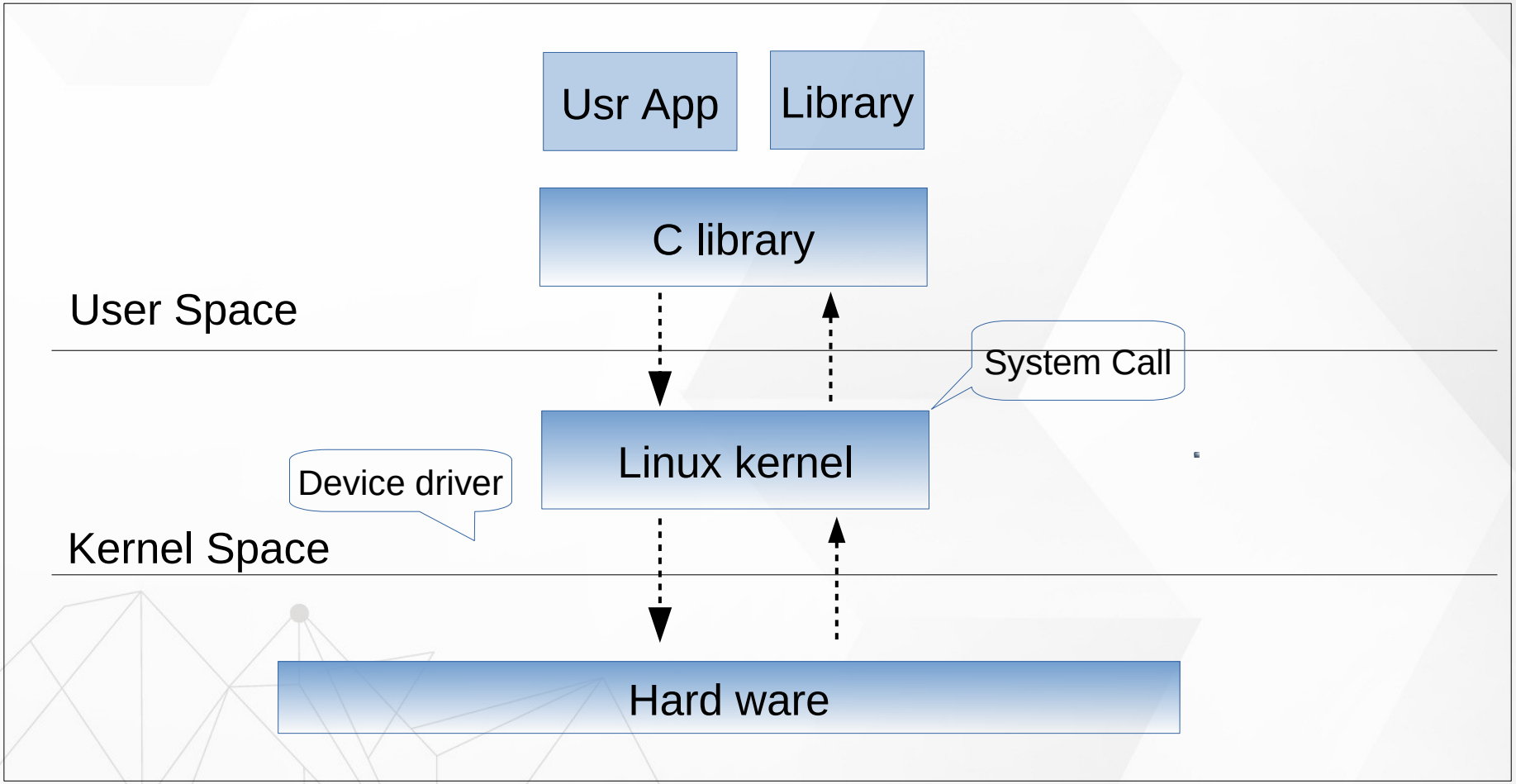
CH9 Linux User Land

Linux kernel



Sys Filesystem

- Allows kernel code to export information to user processes
- SysFS is an in-memory filesystem
- It provides two components
  - A kernel programming interface for exporting these items via sysfs
  - User interface to view and manipulate these items that maps back to the kernel objects which they represent

Sys File System

tree -L 1 /sys/

```
/sys/
├── block
├── bus
├── class
├── dev
├── devices
├── firmware
├── fs
├── hypervisor
├── kernel
├── module
└── power
```

