

# UCSD Embedded Linux Assignment 5

By

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## Step 1. man lsmod

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
LSMOD<8> lsmod LSMOD<8>
NAME
    lsmod - Show the status of modules in the Linux Kernel
SYNOPSIS
    lsmod
DESCRIPTION
    lsmod is a trivial program which nicely formats the contents of the
    /proc/modules, showing what kernel modules are currently loaded.
COPYRIGHT
    This manual page originally Copyright 2002, Rusty Russell, IBM
    Corporation. Maintained by Jon Masters and others.
SEE ALSO
    insmod<8>, modprobe<8>, modinfo<8> depmod<8>
AUTHORS
    Jon Masters <jcm@jonmasters.org>
    Developer
Manual page lsmod<8> line 1 <press h for help or q to quit>
```

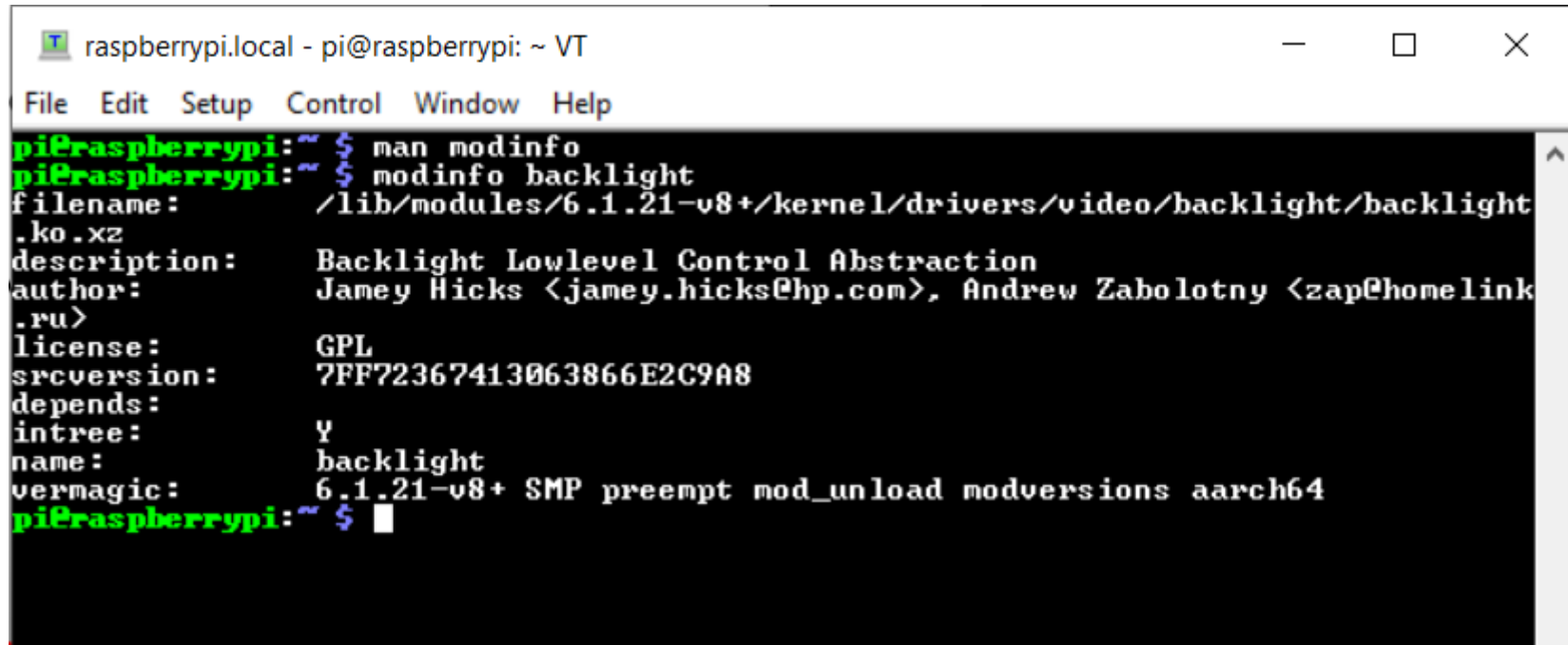
## Step 2. lsmod demo

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ lsmod
Module              Size  Used by
rfcomm              53248  4
cmac                16384  3
algif_hash          16384  1
aes_arm64           16384  3
aes_generic         36864  1 aes_arm64
algif_skcipher      16384  1
af_alg             28672  6 algif_hash,algif_skcipher
bnep               24576  2
hci_uart           53248  1
btbcm              24576  1 hci_uart
bluetooth          565248 31 hci_uart,btbcm,bnep,rfcomm
ecdh_generic        16384  2 bluetooth
ecc                36864  1 ecdh_generic
libaes             16384  3 aes_arm64,bluetooth,aes_generic
8021q              32768  0
garp               16384  1 8021q
stp               16384  1 garp
llc                16384  2 stp,garp
vc4               331776  9
snd_soc_hdmi_codec  20480  2
brcmfmac           331776  0
drm_display_helper  16384  1 vc4
```

