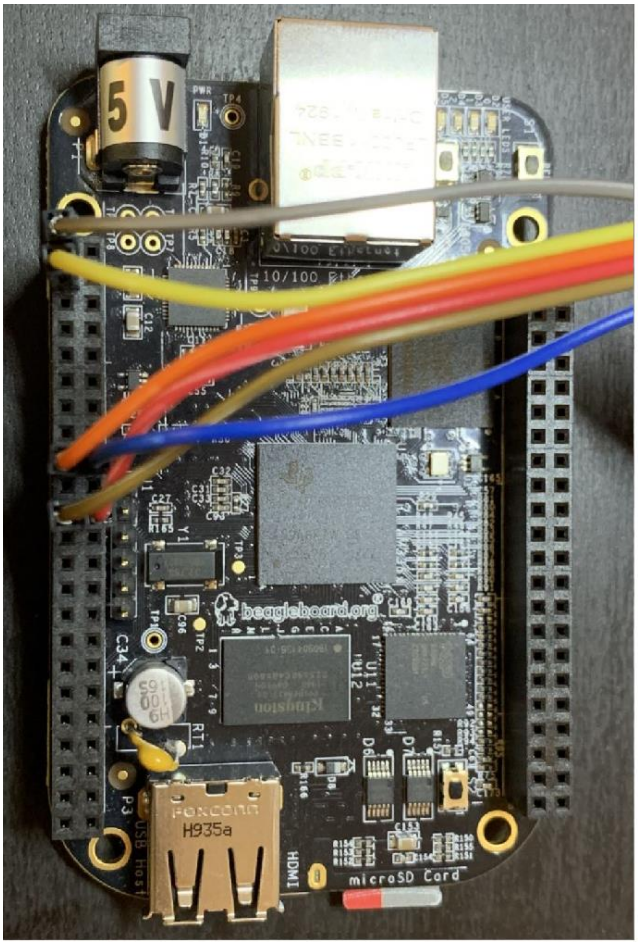
Name	SPI0
Use Peripheral	SPI0
Preferred Voltage	Any
Use Case	Master SPI with 1 chip sele...
IO Set	SPI0_IOSet_1

Signals	Pins	Pull Up/Down	Rx
		Pull Up	☑
☑ D0(spi0_d0)	Any(spi0...	Pull Up	☑
☑ D1(spi0_d1)	Any(spi0...	Pull Up	☐
☑ SCLK(spi0_sclk)	Any(spi0...	Pull Up	☐
☑ Any 1 of the following pins:			
☑ CS0(spi0_cs0)	Any(spi0...	Pull Up	☐
☐ CS1	Any	Pull Up	☑




ZOE-M8Q
FTDI
GRN
SLK
I2C

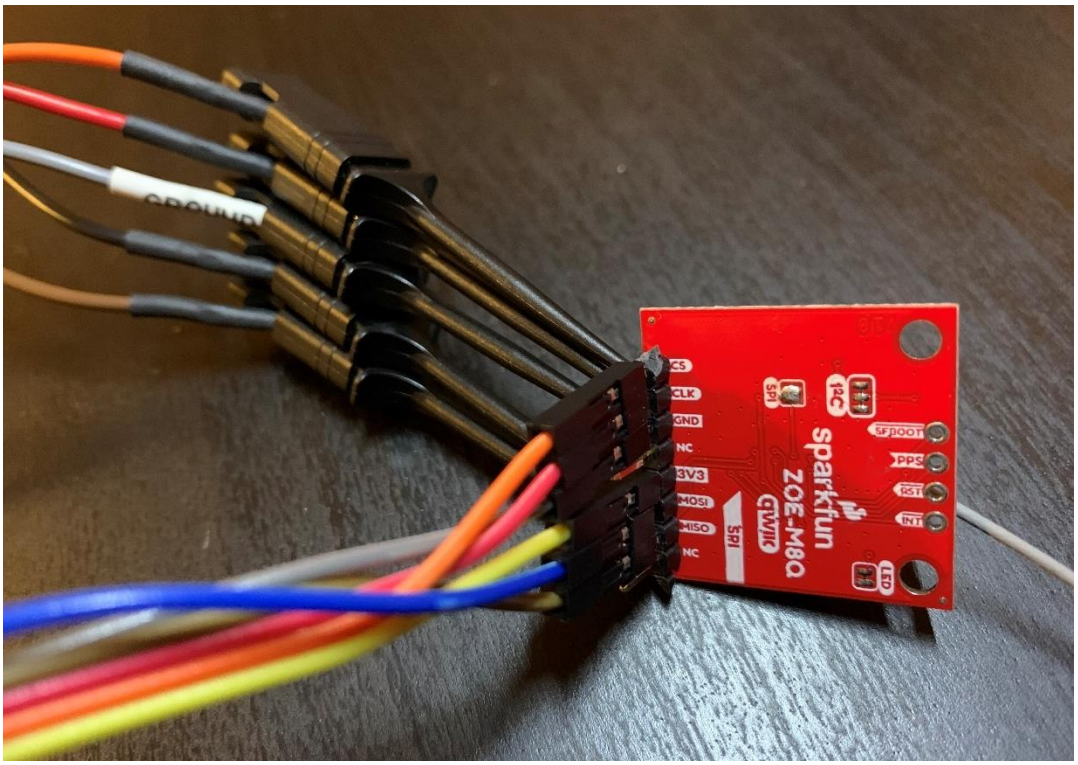

sparkfun
ZOE-M8Q
qwiic
SPI
SRI
I2C
LED
CS
CLK
GND
NC
3V3
MOSI
MISO
NC

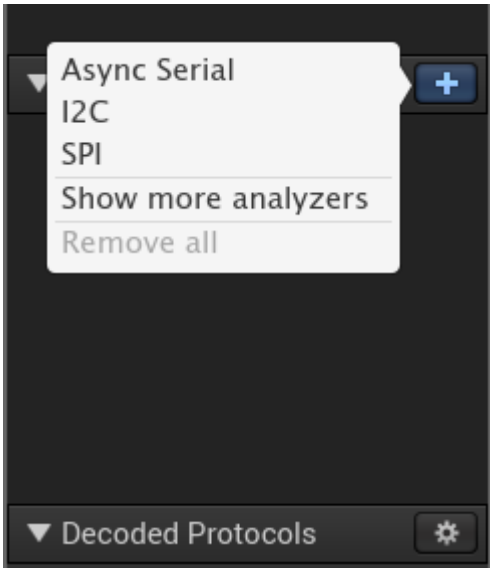


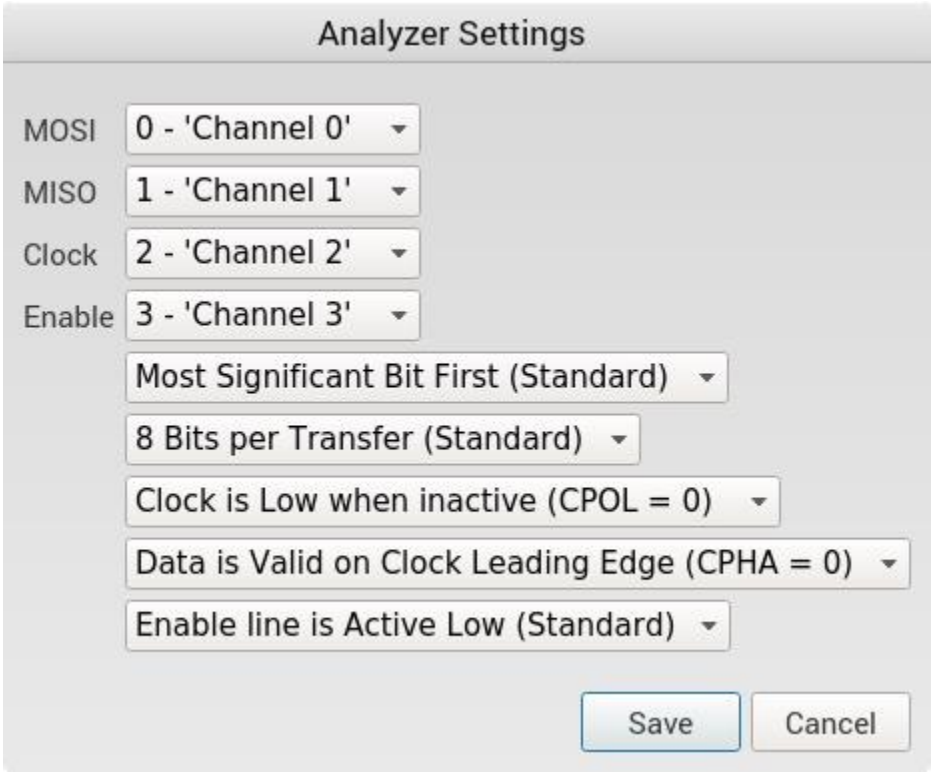
P9

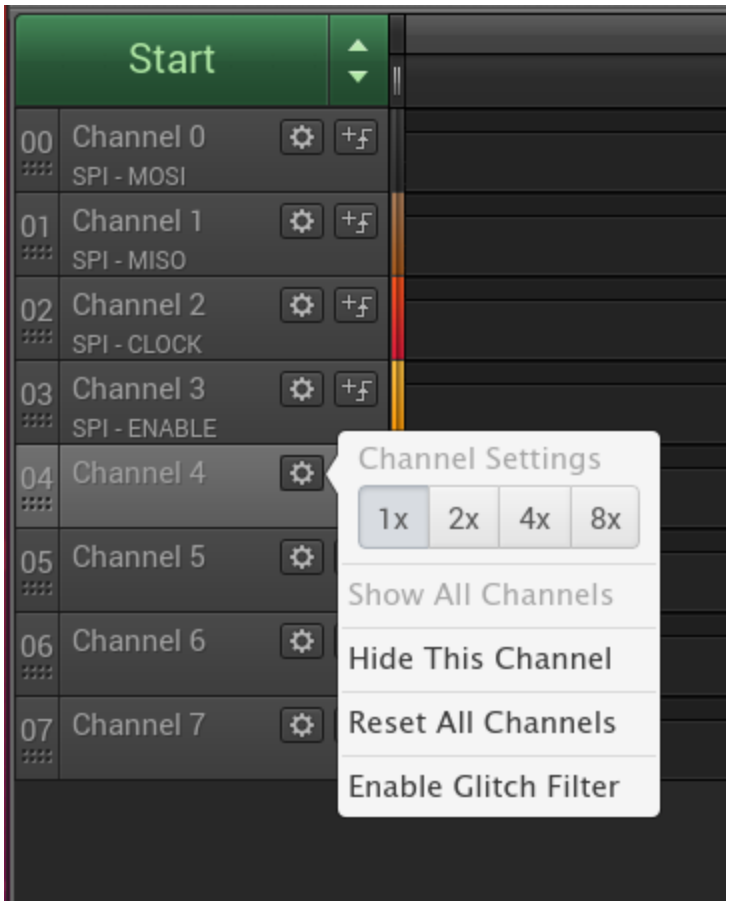
DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETN
GPIO_30	11	12	GPIO_60
GPIO_31	13	14	GPIO_40
GPIO_48	15	16	GPIO_51
SPI0_CS0	17	18	SPI0_D1
SPI1_CS1	19	20	SPI1_CS0
SPI0_D0	21	22	SPI0_SCLK
GPIO_49	23	24	GPIO_15
GPIO_117	25	26	GPIO_14
GPIO_125	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	SPI1_CS1
DGND	43	44	DGND
DGND	45	46	DGND