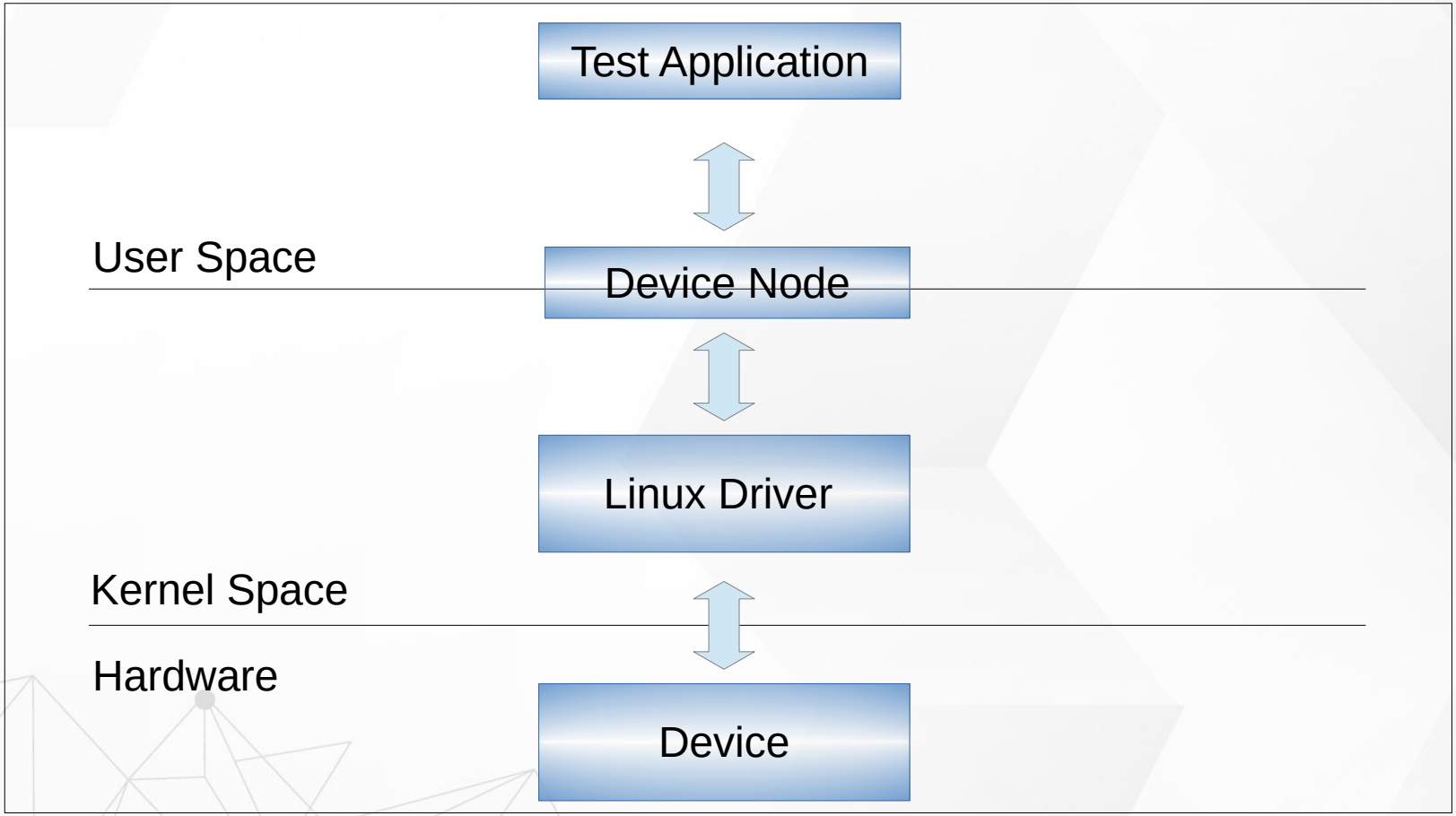
tree -L 1 /sys/class/i2c-dev/i2c-0/

```
/sys/class/i2c-dev/i2c-0/
├── dev
├── device -> ../../../i2c-0
├── name
├── power
├── subsystem -> ../../../../../../class/i2c-dev
└── uevent
```