### Step 3. man modinfo

```
rasberrypi.local - pi@rasberrypi: ~ VT
File Edit Setup Control Window Help
MODINFO<8>                                modinfo                                MODINFO<8>
NAME
  modinfo - Show information about a Linux Kernel module
SYNOPSIS
  modinfo [-B] [-F field] [-k kernel] [modulename!filename...]
  modinfo -U
  modinfo -h
DESCRIPTION
  modinfo extracts information from the Linux Kernel modules given on the
  command line. If the module name is not a filename, then the
  /lib/modules/version directory is searched, as is also done by
  modprobe<8> when loading kernel modules.
  modinfo by default lists each attribute of the module in form fieldname
  : value, for easy reading. The filename is listed the same way
  (although it's not really an attribute).
  This version of modinfo can understand modules of any Linux Kernel
  Manual page modinfo<8> line 1 (press h for help or q to quit)
```

## Step 4. Demo: modinfo backlight



```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ man modinfo
pi@raspberrypi:~$ modinfo backlight
filename:      /lib/modules/6.1.21-v8+/kernel/drivers/video/backlight/backlight
.ko.xz
description:   Backlight Lowlevel Control Abstraction
author:        Jamey Hicks <jamey.hicks@hp.com>, Andrew Zabolotny <zap@homelink
.ru>
license:       GPL
srcversion:    7FF72367413063866E2C9A8
depends:
intree:       Y
name:          backlight
vermagic:     6.1.21-v8+ SMP preempt mod_unload modversions aarch64
pi@raspberrypi:~$
```

## Step 5. Demo: modinfo i2c\_dev

```
vermagic: 6.1.21-v8+ SMP preempt mod_unload modversions aarch64
pi@raspberrypi:~$ modinfo i2c_dev
filename: /lib/modules/6.1.21-v8+/kernel/drivers/i2c/i2c-dev.ko.xz
license: GPL
description: I2C /dev entries driver
author: Simon G. Vogl <simon@tk.uni-linz.ac.at>
author: Frodo Looijaard <frodo1@dds.nl>
srcversion: 64893A5032D01C5C2CF278A
depends:
intree: Y
name: i2c_dev
vermagic: 6.1.21-v8+ SMP preempt mod_unload modversions aarch64
pi@raspberrypi:~$
```

## Step 6. Demo: /lib/modules

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~ $ ls /lib/modules
6.1.21+ 6.1.21-v7+ 6.1.21-v7l+ 6.1.21-v8+
pi@raspberrypi:~ $ uname -r
6.1.21-v8+
pi@raspberrypi:~ $ ls /lib/modules/${uname -r}
kernel          modules.builtin.alias.bin  modules.dep.bin  modules.symbols
modules.alias    modules.builtin.bin       modules.devname  modules.symbols.bin
modules.alias.bin modules.builtin.modinfo    modules.order
modules.builtin  modules.dep               modules.softdep
pi@raspberrypi:~ $
```

## Step 7. man modprobe

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
MODPROBE(8) modprobe MODPROBE(8)
NAME
  modprobe - Add and remove modules from the Linux Kernel
SYNOPSIS
  modprobe [-v] [-U] [-C config-file] [-n] [-i] [-q] [-b] [modulename]
           [module parameters...]

  modprobe [-r] [-v] [-n] [-i] [modulename...]

  modprobe [-c]

  modprobe [--dump-modversions] [filename]
DESCRIPTION
  modprobe intelligently adds or removes a module from the Linux kernel: note that for
  convenience, there is no difference between _ and - in module names (automatic underscore
  conversion is performed). modprobe looks in the module directory /lib/modules/`uname -r`
  for all the modules and other files, except for the optional configuration files in the
  /etc/modprobe.d directory (see modprobe.d(5)). modprobe will also use module options
  specified on the kernel command line in the form of <module>.<option> and blacklists in
  the form of modprobe.blacklist=<module>.

  Note that unlike in 2.4 series Linux kernels (which are not supported by this tool) this
  version of modprobe does not do anything to the module itself: the work of resolving
  symbols and understanding parameters is done inside the kernel. So module failure is
  sometimes accompanied by a kernel message: see dmesg(8).

  modprobe expects an up-to-date modules.dep.bin file as generated by the corresponding
  depmod utility shipped along with modprobe (see depmod(8)). This file lists what other
  modules each module needs (if any), and modprobe uses this to add or remove these
  dependencies automatically.

  If any arguments are given after the modulename, they are passed to the kernel (in
  addition to any options listed in the configuration file).

Manual page modprobe(8) line 1 (press h for help or q to quit)
```