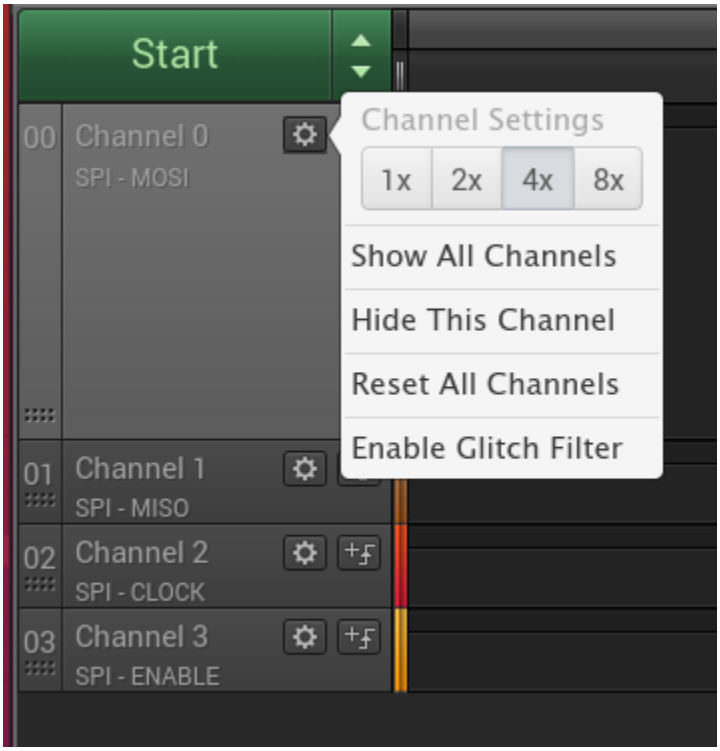
logic
www.saleae.com
CE
1

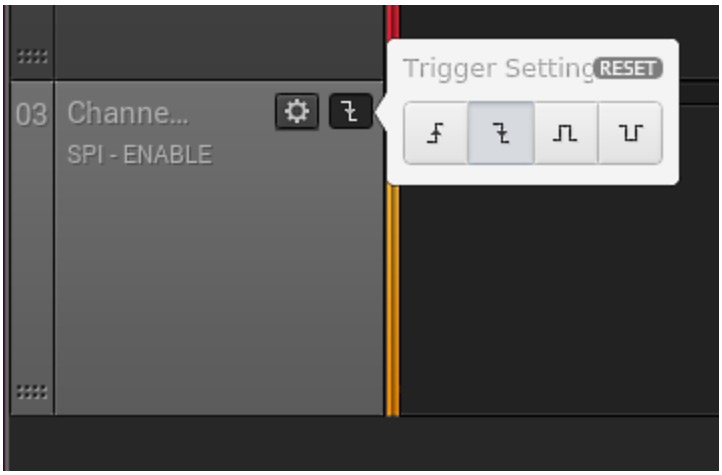

CS
CLK
GND
NC
3V3
MOSI
MISO
NC
SPI
I²C
SPI BOOT
PPS
RST
INT
LED
SPI
sparkfun
ZOE-M8Q
QWIIC

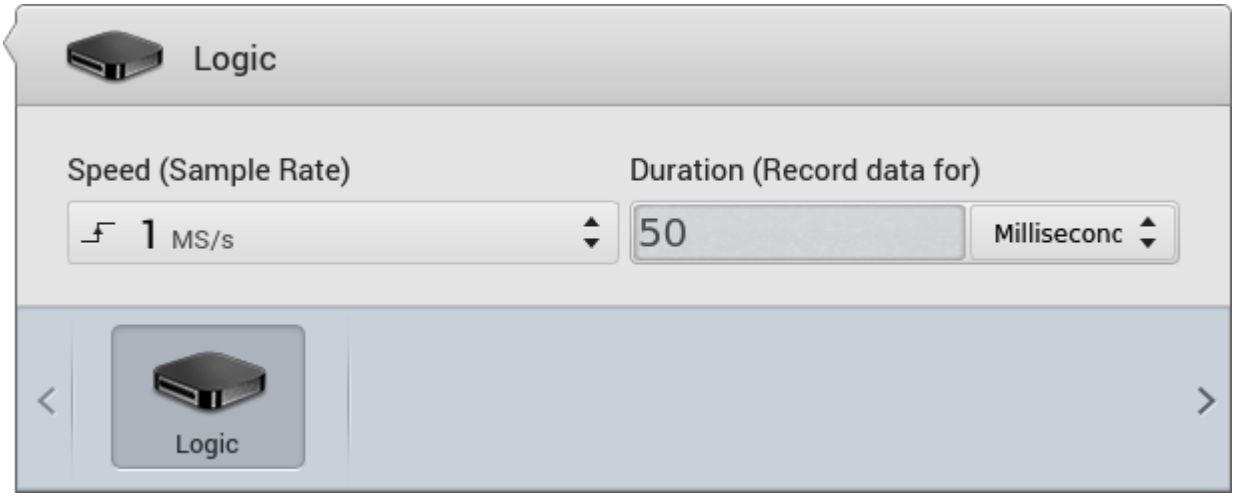

Async Serial
I2C
SPI
Show more analyzers
Remove all
Decoded Protocols

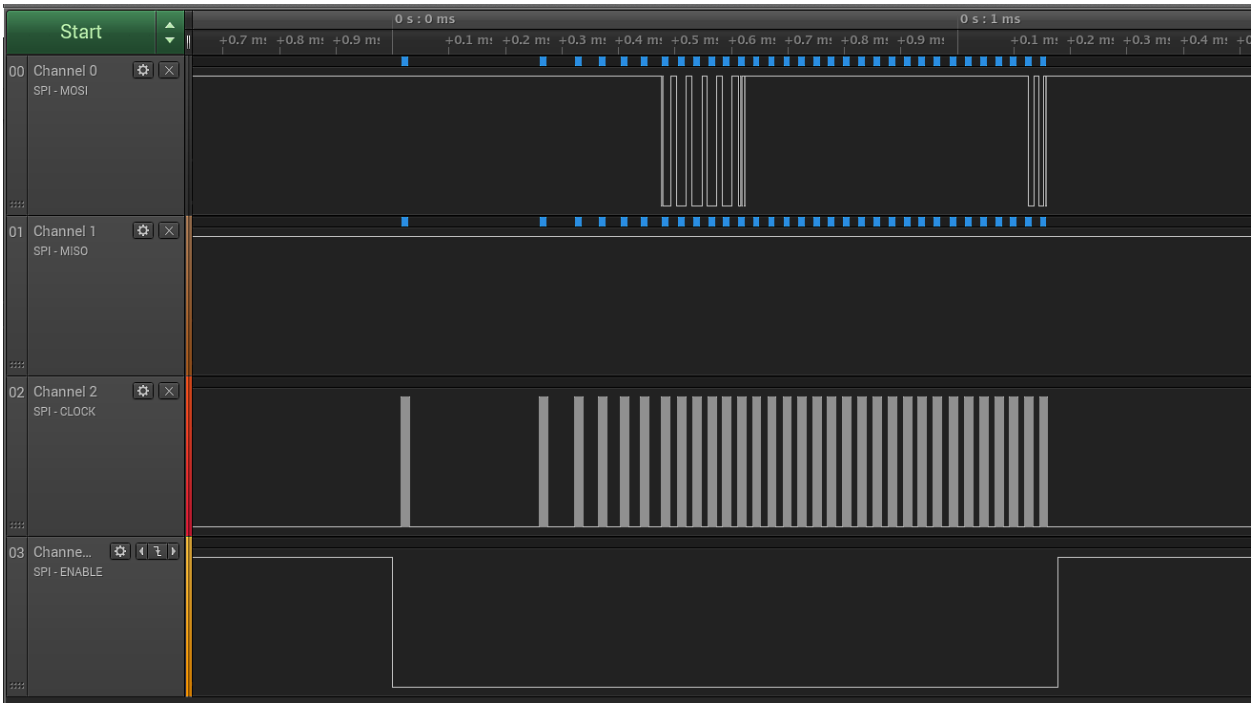

Analyzer Settings
MOSI
0 - 'Channel 0'
MISO
1 - 'Channel 1'
Clock
2 - 'Channel 2'
Enable
3 - 'Channel 3'
Most Significant Bit First (Standard)
8 Bits per Transfer (Standard)
Clock is Low when inactive (CPOL = 0)
Data is Valid on Clock Leading Edge (CPHA = 0)
Enable line is Active Low (Standard)
Save
Cancel

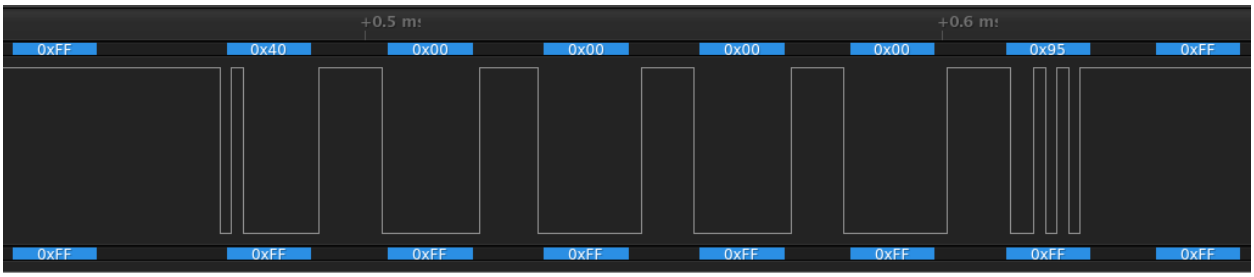

Start
00 Channel 0
SPI - MOSI
01 Channel 1
SPI - MISO
02 Channel 2
SPI - CLOCK
03 Channel 3
SPI - ENABLE
04 Channel 4
05 Channel 5
06 Channel 6
07 Channel 7
Channel Settings
1x
2x
4x
8x
Show All Channels
Hide This Channel
Reset All Channels
Enable Glitch Filter

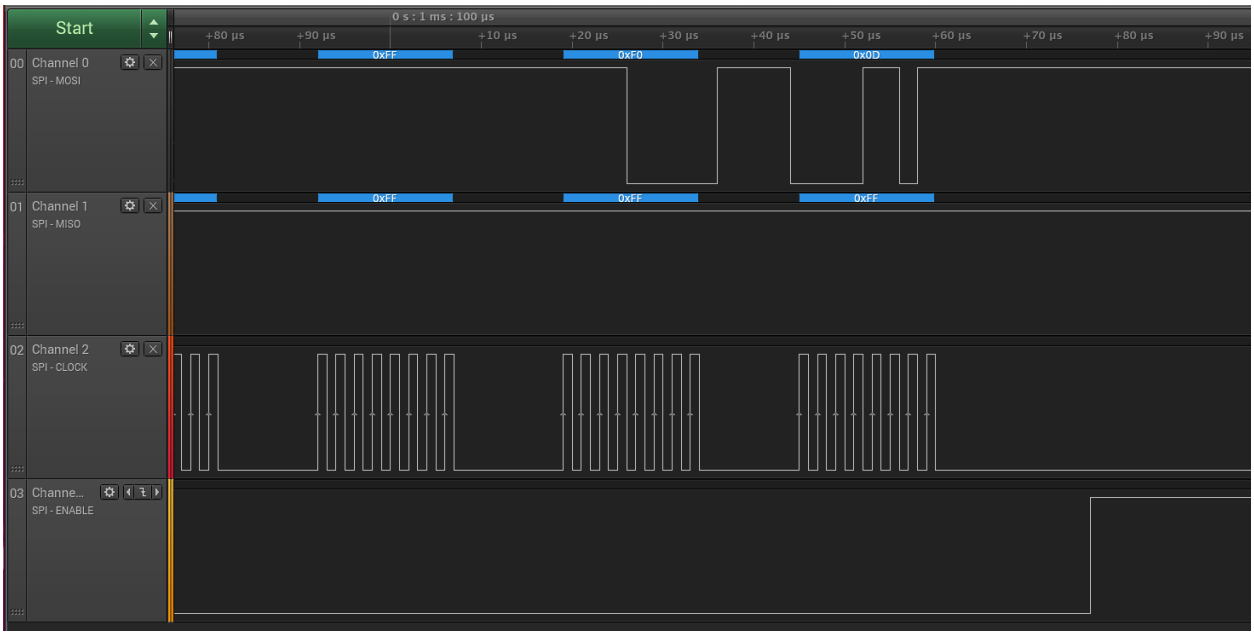

Start
00 Channel 0
SPI - MOSI
Channel Settings
1x
2x
4x
8x
Show All Channels
Hide This Channel
Reset All Channels
Enable Glitch Filter
01 Channel 1
SPI - MISO
02 Channel 2
SPI - CLOCK
03 Channel 3
SPI - ENABLE


Trigger Setting
RESET
03 Channe...
SPI - ENABLE

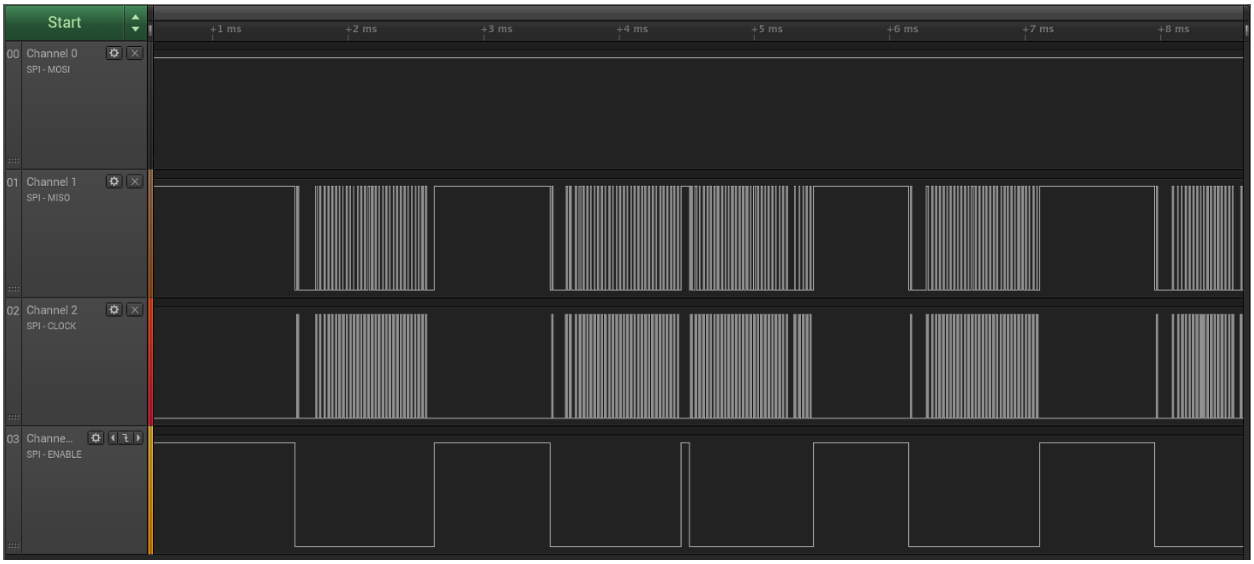

Logic
Speed (Sample Rate)
1 MS/s
Duration (Record data for)
50
Milliseconc
Logic


Start
0 s : 0 ms
0 s : 1 ms
00 Channel 0
SPI - MOSI
01 Channel 1
SPI - MISO
02 Channel 2
SPI - CLOCK
03 Channe...
SPI - ENABLE


+0.5 m
+0.6 m
0xFF
0x40
0x00
0x00
0x00
0x00
0x95
0xFF
0xFF
0xFF
0xFF
0xFF
0xFF
0xFF
0xFF
0xFF


Start
0 s : 1 ms : 100 µs
+80 µs
+90 µs
+10 µs
+20 µs
+30 µs
+40 µs
+50 µs
+60 µs
+70 µs
+80 µs
+90 µs
00 Channel 0
SPI - MOSI
0xFF
0xF0
0x0D
01 Channel 1
SPI - MISO
0xFF
0xFF
0xFF
02 Channel 2
SPI - CLOCK
03 Channe...
SPI - ENABLE