tree -L 1 /sys/class/i2c-dev

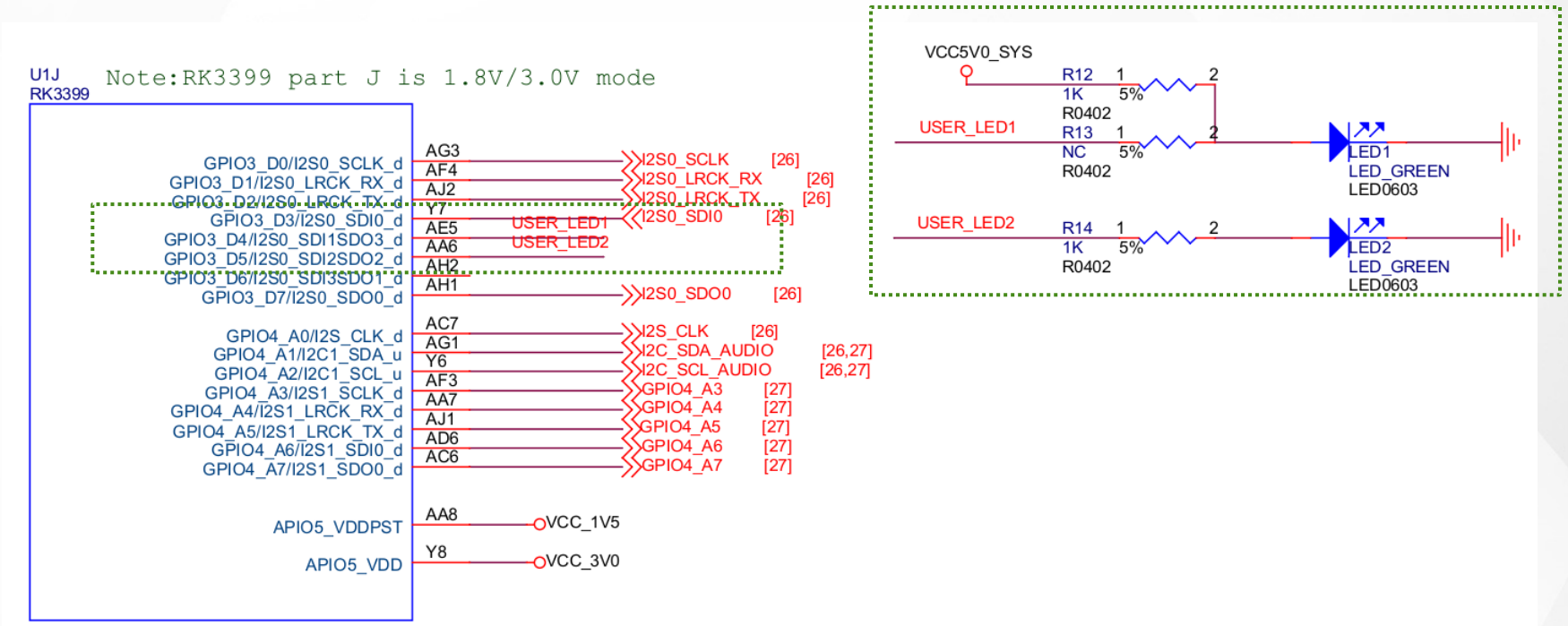
```
/sys/class/i2c-dev/
├── i2c-0 -> ../../devices/pci0000:00/0000:00:02.0/i2c-0/i2c-dev/i2c-0
├── i2c-1 -> ../../devices/pci0000:00/0000:00:02.0/i2c-1/i2c-dev/i2c-1
├── i2c-2 -> ../../devices/pci0000:00/0000:00:02.0/i2c-2/i2c-dev/i2c-2
├── i2c-3 -> ../../devices/pci0000:00/0000:00:02.0/i2c-3/i2c-dev/i2c-3
├── i2c-4 -> ../../devices/pci0000:00/0000:00:02.0/i2c-4/i2c-dev/i2c-4
├── i2c-5 -> ../../devices/pci0000:00/0000:00:02.0/i2c-5/i2c-dev/i2c-5
├── i2c-6 -> ../../devices/pci0000:00/0000:00:02.0/drm/card0/card0-DP-1/i2c-6/i2c-dev/i2c-6
├── i2c-7 -> ../../devices/pci0000:00/0000:00:02.0/drm/card0/card0-DP-2/i2c-7/i2c-dev/i2c-7
└── i2c-8 -> ../../devices/pci0000:00/0000:00:02.0/drm/card0/card0-DP-3/i2c-8/i2c-dev/i2c-8
```

User land and Driver



LED Drivers

LED Schematic



GPIO3_D4/I2S0_SDI1SDO3_d → LED1

GPIO3_D5/I2S0_SDI2SDO2_d → LED2

LED Subsystem

- Control LED convenient with SysFS
  - For example
    - echo 1 > /sys/class/leds/user-led2/shot
- Switch different LED trigger type in SysFS
  - For example
    - echo "gpio" > /sys/class/leds/user-led2/trigger
    - echo "1" > /sys/class/leds/user-led2/brightness
    - echo "0" > /sys/class/leds/user-led2/brightness