## Step 8. Demo: modprobe -r, I played around with the i2c\_dev module

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
videobuf2_memops      16384 2 videobuf2_vmalloc,videobuf2_dma_contig
i2c_bcm2835           16384 0
videobuf2_v4l2        32768 5 bcm2835_codec,bcm2835_v4l2,rpivid_hevc,v4l2_mem2mem,bcm2835_
videobuf2_common      69632 9 bcm2835_codec,videobuf2_vmalloc,videobuf2_dma_contig,videobu
,bcm2835_v4l2,rpivid_hevc,v4l2_mem2mem,videobuf2_memops,bcm2835_isp
i2c_brcmstb           16384 0
snd_timer             36864 1 snd_pcm
videodev              274432 7 bcm2835_codec,videobuf2_v4l2,bcm2835_v4l2,videobuf2_common,rp
hevc,v4l2_mem2mem,bcm2835_isp
vc_sm_cma              36864 2 bcm2835_mmal_vchiq,bcm2835_isp
snd                   106496 8 snd_bcm2835,snd_soc_hdmi_codec,snd_timer,snd_compress,snd_soc
snd_pcm
mc                    61440 7 videodev,bcm2835_codec,videobuf2_v4l2,videobuf2_common,rpivid
v4l2_mem2mem,bcm2835_isp
syscopyarea           16384 1 drm_kms_helper
sysfillrect            16384 1 drm_kms_helper
sysimgblt              16384 1 drm_kms_helper
fb_sys_fops            16384 1 drm_kms_helper
uio_pdrv_genirq        16384 0
nvmem_rmem             16384 0
uio                    24576 1 uio_pdrv_genirq
drm                   581632 17 gpu_sched,drm_kms_helper,drm_dma_helper,v3d,vc4,drm_shmem_he
rm_display_helper
i2c_dev               20480 0
fuse                  135168 3
drm_panel_orientation_quirks 28672 1 drm
backlight              24576 1 drm
ip_tables              32768 0
x_tables               53248 1 ip_tables
ipv6                   557056 36
pi@raspberrypi:~ $ sudo modprobe -r i2c_dev
pi@raspberrypi:~ $ lsmod
Module                Size  Used by
rfcomm                53248  4
cmac                  16384  3
algif_hash            16384  1
```

## Step 9. Demo: Adding the module back

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~ $ modprobe i2c_dev
modprobe: ERROR: could not insert 'i2c_dev': Operation not permitted
pi@raspberrypi:~ $ sudo modprobe i2c_dev
pi@raspberrypi:~ $
```

## Step 10. Installing Kernel Headers Step 1

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ sudo apt update
Hit:1 http://archive.raspberrypi.org/debian bullseye InRelease
Hit:2 http://raspbian.raspberrypi.org/raspbian bullseye InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
150 packages can be upgraded. Run 'apt list --upgradable' to see them.
pi@raspberrypi:~$ sudo apt upgrade
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Calculating upgrade... Done
The following package was automatically installed and is no longer required:
  libfuse2
Use 'sudo apt autoremove' to remove it.
The following packages will be upgraded:
  adduser base-files bind9-host bind9-libs chromium-browser chromium-browser-l10n
  chromium-codecs-ffmpeg-extra cpio cups cups-browsed cups-client cups-common
  cups-core-drivers cups-daemon cups-filters cups-filters-core-drivers
  cups-ipp-utils cups-ppdc cups-server-common curl dbus dbus-user-session dbus-x11
  distro-info-data ffmpeg file firmware-atheros firmware-brcm80211
  firmware-libertas firmware-misc-nonfree firmware-realtek ghostscript
  gstreamer1.0-alsa gstreamer1.0-plugins-bad gstreamer1.0-plugins-base
  gstreamer1.0-plugins-good gstreamer1.0-x libaom0 libavcodec58 libavdevice58
  libavfilter7 libavformat58 libavresample4 libavutil56 libblas3 libbsd0 libc-bin
  libc-dev-bin libc-devtools libc-l10n libc6 libc6-dbg libc6-dev libcamera-apps
  libcamera-tools libcamera0 libcups2 libcupsfilters1 libcupsimage2 libcurl3-gnutls
  libcurl4 libdbus-1-3 libflac8 libfontembed1 libgs9 libgs9-common libgssapi-krb5-2
  libgstreamer-gli.0-0 libgstreamer-plugins-bad1.0-0 libgstreamer-plugins-base1.0-0
  libjavascriptcoregtk-4.0-18 libjson-c5 libk5crypto3 libkrb5-3 libkrb5support0
  liblapack3 libmagic-mgc libmagic1 libncurses6 libncursesw6 libpan-systemd
  libpostproc55 libprotobuf-lite23 librsvg2-2 librsvg2-common libssh-gcrypt-4
  libssl1.1 libswresample3 libswscale5 libsyntax2 libsystemd0 libtinfo5 libtinfo6
  libudev1 libvlc-bin libvlc5 libvlccore9 libvpx6 libwebkit2gtk-4.0-37 libwebp6
  libwebpdemux2 libwebpmux3 libx11-6 libx11-data libx11-xcb1 libxpm4 locales
  logrotate lxplug-bluetooth lxplug-cputemp lxplug-menu lxplug-network
```

## Step 11. Installing Kernel Headers Step 2