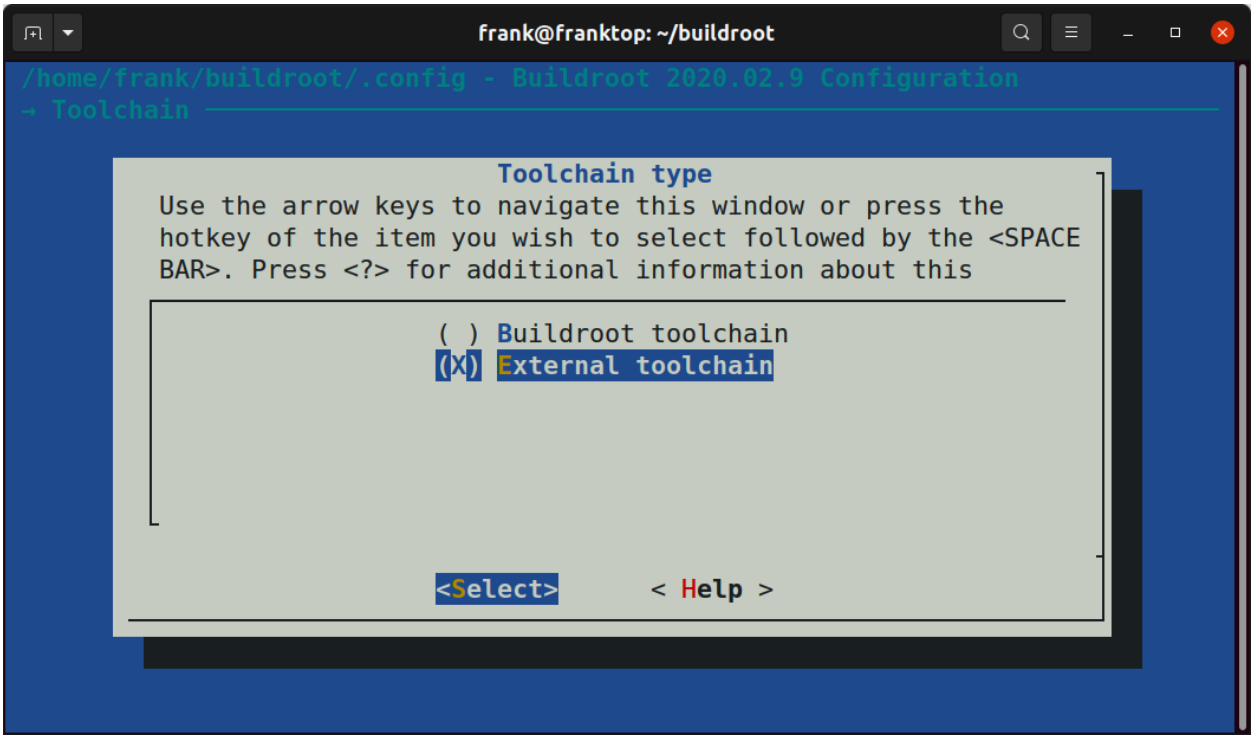
Start
1 s
2 s
00 Channel 0
SPI - MOSI
01 Channel 1
SPI - MISO
02 Channel 2
SPI - CLOCK
03 Channe...
SPI - ENABLE

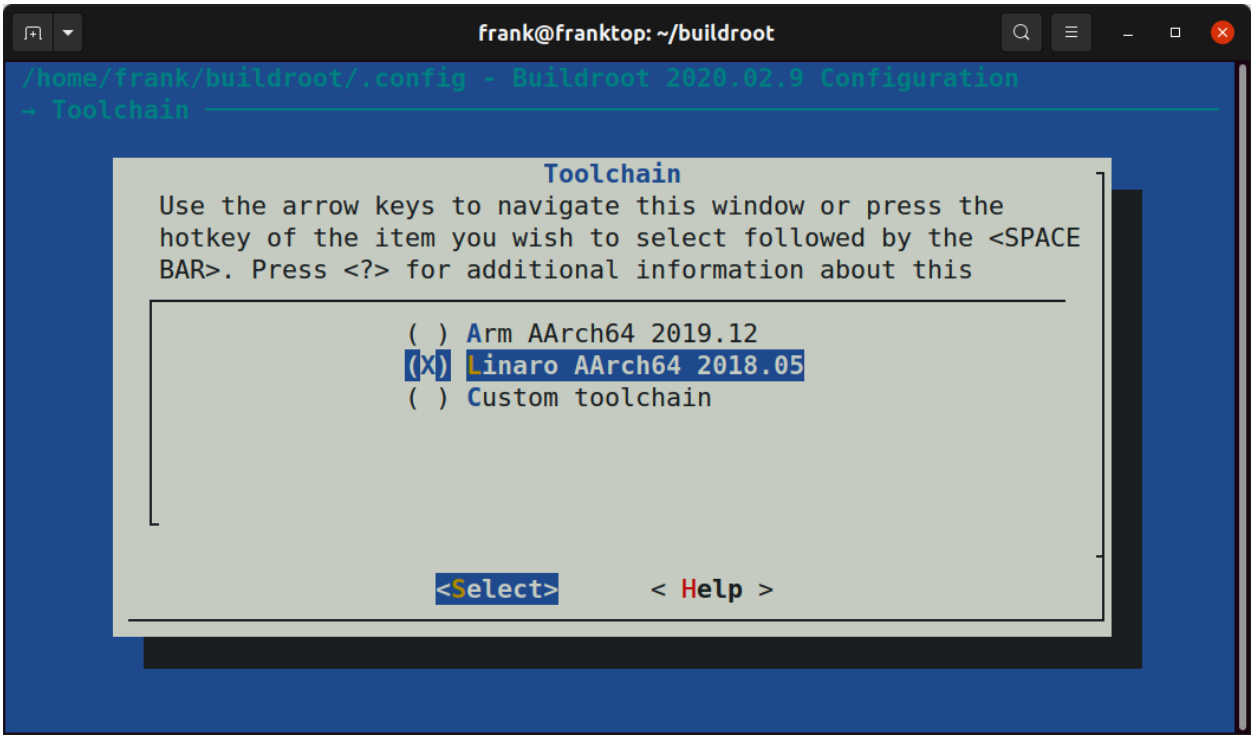

Start
+1 ms
+2 ms
+3 ms
+4 ms
+5 ms
+6 ms
+7 ms
+8 ms
00 Channel 0
SPI - MOSI
01 Channel 1
SPI - MISO
02 Channel 2
SPI - CLOCK
03 Channe...
SPI - ENABLE

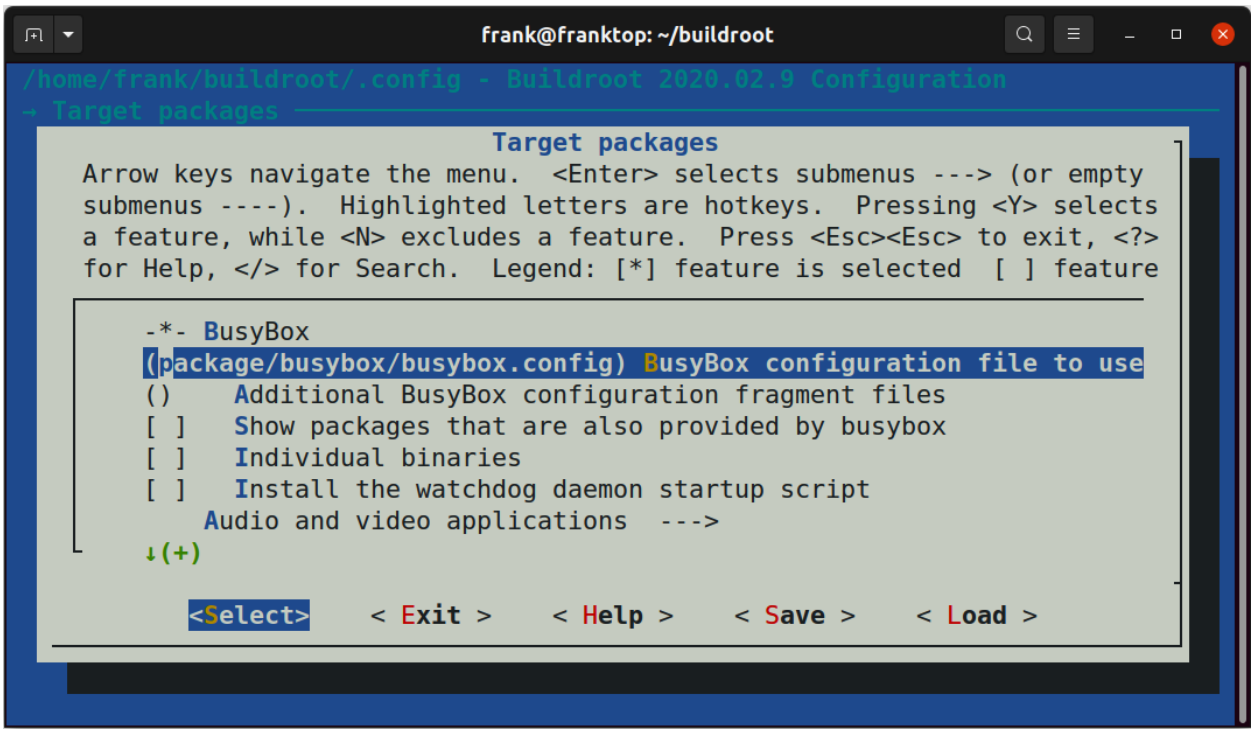
Chapter 13: Starting Up – The init Program