LED SysFS

```
root@rockpi4b:/sys/class/leds/user-led2# ls -l

brightness
device -> ../../../gpio-leds
max_brightness
power
subsystem -> ../../../../../class/leds
trigger
uevent

root@rockpi4b:/sys/class/leds/user-led2# cat trigger
none rc-feedback kbd-scrolllock kbd-numlock kbd-capslock
kbd-kanalock kbd-shiftlock kbd-altgrlock kbd-ctrllock kbd-altlock
kbd-shiftllock kbd-shiftrlock kbd-ctrlllock kbd-ctrlrlock m
timer oneshot heartbeat backlight [gpio] cpu0 cpu1 cpu2 cpu


root@rockpi4b:/sys/class/leds/user-led2# echo heartbeat > trigger

root@rockpi4b:/sys/class/leds/user-led2# cat trigger
none rc-feedback kbd-scrolllock kbd-numlock kbd-capslock
kbd-kanalock kbd-shiftlock kbd-altgrlock kbd-ctrllock kbd-altlock
kbd-shiftllock kbd-shiftrlock kbd-ctrlllock kbd-ctrlrlock mmc0 mmc1
timer oneshot [heartbeat] backlight gpio cpu0 cpu1 cpu2 cpu3 cpu4 cpu5
```

Check trigger type

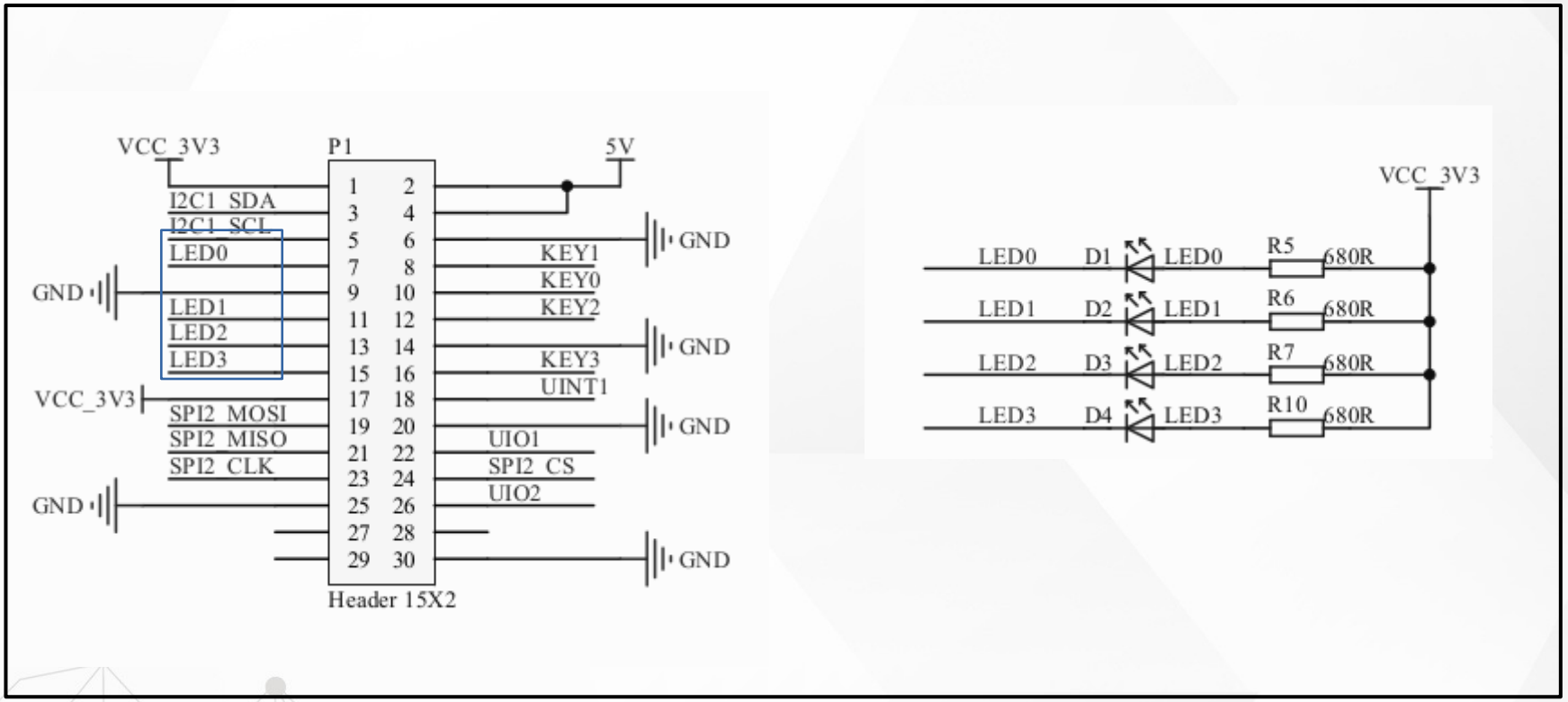
Switch trigger type

GPIO Control

Driver LED in User Space

- Paths in Sysfs