```
raspberrypi.local - pi@raspberrypi: ~ VT
File Edit Setup Control Window Help
pi@raspberrypi:~$ sudo apt-cache search linux-headers
linux-headers-5.10.0-26-common - Common header files for Linux 5.10.0-26
linux-headers-5.10.0-26-common-rp - Common header files for Linux 5.10.0-26-rp
linux-libc-dev-alpha-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-amd64-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-arm64-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-armel-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-armhf-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-hppa-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-i386-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-m68k-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-mips-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-mips64-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-mips64el-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-mips64r6-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-mips64r6el-cross - Linux Kernel Headers for development (for cross-com
piling)
linux-libc-dev-mipsel-cross - Linux Kernel Headers for development (for cross-compili
ng)
linux-libc-dev-mipsn32-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-mipsn32el-cross - Linux Kernel Headers for development (for cross-comp
iling)
linux-libc-dev-mipsn32r6-cross - Linux Kernel Headers for development (for cross-comp
iling)
linux-libc-dev-mipsn32r6el-cross - Linux Kernel Headers for development (for cross-co
mpiling)
linux-libc-dev-mipsr6-cross - Linux Kernel Headers for development (for cross-compili
ng)
linux-libc-dev-mipsr6el-cross - Linux Kernel Headers for development (for cross-compi
ling)
linux-libc-dev-powerpc-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-ppc64-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-ppc64el-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-riscv64-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-s390x-cross - Linux Kernel Headers for development (for cross-compilin
g)
linux-libc-dev-sh4-cross - Linux Kernel Headers for development (for cross-compiling)
linux-libc-dev-sparc64-cross - Linux Kernel Headers for development (for cross-compil
ing)
linux-libc-dev-x32-cross - Linux Kernel Headers for development (for cross-compiling)
```


## Step 12. Installing Kernel Headers Step 3

```
pi@raspberrypi:~$ sudo apt install raspberrypi-kernel-headers
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following package was automatically installed and is no longer required:
  libfuse2
Use 'sudo apt autoremove' to remove it.
The following NEW packages will be installed:
  raspberrypi-kernel-headers
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 30.0 MB of archives.
After this operation, 193 MB of additional disk space will be used.
Get:1 http://archive.raspberrypi.org/debian bullseye/main armhf raspberrypi-kernel-he
aders armhf 1:1.20230405-1 [30.0 MB]
Fetched 30.0 MB in 5s (6,429 kB/s)
Selecting previously unselected package raspberrypi-kernel-headers.
(Reading database ... 106638 files and directories currently installed.)
Preparing to unpack .../raspberrypi-kernel-headers_1%3a1.20230405-1_armhf.deb ...
Unpacking raspberrypi-kernel-headers (1:1.20230405-1) ...
Progress: [ 20%] [#####.....]
```

## Step 13. Installing Kernel Headers Step 4

```
Setting up raspberrypi-kernel-headers (1:1.20230403-1) ...  
pi@raspberrypi:~$ dpkg -L raspberrypi-kernel-headers | head  
/  
/lib  
/lib/modules  
/lib/modules/6.1.21+  
/lib/modules/6.1.21-v7+  
/lib/modules/6.1.21-v7l+  
/usr  
/usr/share  
/usr/share/doc  
/usr/share/doc/raspberrypi-kernel-headers  
pi@raspberrypi:~$
```

## Step 14. Makefile

 raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT

File Edit Setup Control Window Help

```
pi@raspberrypi:~/km-1-hello $ cat Makefile
#Makefile for building kernel module
obj-m := km-1-hello.o

KERNEL_SRC ?= /lib/modules/$(shell uname -r)/build

all default: modules
install: modules_install

modules modules_install help clean:
    $(MAKE) -C $(KERNEL_SRC) M=$(shell pwd) $@
pi@raspberrypi:~/km-1-hello $
```

## Step 15. km-1-hello.c

```
raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT
File Edit Setup Control Window Help
pi@raspberrypi:~/km-1-hello $ cat km-1-hello.c
#include <linux/init.h>
#include <linux/module.h>
#include <linux/kernel.h>

MODULE_LICENSE("GPL");
MODULE_AUTHOR("Kai Chang<kevin821027@gmail.com>");
MODULE_DESCRIPTION("Hello World Kernel Module");
MODULE_VERSION("0.1");

static int __init hello_init(void)
{
    printk(KERN_INFO "Hello Kernel Module\n");
    return 0;
}

static void __exit hello_exit(void)
{
    printk(KERN_INFO "Goodbye Kernel Module\n");
}

module_init(hello_init);
module_exit(hello_exit);
pi@raspberrypi:~/km-1-hello $
```



## Step 16. make error

```
pi@raspberrypi:~/km-1-hello $ make
make -C /lib/modules/6.1.21-v8+/build M=/home/pi/km-1-hello modules
make[1]: *** /lib/modules/6.1.21-v8+/build: No such file or directory. Stop.
make: *** [Makefile:9: modules] Error 2
pi@raspberrypi:~/km-1-hello $ █
```

## Step 17. Modify the /boot/config.txt file

raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT

File Edit Setup Control Window Help

GNU nano 5.4

/boot/config.txt