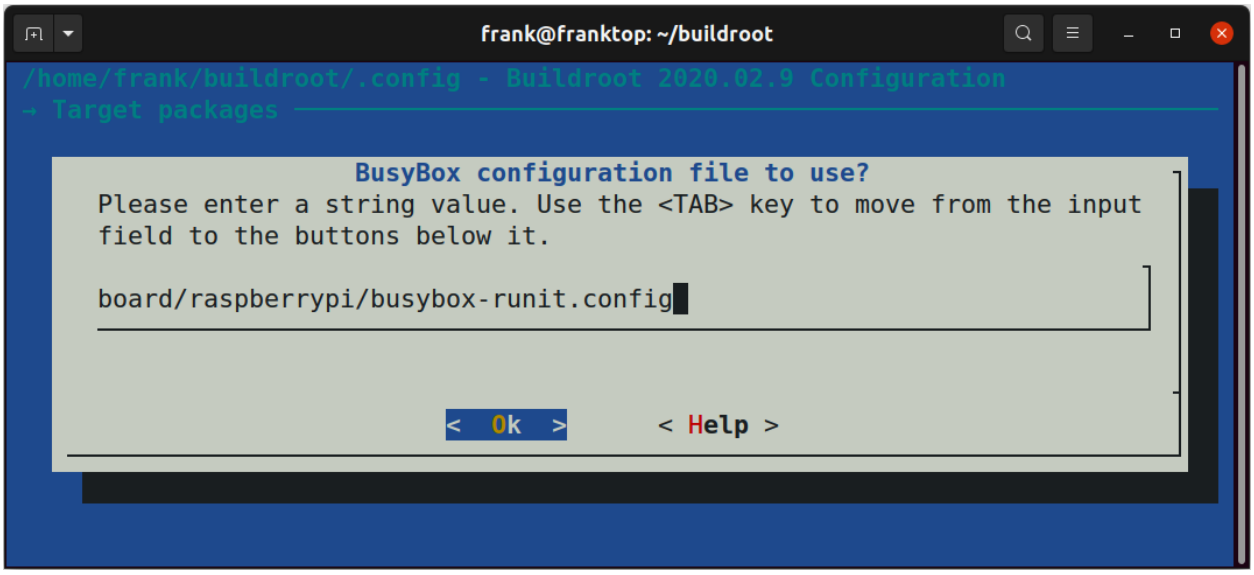
No Images

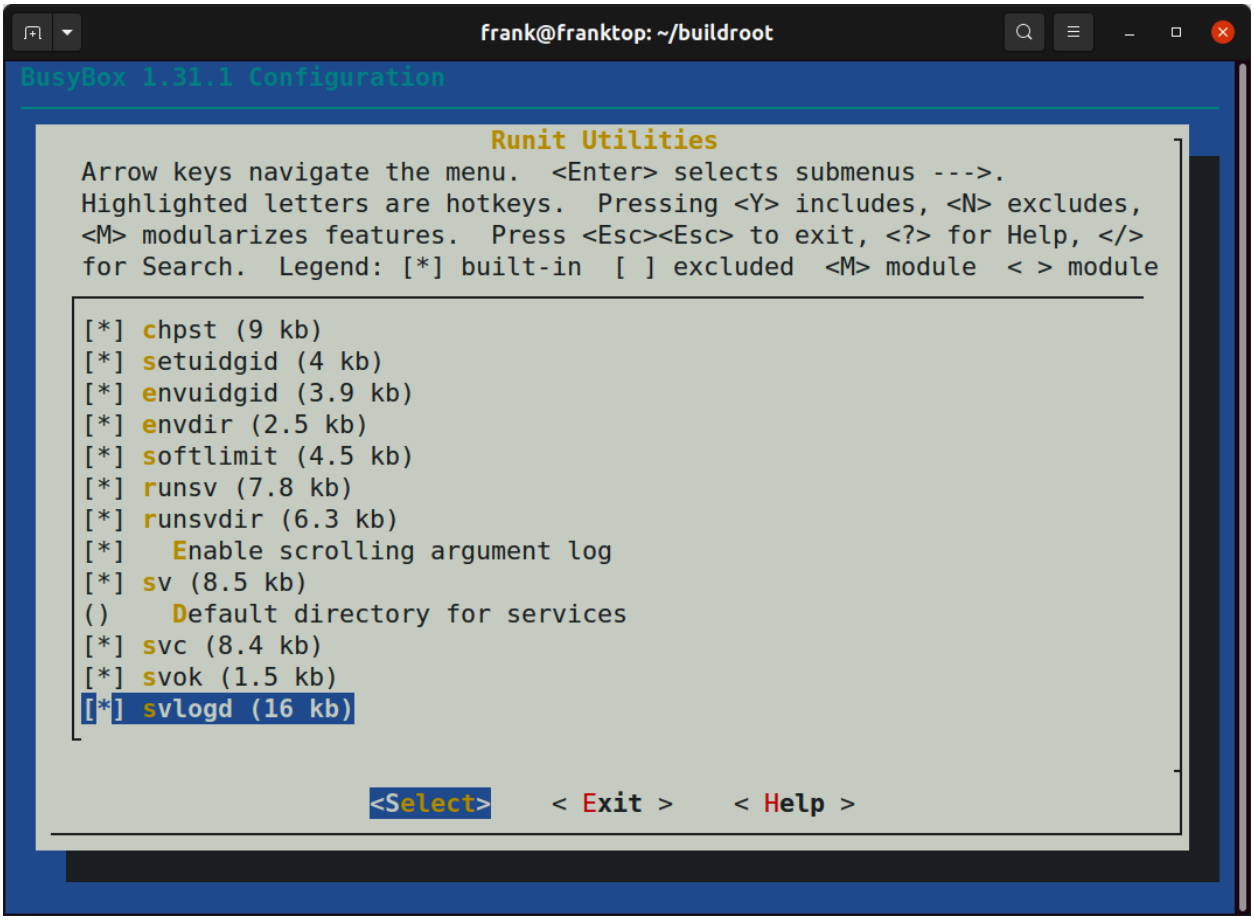
Chapter 14: Starting with BusyBox runit

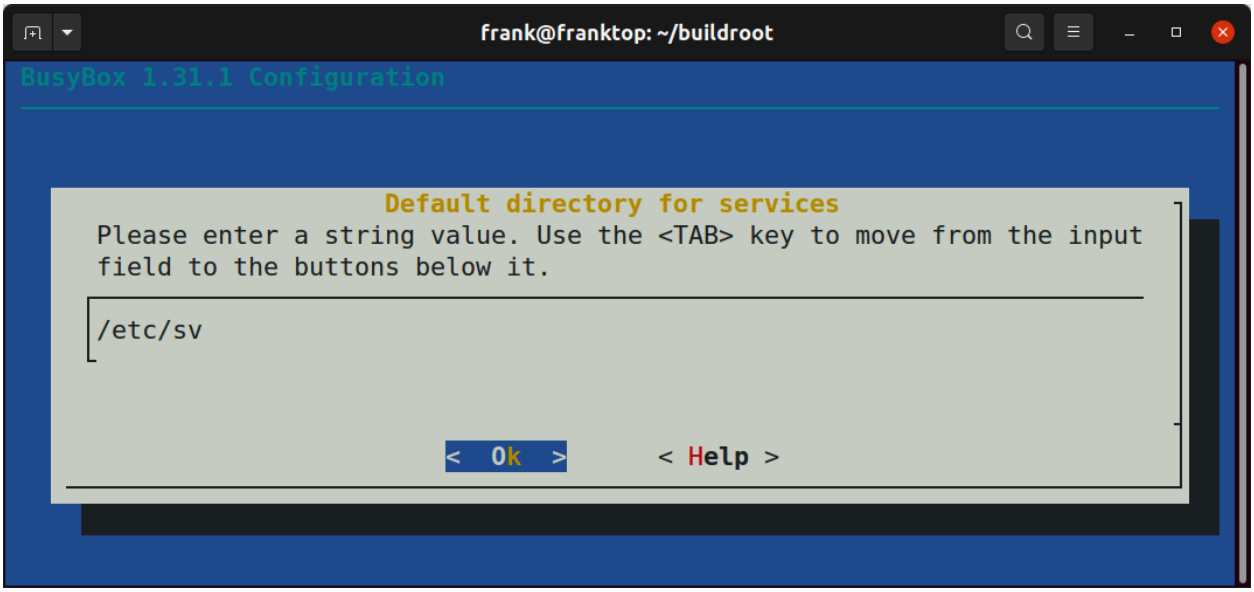




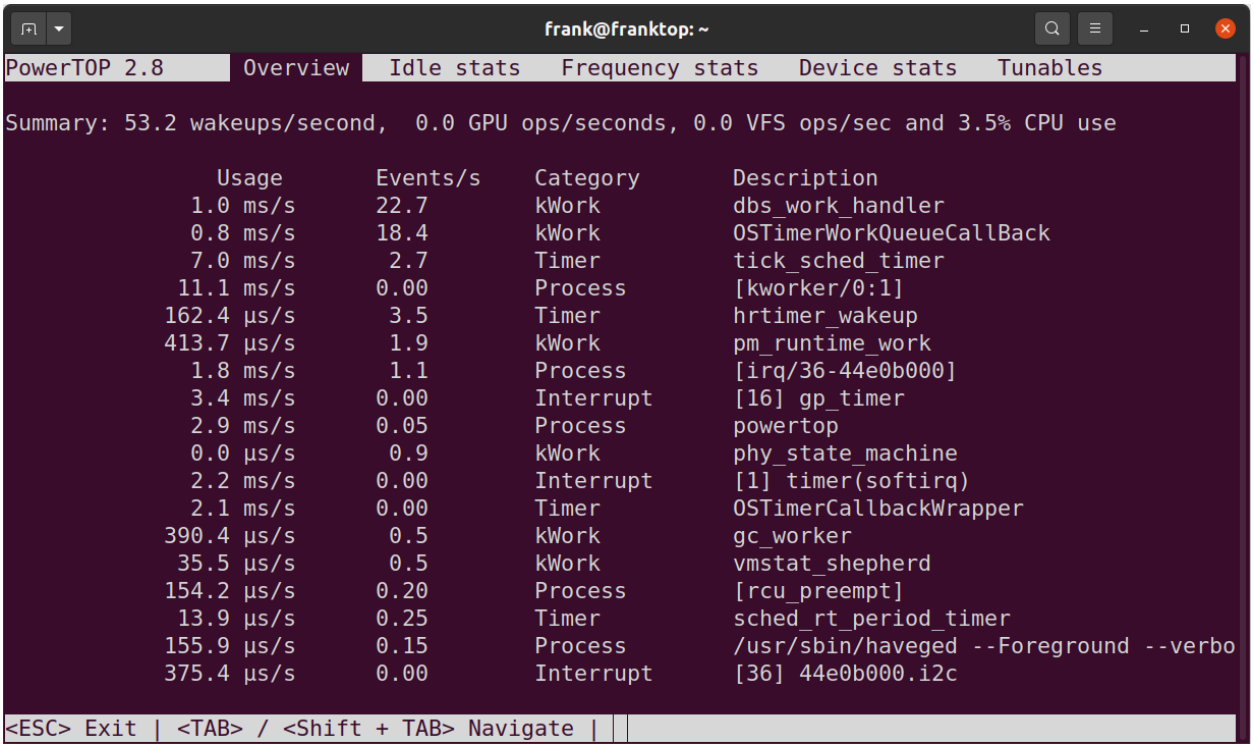

frank@franktop: ~/buildroot
/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ Target packages
Target packages
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature
-*- BusyBox
(package/busybox/busybox.config) BusyBox configuration file to use
() Additional BusyBox configuration fragment files
[ ] Show packages that are also provided by busybox
[ ] Individual binaries
[ ] Install the watchdog daemon startup script
Audio and video applications --->
↓(+)
<Select> < Exit > < Help > < Save > < Load >

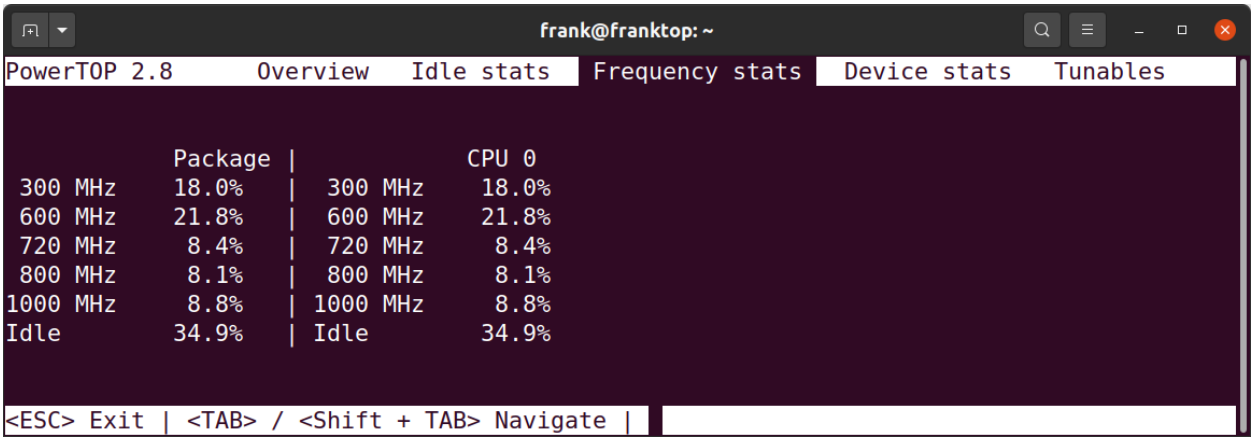

frank@franktop: ~/buildroot
/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ Target packages
BusyBox configuration file to use?
Please enter a string value. Use the <TAB> key to move from the input field to the buttons below it.
board/raspberrypi/busybox-runit.config
< Ok > < Help >

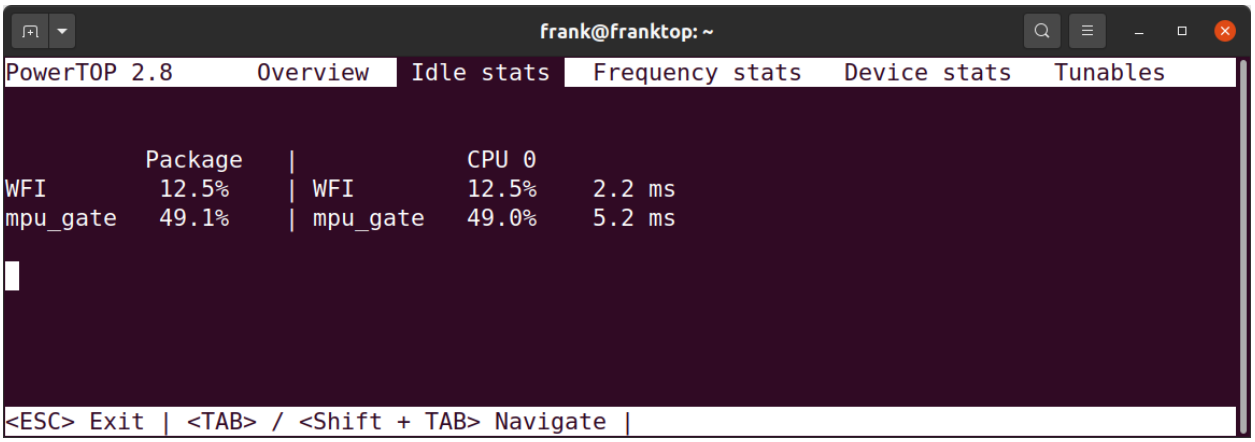

frank@franktop: ~/buildroot
BusyBox 1.31.1 Configuration
Runit Utilities
Arrow keys navigate the menu. <Enter> selects submenus --->.
Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes,
<M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </>
for Search. Legend: [*] built-in [ ] excluded <M> module < > module
[*] chpst (9 kb)
[*] setuidgid (4 kb)
[*] envuidgid (3.9 kb)
[*] envdir (2.5 kb)
[*] softlimit (4.5 kb)
[*] runsv (7.8 kb)
[*] runsvdir (6.3 kb)
[*] Enable scrolling argument log
[*] sv (8.5 kb)
() Default directory for services
[*] svc (8.4 kb)
[*] svok (1.5 kb)
[*] svlogd (16 kb)
<Select> < Exit > < Help >


frank@franktop: ~/buildroot
BusyBox 1.31.1 Configuration
Default directory for services
Please enter a string value. Use the <TAB> key to move from the input
field to the buttons below it.
/etc/sv
< Ok > < Help >

Chapter 15: Managing Power



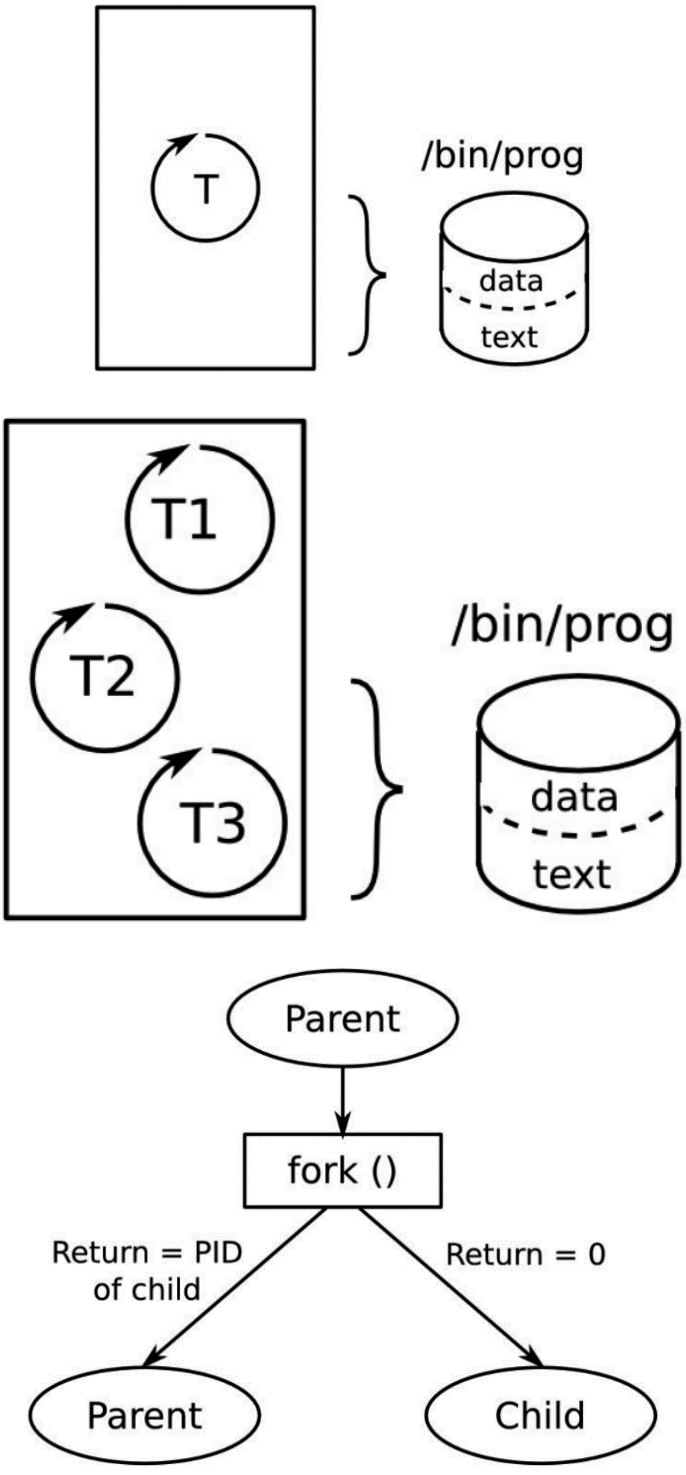


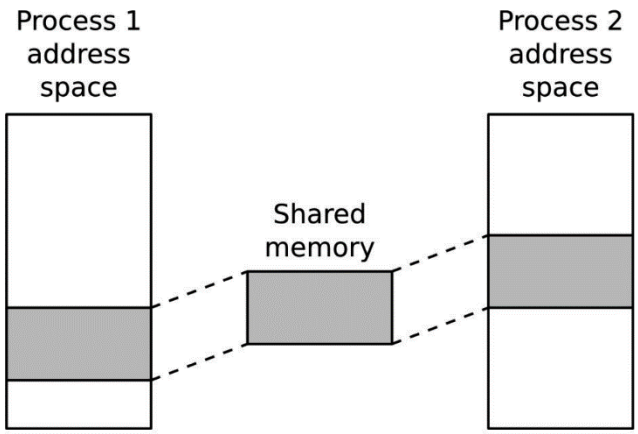

frank@franktop: ~
PowerTOP 2.8 Overview Idle stats Frequency stats Device stats Tunables
Package | CPU 0
WFI 12.5% | WFI 12.5% 2.2 ms
mpu_gate 49.1% | mpu_gate 49.0% 5.2 ms
<ESC> Exit | <TAB> / <Shift + TAB> Navigate |