```
# Disable compensation for displays with overscan
disable_overscan=1
```

```
[cm4]
```

```
# Enable host mode on the 2711 built-in XHCI USB controller.
# This line should be removed if the legacy DWC2 controller is required
# (e.g. for USB device mode) or if USB support is not required.
otg_mode=1
```

```
[all]
```

```
[pi4]
```

```
# Run as fast as firmware / board allows
arm_boost=1
```


```
# Kai Added 2023-10-24
```

```
arm_64bit=0
```

```
[all]
```

```
gpu_mem=128
```

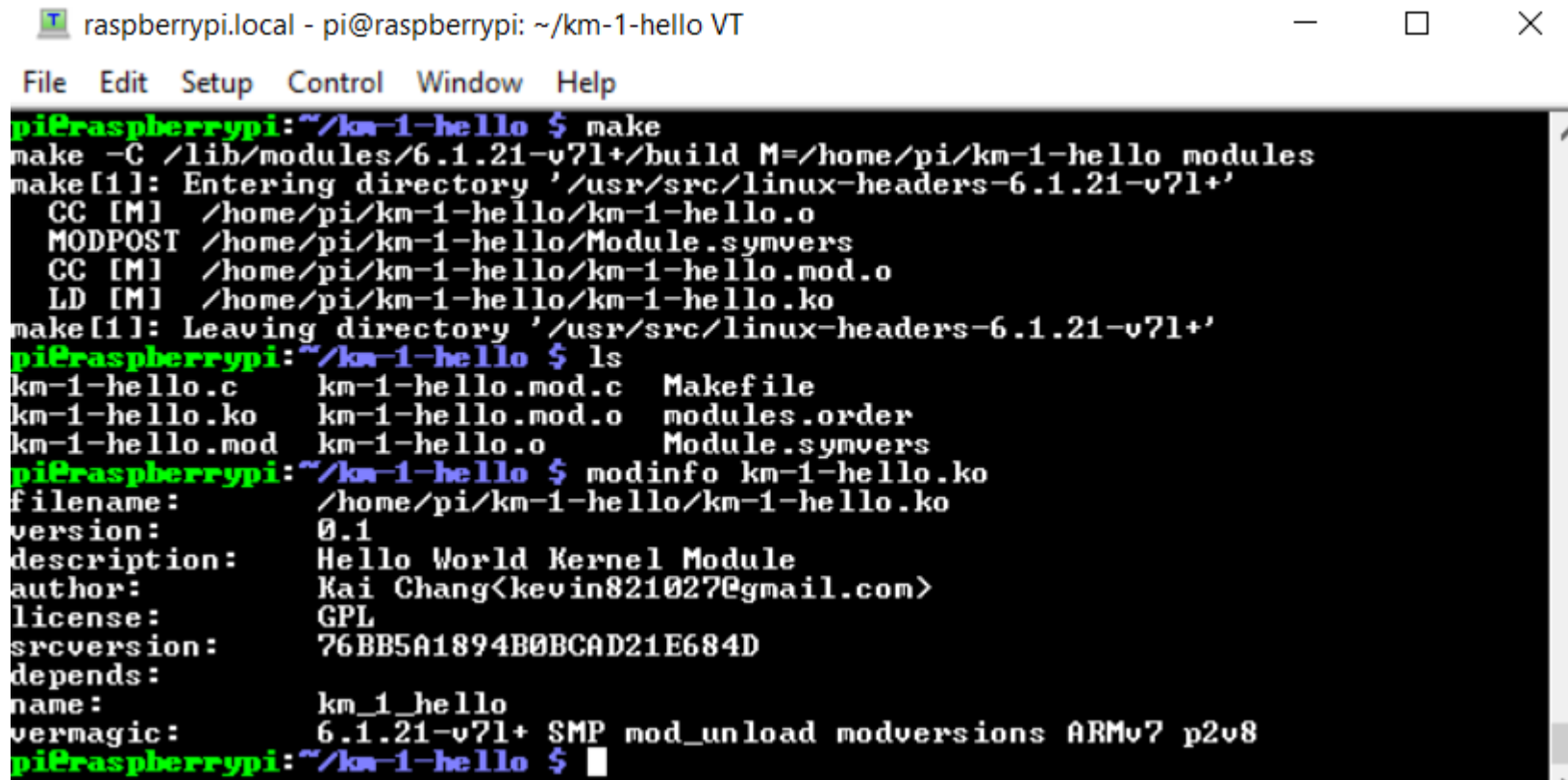
Step 18. After rebooting, version becomes v71+

 raspberrypi.local - pi@raspberrypi: ~ VT

File Edit Setup Control Window Help

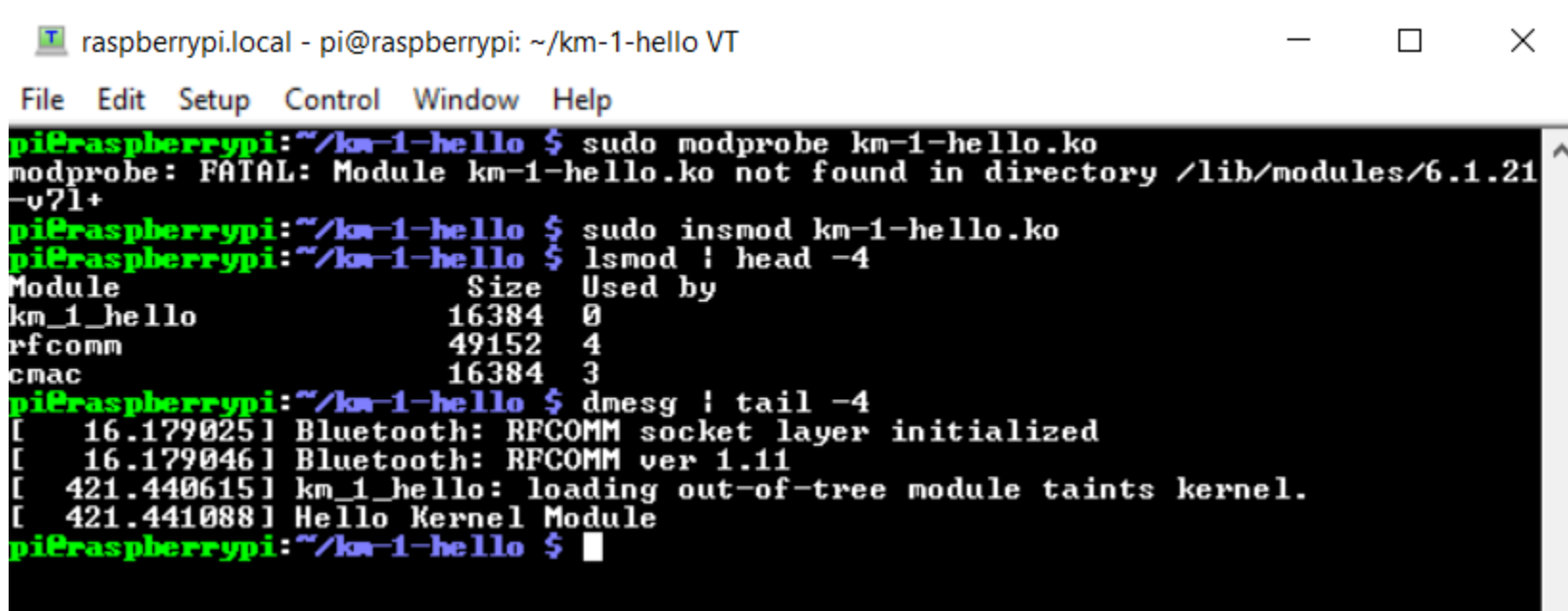
```
pi@raspberrypi:~$ uname -r  
6.1.21-v71+  
pi@raspberrypi:~$
```

Step 19. After changing to v71+, the build is successful