Chapter 16: Packaging Python

No Images

Chapter 17: Learning about Processes and Threads

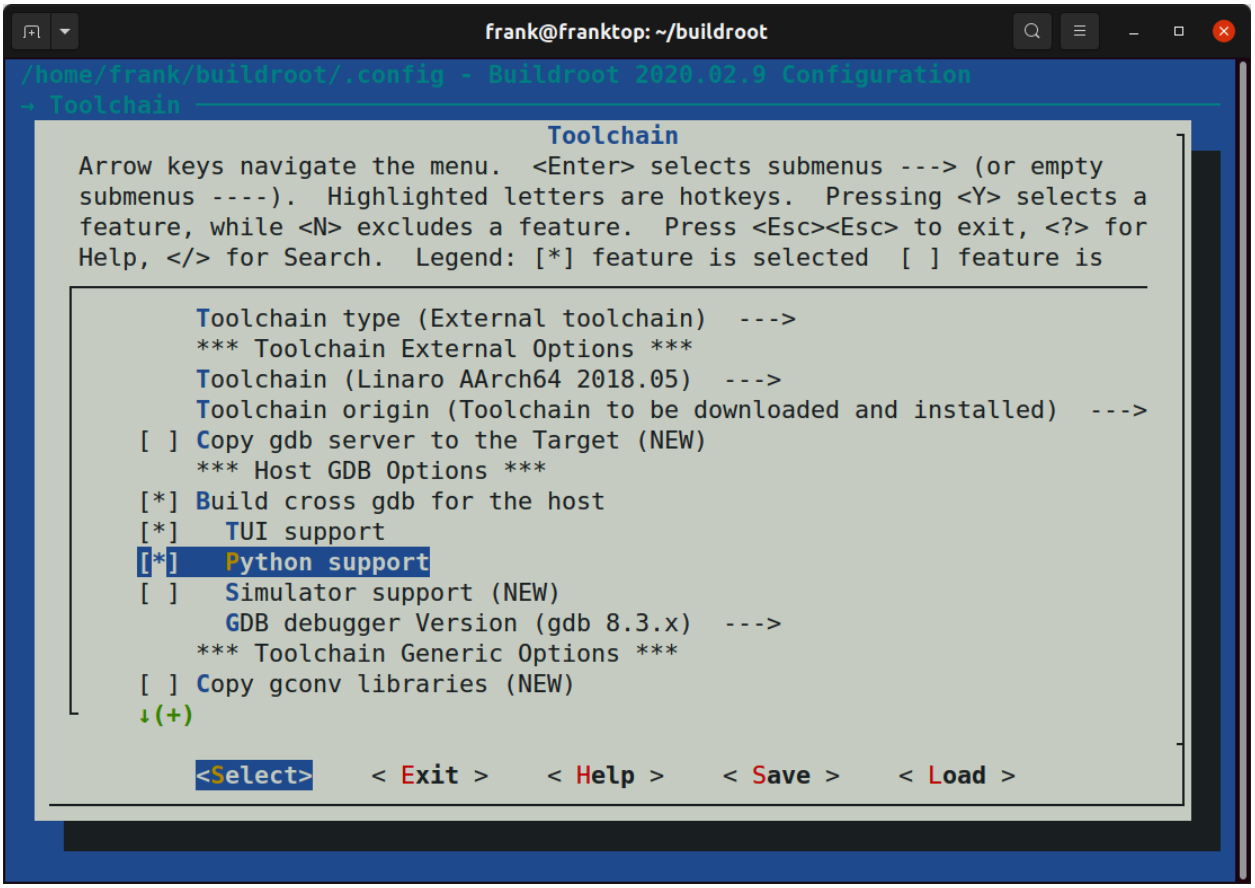


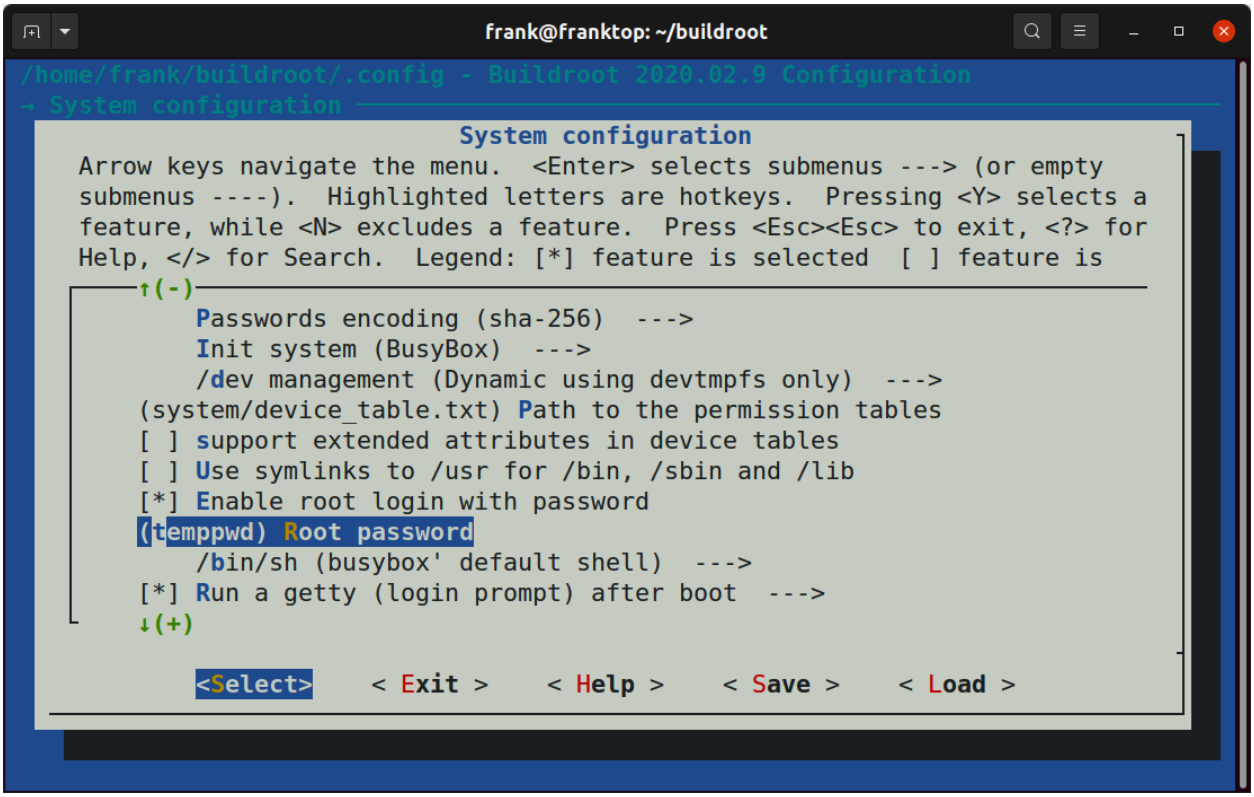

Process 1
address
space
Shared
memory
Process 2
address
space

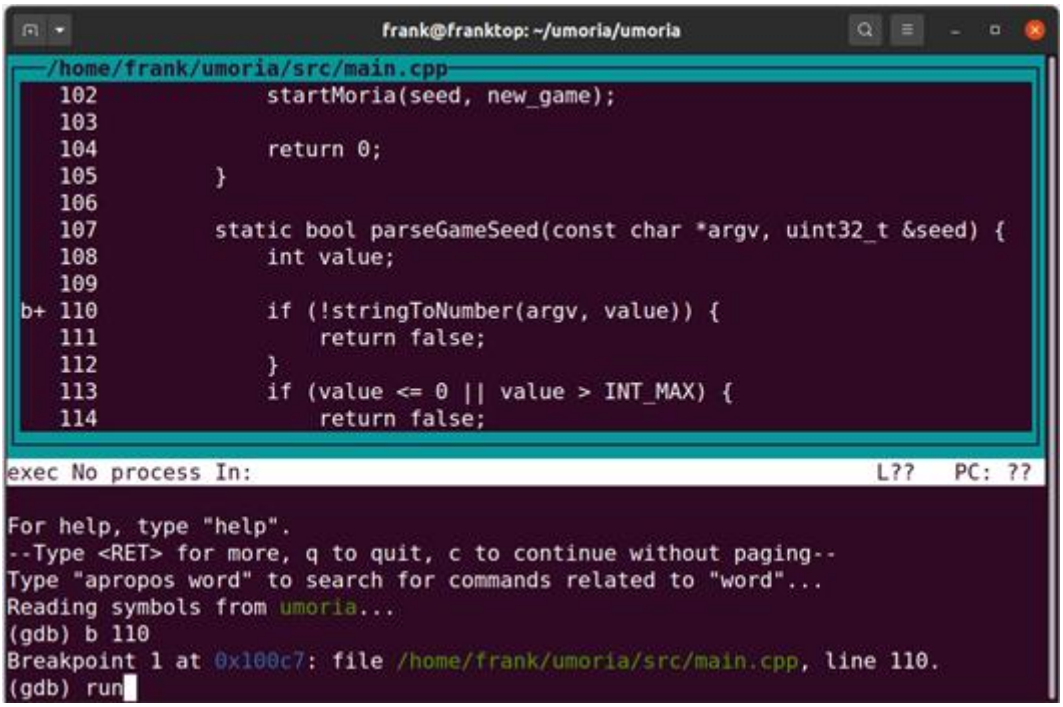
Chapter 18: Managing Memory

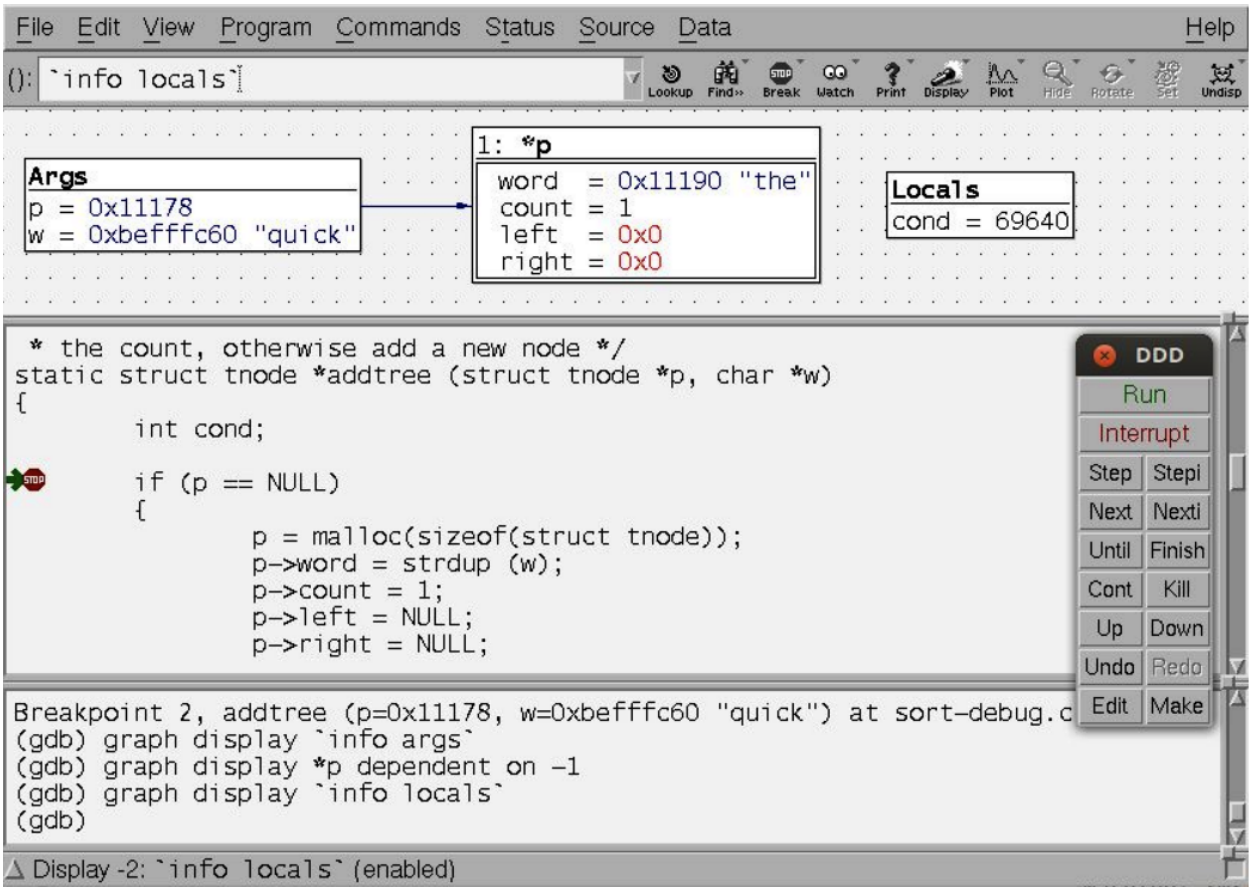
No Images

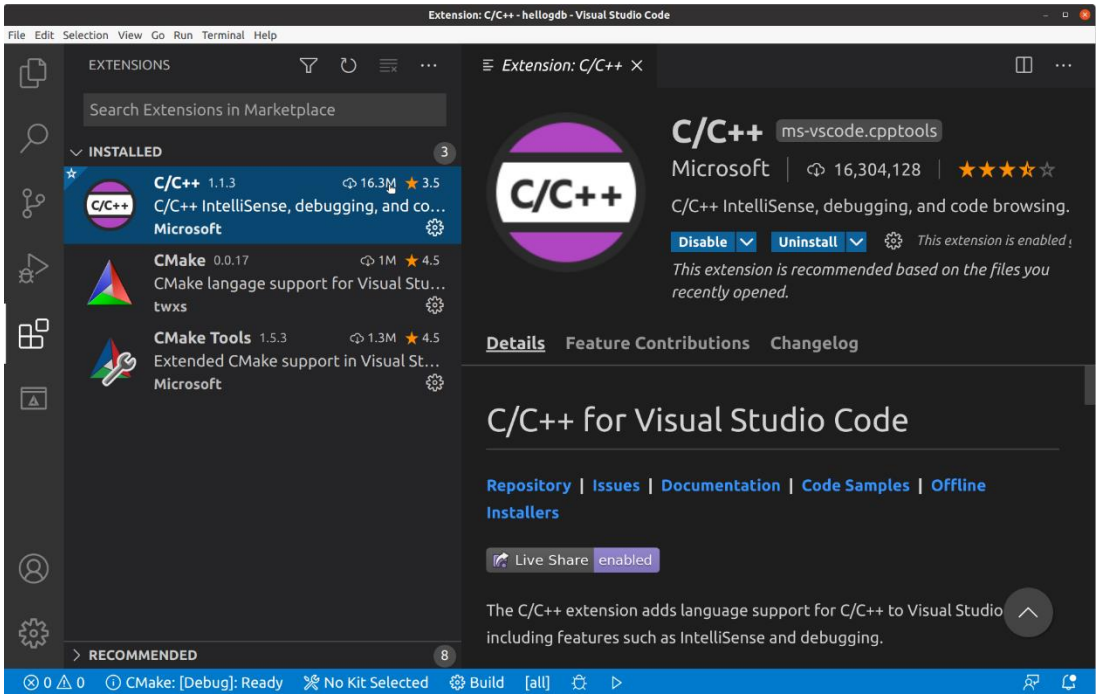
Chapter 19: Debugging with GDB

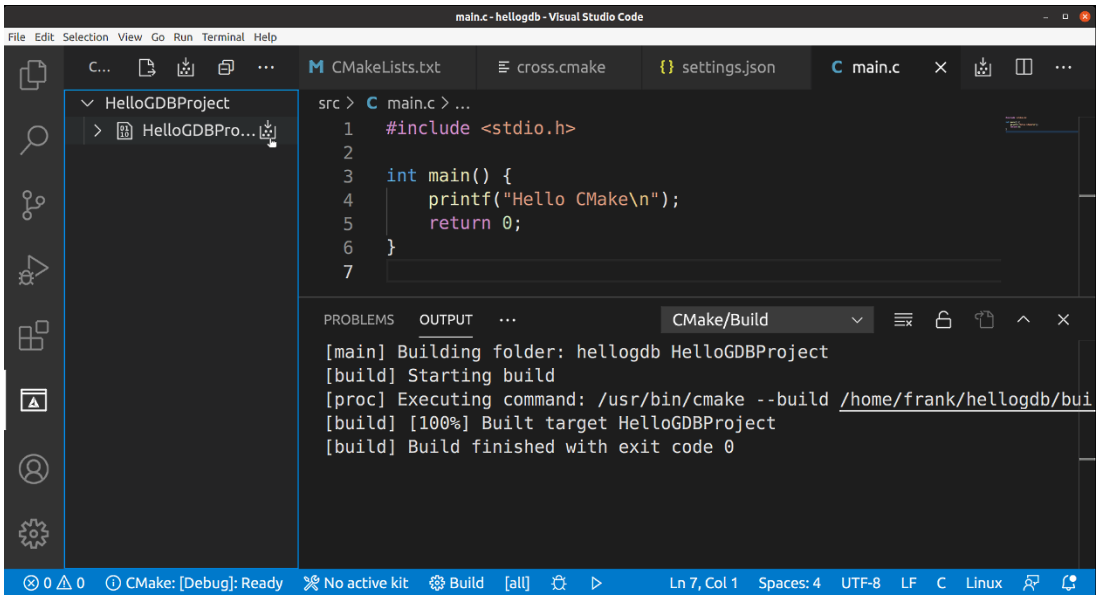


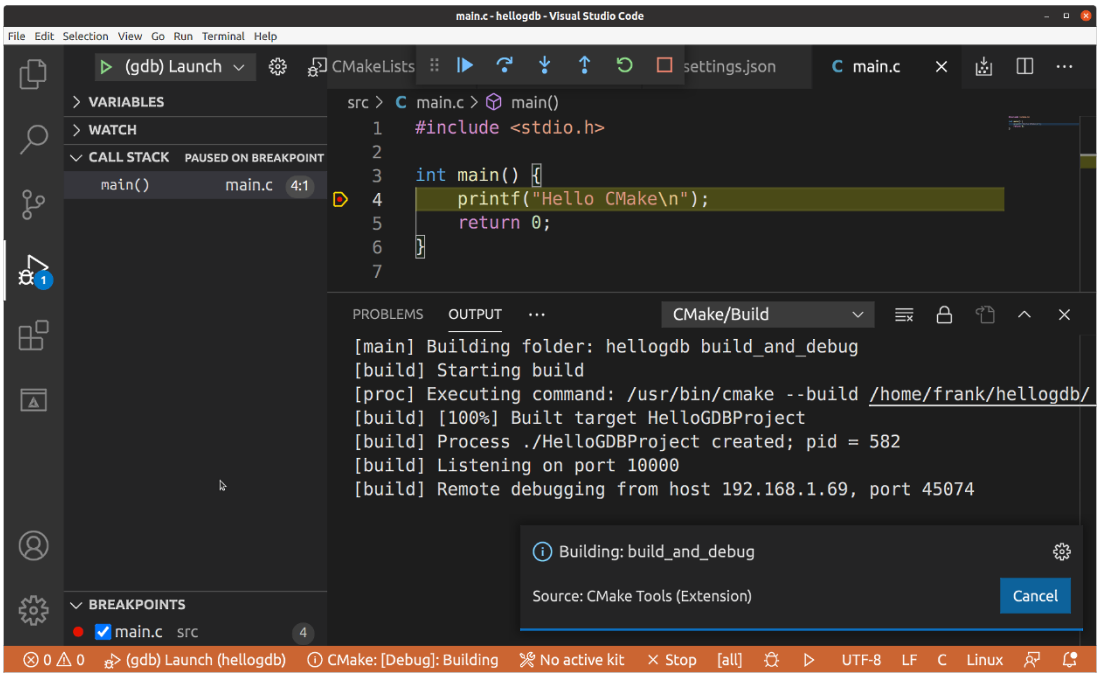

frank@franktop: ~/buildroot
/home/frank/buildroot/.config - Buildroot 2020.02.9 Configuration
→ System configuration
System configuration
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----). Highlighted letters are hotkeys. Pressing <Y> selects a feature, while <N> excludes a feature. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature is selected [ ] feature is
↑(-)
Passwords encoding (sha-256) --->
Init system (BusyBox) --->
/dev management (Dynamic using devtmpfs only) --->
(system/device_table.txt) Path to the permission tables
[ ] support extended attributes in device tables
[ ] Use symlinks to /usr for /bin, /sbin and /lib
[*] Enable root login with password
(temppwd) Root password
/bin/sh (busybox' default shell) --->
[*] Run a getty (login prompt) after boot --->
↓(+)
<Select> < Exit > < Help > < Save > < Load >


frank@franktop: ~/umoria/umoria
/home/frank/umoria/src/main.cpp
102 startMoria(seed, new_game);
103
104 return 0;
105 }
106
107 static bool parseGameSeed(const char *argv, uint32_t &seed) {
108 int value;
109
b+ 110 if (!stringToNumber(argv, value)) {
111 return false;
112 }
113 if (value <= 0 || value > INT_MAX) {
114 return false;
exec No process In: L?? PC: ??
For help, type "help".
--Type <RET> for more, q to quit, c to continue without paging--
Type "apropos word" to search for commands related to "word"...
Reading symbols from umoria...
(gdb) b 110
Breakpoint 1 at 0x100c7: file /home/frank/umoria/src/main.cpp, line 110.
(gdb) run


File Edit View Program Commands Status Source Data Help
(): `info locals`
Lookup Find» Break Watch Print Display Plot Hide Rotate Set Undisp
Args
p = 0x11178
w = 0xbefffc60 "quick"
1: *p
word = 0x11190 "the"
count = 1
left = 0x0
right = 0x0
Locals
cond = 69640
* the count, otherwise add a new node */
static struct tnode *addtree (struct tnode *p, char *w)
{
int cond;
if (p == NULL)
{
p = malloc(sizeof(struct tnode));
p->word = strdup (w);
p->count = 1;
p->left = NULL;
p->right = NULL;
DDD
Run
Interrupt
Step Stepi
Next Nexti
Until Finish
Cont Kill
Up Down
Undo Redo
Edit Make
Breakpoint 2, addtree (p=0x11178, w=0xbefffc60 "quick") at sort-debug.c
(gdb) graph display `info args`
(gdb) graph display *p dependent on -1
(gdb) graph display `info locals`
(gdb)
Display -2: `info locals` (enabled)


Extension: C/C++ - hellogdb - Visual Studio Code
File Edit Selection View Go Run Terminal Help
EXTENSIONS
Search Extensions in Marketplace
INSTALLED 3
C/C++ 1.1.3 16.3M 3.5
C/C++ IntelliSense, debugging, and co...
Microsoft
CMake 0.0.17 1M 4.5
CMake langage support for Visual Stu...
twxs
CMake Tools 1.5.3 1.3M 4.5
Extended CMake support in Visual St...
Microsoft
RECOMMENDED 8
Extension: C/C++
C/C++ ms-vscode.cpptools
Microsoft 16,304,128
C/C++ IntelliSense, debugging, and code browsing.
Disable Uninstall This extension is enabled
This extension is recommended based on the files you recently opened.
Details Feature Contributions Changelog
C/C++ for Visual Studio Code
Repository | Issues | Documentation | Code Samples | Offline Installers
Live Share enabled
The C/C++ extension adds language support for C/C++ to Visual Studio including features such as IntelliSense and debugging.
0 0 CMake: [Debug]: Ready No Kit Selected Build [all]

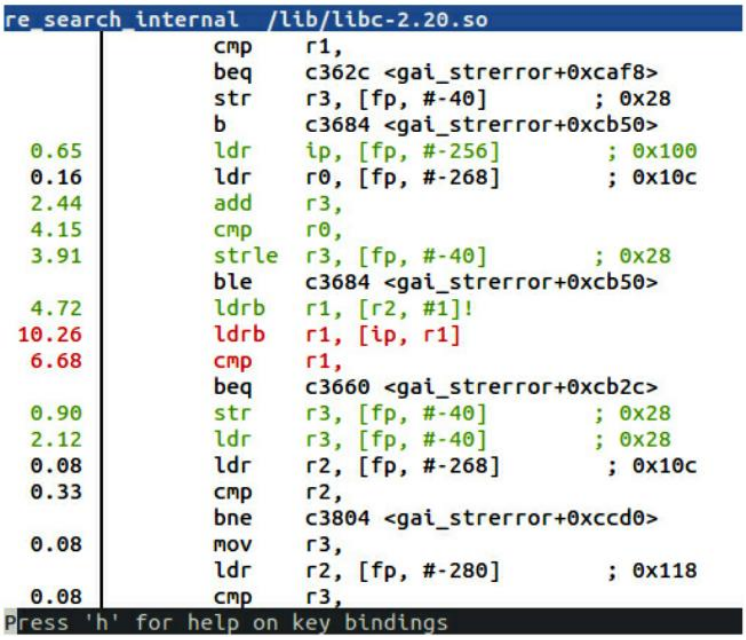

main.c - hellogdb - Visual Studio Code
File Edit Selection View Go Run Terminal Help
CMakeLists.txt
cross.cmake
settings.json
main.c
HelloGDBProject
HelloGDBPro...
src > main.c > ...
#include <stdio.h>
int main() {
printf("Hello CMake\n");
return 0;
}
PROBLEMS
OUTPUT
CMake/Build
[main] Building folder: hellogdb HelloGDBProject
[build] Starting build
[proc] Executing command: /usr/bin/cmake --build /home/frank/hellogdb/bui
[build] [100%] Built target HelloGDBProject
[build] Build finished with exit code 0
0 0
CMake: [Debug]: Ready
No active kit
Build
[all]
Ln 7, Col 1
Spaces: 4
UTF-8
LF
C
Linux