```
raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT
File Edit Setup Control Window Help
pi@raspberrypi:~/km-1-hello $ make
make -C /lib/modules/6.1.21-v71+/build M=/home/pi/km-1-hello modules
make[1]: Entering directory '/usr/src/linux-headers-6.1.21-v71+'
  CC [M] /home/pi/km-1-hello/km-1-hello.o
  MODPOST /home/pi/km-1-hello/Module.symvers
  CC [M] /home/pi/km-1-hello/km-1-hello.mod.o
  LD [M] /home/pi/km-1-hello/km-1-hello.ko
make[1]: Leaving directory '/usr/src/linux-headers-6.1.21-v71+'
pi@raspberrypi:~/km-1-hello $ ls
km-1-hello.c      km-1-hello.mod.c  Makefile
km-1-hello.ko     km-1-hello.mod.o  modules.order
km-1-hello.mod    km-1-hello.o      Module.symvers
pi@raspberrypi:~/km-1-hello $ modinfo km-1-hello.ko
filename:         /home/pi/km-1-hello/km-1-hello.ko
version:          0.1
description:      Hello World Kernel Module
author:           Kai Chang<kevin821027@gmail.com>
license:          GPL
srcversion:       76BB5A1894B0BCAD21E684D
depends:
name:             km_1_hello
vermagic:         6.1.21-v71+ SMP mod_unload modversions ARMv7 p2v8
pi@raspberrypi:~/km-1-hello $
```

## Step 20. Loading Kernel Module



A terminal window titled "raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT" with standard window controls. The terminal shows the following commands and output:

```
pi@raspberrypi:~/km-1-hello $ sudo modprobe km-1-hello.ko
modprobe: FATAL: Module km-1-hello.ko not found in directory /lib/modules/6.1.21-071+
pi@raspberrypi:~/km-1-hello $ sudo insmod km-1-hello.ko
pi@raspberrypi:~/km-1-hello $ lsmod | head -4
Module                Size  Used by
km_1_hello             16384  0
rfcomm                 49152  4
cmac                   16384  3
pi@raspberrypi:~/km-1-hello $ dmesg | tail -4
[ 16.179025] Bluetooth: RFCOMM socket layer initialized
[ 16.179046] Bluetooth: RFCOMM ver 1.11
[ 421.440615] km_1_hello: loading out-of-tree module taints kernel.
[ 421.441088] Hello Kernel Module
pi@raspberrypi:~/km-1-hello $
```

## Step 21. Unloading Kernel Module

```
raspberrypi.local - pi@raspberrypi: ~/km-1-hello VT
File Edit Setup Control Window Help
pi@raspberrypi:~/km-1-hello $ sudo rmmod km_1_hello
pi@raspberrypi:~/km-1-hello $ lsmod | head -4
Module                Size  Used by
rfcomm                 49152  4
cmac                   16384  3
algif_hash             16384  1
pi@raspberrypi:~/km-1-hello $ sudo dmesg | tail -4
[ 16.179046] Bluetooth: RFCOMM ver 1.11
[ 421.440615] km_1_hello: loading out-of-tree module taints kernel.
[ 421.441088] Hello Kernel Module
[ 494.735952] Goodbye Kernel Module
pi@raspberrypi:~/km-1-hello $
```

## Step 22. Download Rpi source

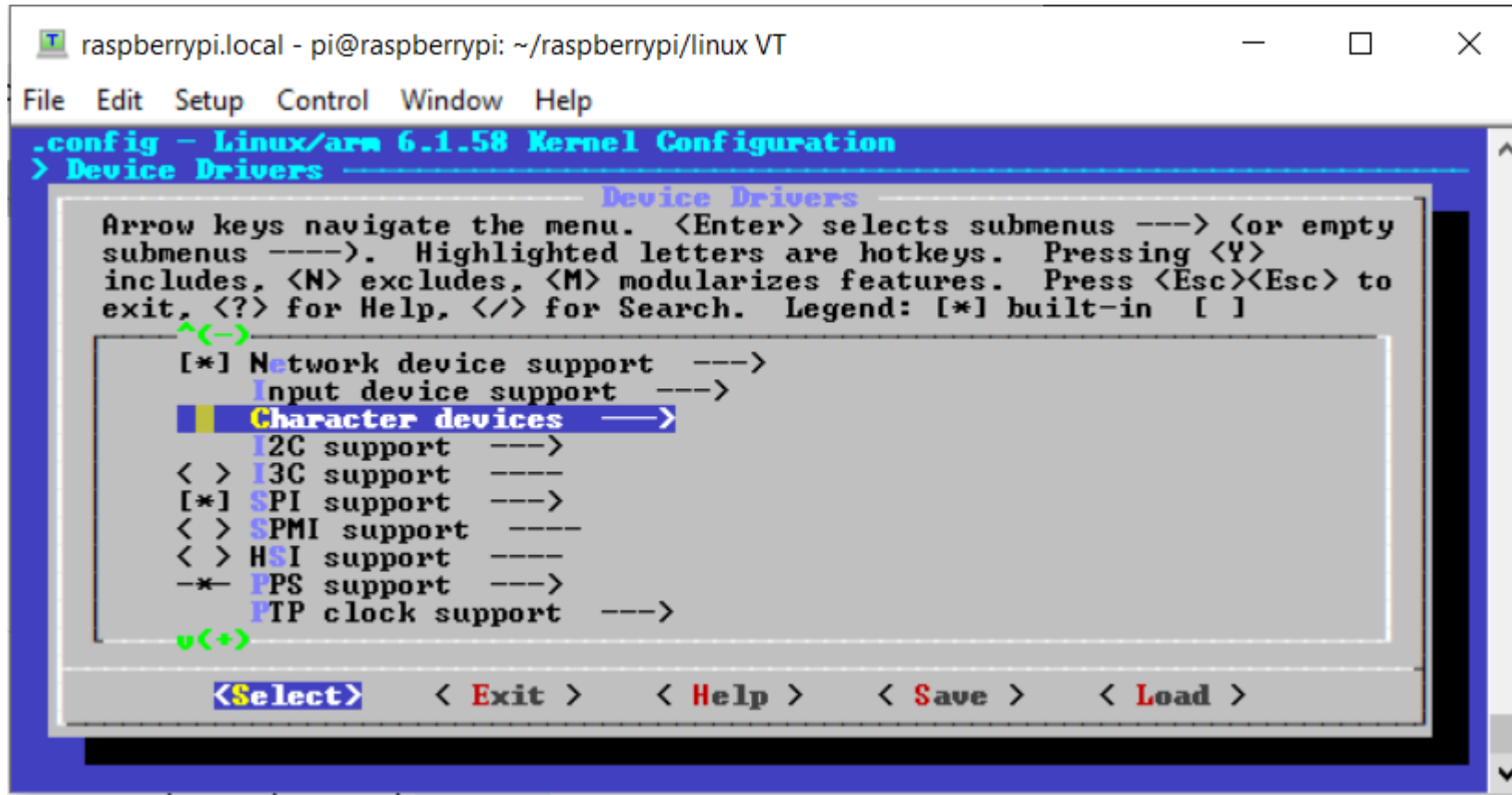
```
raspberrypi.local - pi@raspberrypi: ~/raspberrypi/linux VT
File Edit Setup Control Window Help
pi@raspberrypi:~/k-1-hello $ cd ..
pi@raspberrypi:~ $ mkdir raspberrypi
pi@raspberrypi:~ $ cd raspberrypi/
pi@raspberrypi:~/raspberrypi $ git clone --depth=1 https://github.com/raspberrypi/linux
Cloning into 'linux'...
remote: Enumerating objects: 84111, done.
remote: Counting objects: 100% (84111/84111), done.
remote: Compressing objects: 100% (79566/79566), done.
remote: Total 84111 (delta 7475), reused 22536 (delta 3677), pack-reused 0
Receiving objects: 100% (84111/84111), 232.44 MiB | 4.79 MiB/s, done.
Resolving deltas: 100% (7475/7475), done.
Updating files: 100% (79412/79412), done.
pi@raspberrypi:~/raspberrypi $ ls
linux
pi@raspberrypi:~/raspberrypi $ cd linux
pi@raspberrypi:~/raspberrypi/linux $ ls
arch      crypto    init      kernel    mm         samples   usr
block     Documenta io_uring  lib       net        scripts   virt
certs     drivers  ipc       LICENSES  README    security
COPYING   fs        Kbuild   MAINTAINERS  README.md  sound
CREDITS   include  Kconfig  Makefile    rust       tools
pi@raspberrypi:~/raspberrypi/linux $
```

## Step 23. Default Kernel Configuration