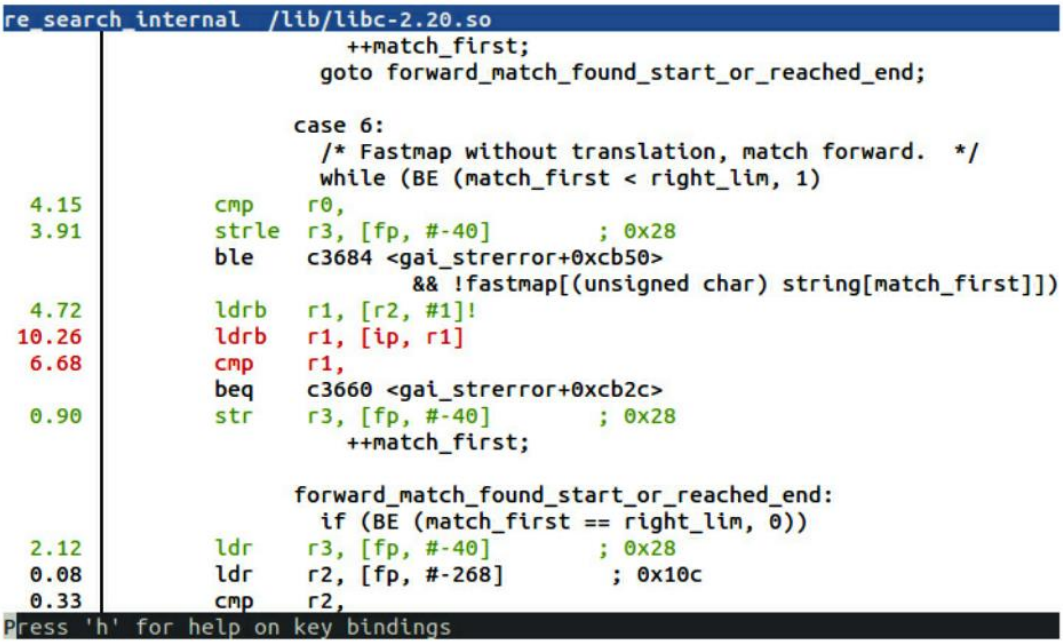

main.c - hellogdb - Visual Studio Code
File Edit Selection View Go Run Terminal Help
(gdb) Launch
CMakeLists
settings.json
main.c
VARIABLES
WATCH
CALL STACK
PAUSED ON BREAKPOINT
main()
main.c
4:1
src > main.c > main()
#include <stdio.h>
int main() {
printf("Hello CMake\n");
return 0;
}
PROBLEMS
OUTPUT
CMake/Build
[main] Building folder: hellogdb build_and_debug
[build] Starting build
[proc] Executing command: /usr/bin/cmake --build /home/frank/hellogdb/
[build] [100%] Built target HelloGDBProject
[build] Process ./HelloGDBProject created; pid = 582
[build] Listening on port 10000
[build] Remote debugging from host 192.168.1.69, port 45074
Building: build_and_debug
Source: CMake Tools (Extension)
Cancel
BREAKPOINTS
main.c src
4
0 0
(gdb) Launch (hellogdb)
CMake: [Debug]: Building
No active kit
Stop
[all]
UTF-8
LF
C
Linux

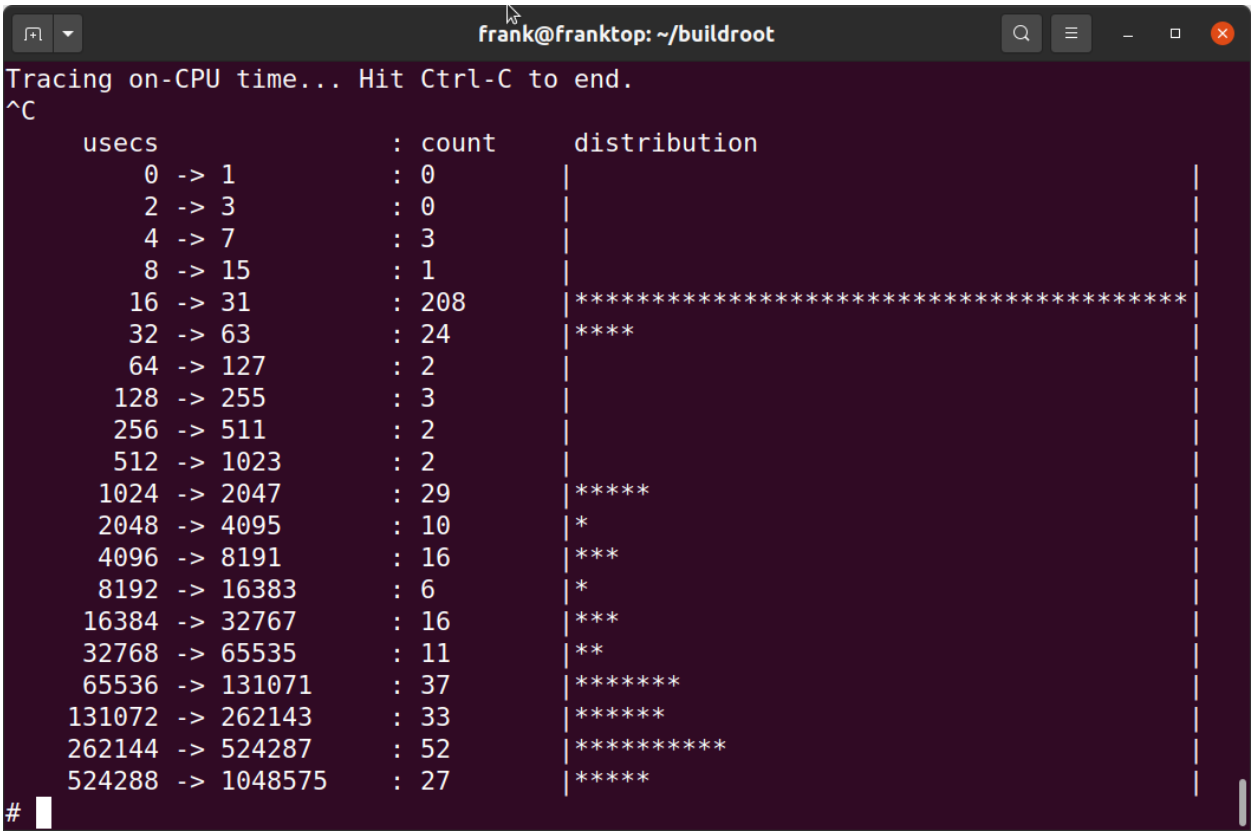
Chapter 20: Profiling and Tracing

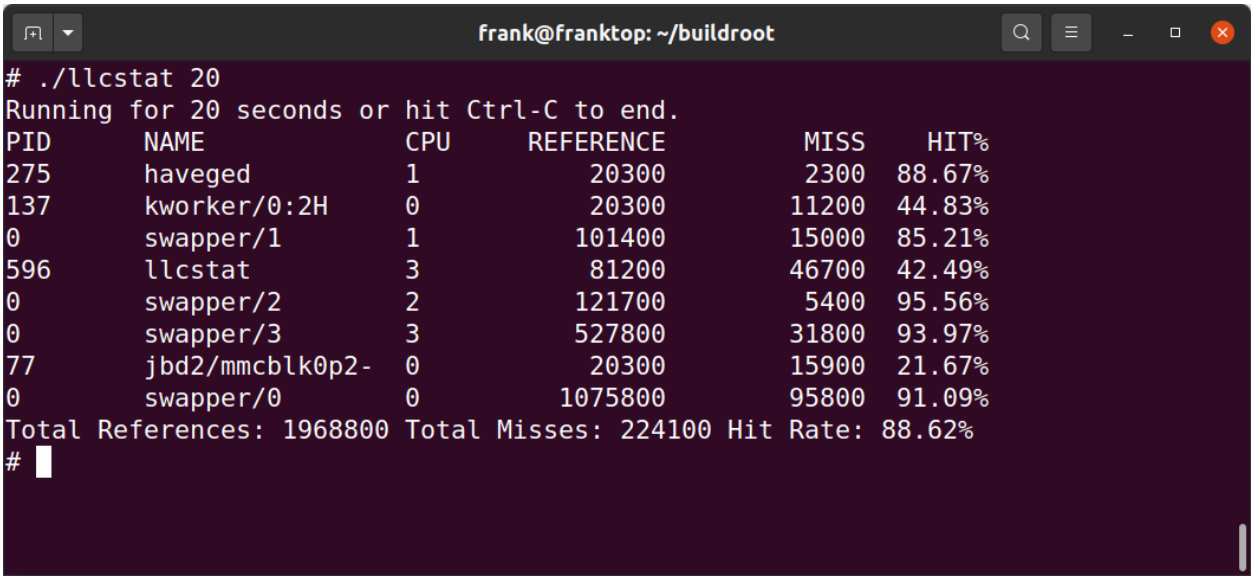
```
Samples: 9K of event 'cycles', Event count (approx.): 2006177260
 11.29%   grep  libc-2.20.so       [.] re_search_internal
  8.80%   grep  busybox.nosuid     [.] bb_get_chunk_from_file
  5.55%   grep  libc-2.20.so       [.] _int_malloc
  5.40%   grep  libc-2.20.so       [.] _int_free
  3.74%   grep  libc-2.20.so       [.] realloc
  2.59%   grep  libc-2.20.so       [.] malloc
  2.51%   grep  libc-2.20.so       [.] regexec@@GLIBC_2.4
  1.64%   grep  busybox.nosuid     [.] grep_file
  1.57%   grep  libc-2.20.so       [.] malloc_consolidate
  1.33%   grep  libc-2.20.so       [.] strlen
  1.33%   grep  libc-2.20.so       [.] memset
  1.26%   grep  [kernel.kallsyms]  [k] __copy_to_user_std
  1.20%   grep  libc-2.20.so       [.] free
  1.10%   grep  libc-2.20.so       [.] _int_realloc
  0.95%   grep  libc-2.20.so       [.] re_string_reconstruct
  0.79%   grep  busybox.nosuid     [.] xrealloc
  0.75%   grep  [kernel.kallsyms]  [k] __do_softirq
  0.72%   grep  [kernel.kallsyms]  [k] preempt_count_sub
  0.68%   find  [kernel.kallsyms]  [k] __do_softirq
  0.53%   grep  [kernel.kallsyms]  [k] __dev_queue_xmit
  0.52%   grep  [kernel.kallsyms]  [k] preempt_count_add
  0.47%   grep  [kernel.kallsyms]  [k] finish_task_switch.isra.85
Press '?' for help on key bindings
```

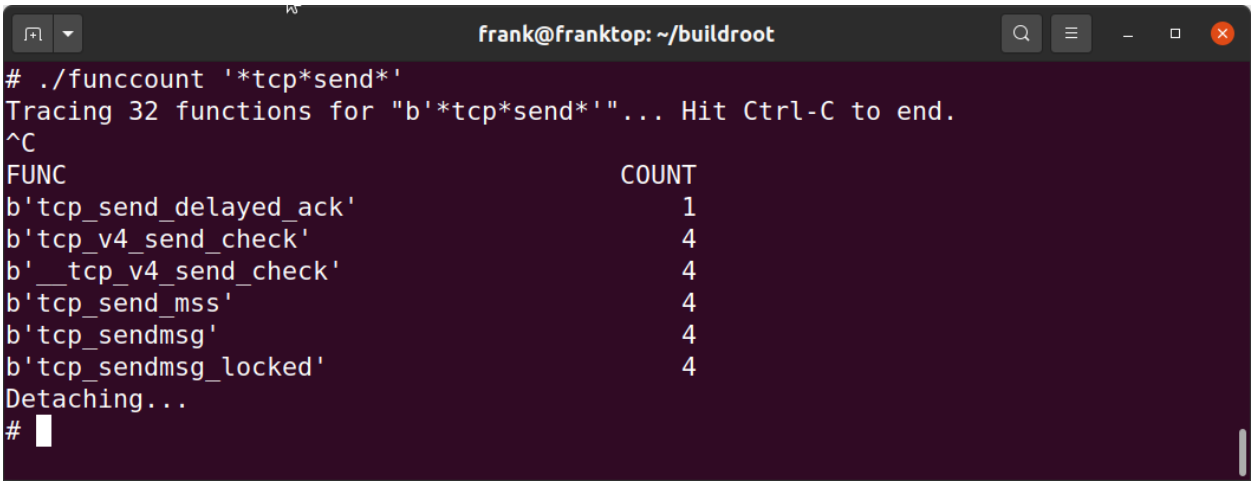
```
Samples: 10K of event 'cycles', Event count (approx.): 2256721655
-   9.95%   grep  libc-2.20.so       [.] re_search_internal
   - re_search_internal
        95.96% 0
        3.50% 0x208
+   8.19%   grep  busybox.nosuid     [.] bb_get_chunk_from_file
+   5.07%   grep  libc-2.20.so       [.] _int_free
+   4.76%   grep  libc-2.20.so       [.] _int_malloc
+   3.75%   grep  libc-2.20.so       [.] realloc
+   2.63%   grep  libc-2.20.so       [.] malloc
+   2.04%   grep  libc-2.20.so       [.] regexec@@GLIBC_2.4
+   1.43%   grep  busybox.nosuid     [.] grep_file
+   1.37%   grep  libc-2.20.so       [.] memset
+   1.29%   grep  libc-2.20.so       [.] malloc_consolidate
+   1.22%   grep  libc-2.20.so       [.] _int_realloc
+   1.15%   grep  libc-2.20.so       [.] free
+   1.01%   grep  [kernel.kallsyms]  [k] __copy_to_user_std
+   0.98%   grep  libc-2.20.so       [.] strlen
+   0.89%   grep  libc-2.20.so       [.] re_string_reconstruct
+   0.73%   grep  [kernel.kallsyms]  [k] preempt_count_sub
+   0.68%   grep  [kernel.kallsyms]  [k] finish_task_switch.isra.85
+   0.62%   grep  busybox.nosuid     [.] xrealloc
+   0.57%   grep  [kernel.kallsyms]  [k] __do_softirq
Press '?' for help on key bindings
```

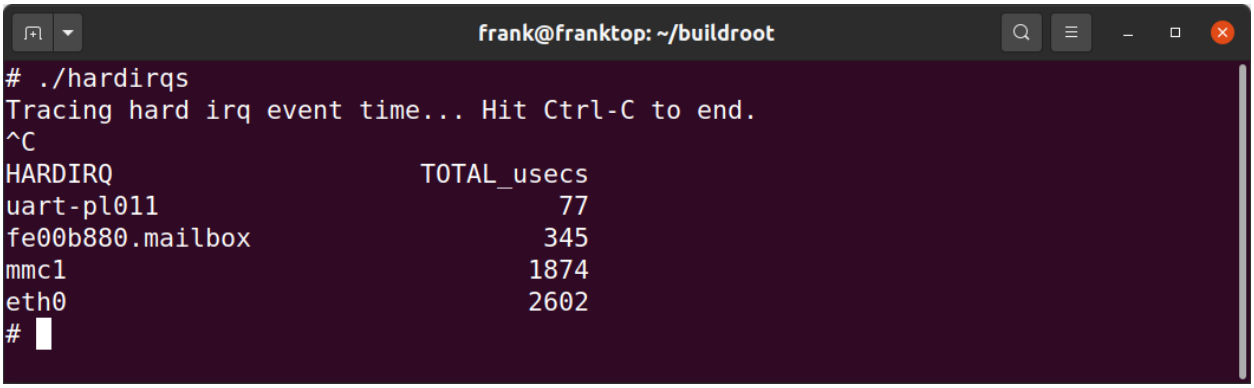

re_search_internal /lib/libc-2.20.so
cmp r1,
beq c362c <gai_strerror+0xcaf8>
str r3, [fp, #-40] ; 0x28
b c3684 <gai_strerror+0xcb50>
0.65 ldr ip, [fp, #-256] ; 0x100
0.16 ldr r0, [fp, #-268] ; 0x10c
2.44 add r3,
4.15 cmp r0,
3.91 strle r3, [fp, #-40] ; 0x28
ble c3684 <gai_strerror+0xcb50>
4.72 ldrb r1, [r2, #1]!
10.26 ldrb r1, [ip, r1]
6.68 cmp r1,
beq c3660 <gai_strerror+0xcb2c>
0.90 str r3, [fp, #-40] ; 0x28
2.12 ldr r3, [fp, #-40] ; 0x28
0.08 ldr r2, [fp, #-268] ; 0x10c
0.33 cmp r2,
bne c3804 <gai_strerror+0xccd0>
0.08 mov r3,
ldr r2, [fp, #-280] ; 0x118
0.08 cmp r3,
Press 'h' for help on key bindings


re_search_internal /lib/libc-2.20.so
++match_first;
goto forward_match_found_start_or_reached_end;
case 6:
/* Fastmap without translation, match forward. */
while (BE (match_first < right_lim, 1)
4.15 cmp r0,
3.91 strle r3, [fp, #-40] ; 0x28
ble c3684 <gai_strerror+0xcb50>
&& !fastmap[(unsigned char) string[match_first]])
4.72 ldrb r1, [r2, #1]!
10.26 ldrb r1, [ip, r1]
6.68 cmp r1,
beq c3660 <gai_strerror+0xcb2c>
0.90 str r3, [fp, #-40] ; 0x28
++match_first;
forward_match_found_start_or_reached_end:
if (BE (match_first == right_lim, 0))
2.12 ldr r3, [fp, #-40] ; 0x28
0.08 ldr r2, [fp, #-268] ; 0x10c
0.33 cmp r2,
Press 'h' for help on key bindings

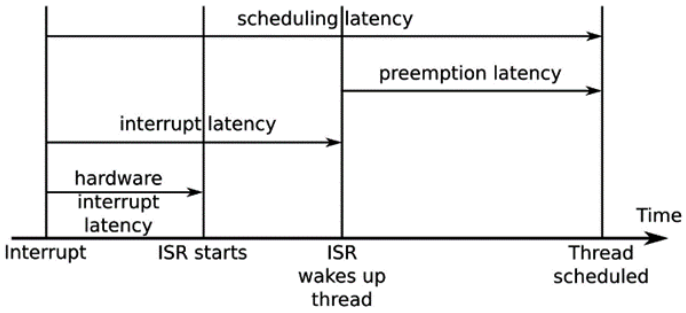

frank@franktop: ~/buildroot
Tracing on-CPU time... Hit Ctrl-C to end.
^C
usecs : count distribution
0 -> 1 : 0 |
2 -> 3 : 0 |
4 -> 7 : 3 |
8 -> 15 : 1 |
16 -> 31 : 208 |**********
32 -> 63 : 24 |****
64 -> 127 : 2 |
128 -> 255 : 3 |
256 -> 511 : 2 |
512 -> 1023 : 2 |
1024 -> 2047 : 29 |*****
2048 -> 4095 : 10 |*
4096 -> 8191 : 16 |***
8192 -> 16383 : 6 |*
16384 -> 32767 : 16 |***
32768 -> 65535 : 11 |**
65536 -> 131071 : 37 |*******
131072 -> 262143 : 33 |******
262144 -> 524287 : 52 |**********
524288 -> 1048575 : 27 |*****
#

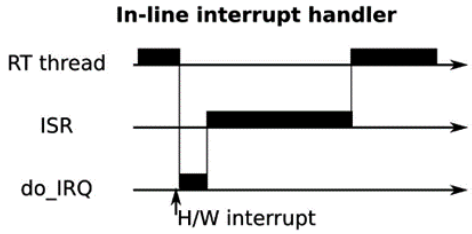

frank@franktop: ~/buildroot
./llcstat 20
Running for 20 seconds or hit Ctrl-C to end.
PID NAME CPU REFERENCE MISS HIT%
275 haveged 1 20300 2300 88.67%
137 kworker/0:2H 0 20300 11200 44.83%
0 swapper/1 1 101400 15000 85.21%
596 llcstat 3 81200 46700 42.49%
0 swapper/2 2 121700 5400 95.56%
0 swapper/3 3 527800 31800 93.97%
77 jbd2/mmcblk0p2- 0 20300 15900 21.67%
0 swapper/0 0 1075800 95800 91.09%
Total References: 1968800 Total Misses: 224100 Hit Rate: 88.62%
#

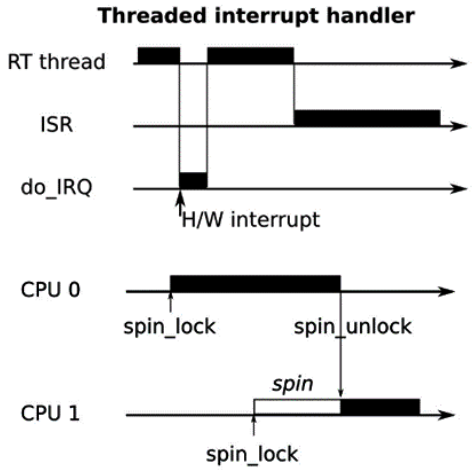

frank@franktop: ~/buildroot
./funccount '*tcp*send*'
Tracing 32 functions for "b'*tcp*send*'"... Hit Ctrl-C to end.
^C
FUNC COUNT
b'tcp_send_delayed_ack' 1
b'tcp_v4_send_check' 4
b'__tcp_v4_send_check' 4
b'tcp_send_mss' 4
b'tcp_sendmsg' 4
b'tcp_sendmsg_locked' 4
Detaching...
#

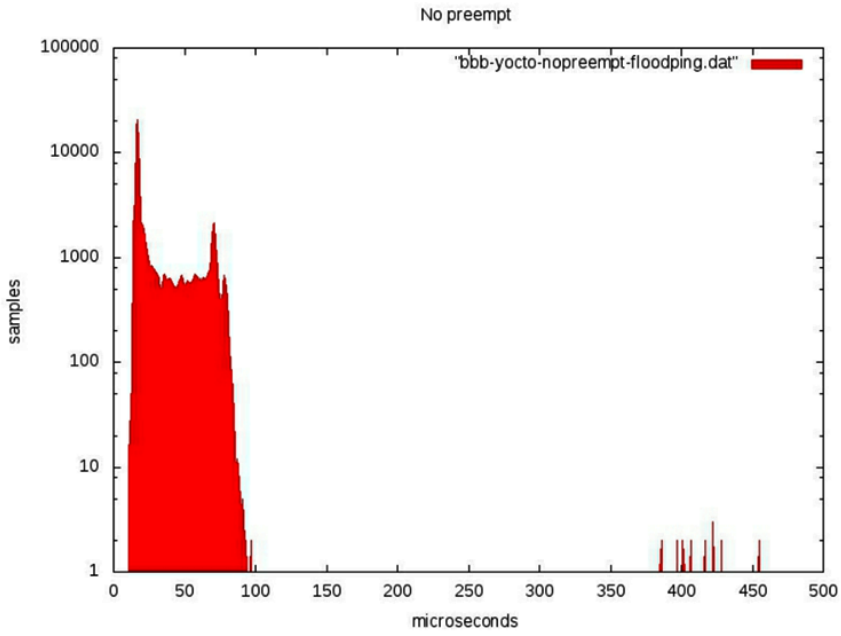

frank@franktop: ~/buildroot
./hardirqs
Tracing hard irq event time... Hit Ctrl-C to end.
^C
HARDIRQ TOTAL_usecs
uart-pl011 77
fe00b880.mailbox 345
mmc1 1874
eth0 2602
#

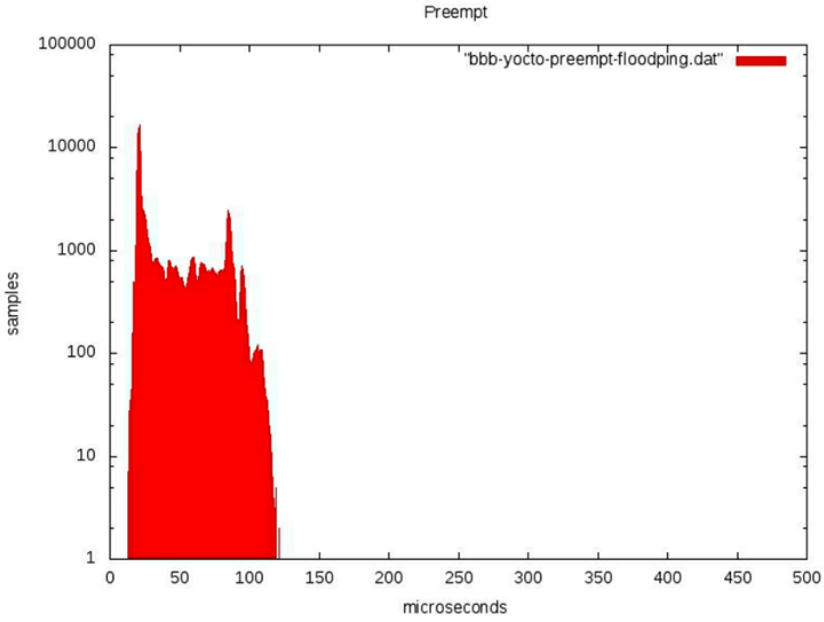
Chapter 21: Real-Time Programming

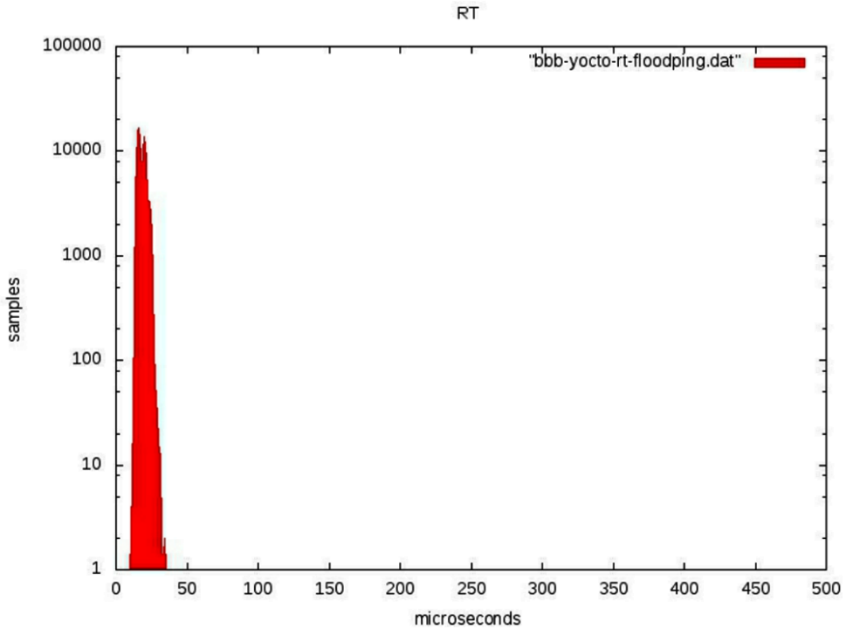







No preempt
"bbb-yocto-nopreempt-floodping.dat"
100000
10000
1000
100
10
1
samples
0
50
100
150
200
250
300
350
400
450
500
microseconds


Preempt
"bbb-yocto-preempt-floodping.dat"
100000
10000
1000
100
10
1
samples
0
50
100
150
200
250
300
350
400
450
500
microseconds


RT
"bbb-yocto-rt-floodping.dat"
100000
10000
1000
100
10
1
samples
0
50
100
150
200
250
300
350
400
450
500
microseconds