```
raspberrypi.local - pi@raspberrypi: ~/raspberrypi/linux VT
File Edit Setup Control Window Help
pi@raspberrypi:~/raspberrypi/linux $ KERNEL=kernel8
pi@raspberrypi:~/raspberrypi/linux $ make bcm2711_defconfig
HOSTCC scripts/basic/fixdep
HOSTCC scripts/kconfig/conf.o
HOSTCC scripts/kconfig/confdata.o
HOSTCC scripts/kconfig/expr.o
LEX scripts/kconfig/lexer.lex.c
YACC scripts/kconfig/parser.tab.[ch]
HOSTCC scripts/kconfig/lexer.lex.o
HOSTCC scripts/kconfig/menu.o
HOSTCC scripts/kconfig/parser.tab.o
HOSTCC scripts/kconfig/preprocess.o
HOSTCC scripts/kconfig/symbol.o
HOSTCC scripts/kconfig/util.o
HOSTLD scripts/kconfig/conf
#
# configuration written to .config
#
pi@raspberrypi:~/raspberrypi/linux $
```



## Step 24. make menuconfig



## Step 25. Kernel Source Code drivers/char/broadcom

```
raspberrypi.local - pi@raspberrypi: ~/raspberrypi/linux VT
File Edit Setup Control Window Help
pi@raspberrypi:~/raspberrypi/linux $ wc -l drivers/char/boradcom/*
wc: 'drivers/char/boradcom/*': No such file or directory
pi@raspberrypi:~/raspberrypi/linux $ ls
arch      CREDITS  fs        ipc        lib        mm          rust      sound
block     crypto   include   Kbuild     LICENSES   net         samples   tools
certs     Documentation  init      Kconfig    MAINTAINERS  README     scripts   usr
COPYING   drivers  io_uring  kernel     Makefile    README.md  security  virt
pi@raspberrypi:~/raspberrypi/linux $ ls drivers/char/broadcom/
bcm2835_smi_dev.c  Kconfig  Makefile  rpivid-mem.c  vcio.c  vc_mem.c
pi@raspberrypi:~/raspberrypi/linux $ wc -l drivers/char/broadcom/*
409 drivers/char/broadcom/bcm2835_smi_dev.c
41  drivers/char/broadcom/Kconfig
4   drivers/char/broadcom/Makefile
270 drivers/char/broadcom/rpivid-mem.c
186 drivers/char/broadcom/vcio.c
632 drivers/char/broadcom/vc_mem.c
1542 total
pi@raspberrypi:~/raspberrypi/linux $
```

Step 26. ls /dev/gpiomem. Question: Why my last command did not show anything

```
raspberrypi.local - pi@raspberrypi: ~/raspberrypi/linux VT
File Edit Setup Control Window Help
pi@raspberrypi:~/raspberrypi/linux $ ls -l /dev/gpiomem
crw-rw---- 1 root gpio 245, 0 Oct 25 07:20 /dev/gpiomem
pi@raspberrypi:~/raspberrypi/linux $ lsmod | grep gpio
pi@raspberrypi:~/raspberrypi/linux $ grep DEUGPIOMEM .config
pi@raspberrypi:~/raspberrypi/linux $
```