- /sys/class/gpio:
  - Control interfaces used to get userspace control over GPIOs;
  - GPIOs themselves
  - GPIO controllers("gpio_chip" instances)
- /sys/class/gpio/
  - "export" : ask the kernel to export GPIO to userspace by writing
    - "echo 19 > export"
    - create a "gpio19" node in /sys/class/gpio
  - "unexport" : Reverses the effect of exporting to userspace
    - "echo 19 > unexport"
    - remove "gpio19" node from /sys/class/gpio

Cadtc Ext Board LED



RockPi4B HEAD

Rock Pi 4 A/B/C general purpose input-output (GPIO) connector

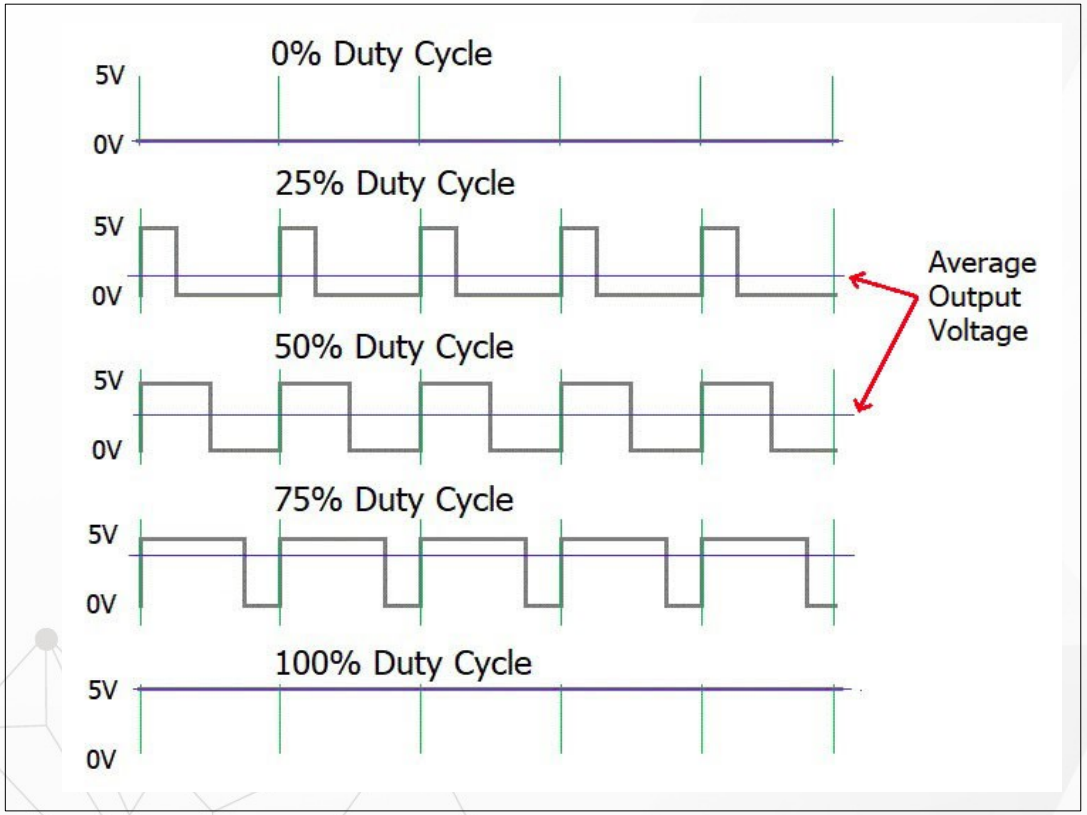
ROCK Pi 4 has a 40-pin expansion header. Each pin is distinguished by color.

GPIO number	Function2	Function1	GPIO	Pin#	Pin#	GPIO	Function1	Function2	GPIO number
		+3.3V		1	2		+5.0V		
71		I2C7_SDA	GPIO2_A7	3	4		+5.0V		
72		I2C7_SCL	GPIO2_B0	5	6		GND		
75		SPI2_CLK	GPIO2_B3	7	8	GPIO4_C4	UART2_TXD		148
		GND		9	10	GPIO4_C3	UART2_RXD		147
146		PWM0	GPIO4_C2	11	12	GPIO4_A3	I2S1_SCLK		131
150		PWM1	GPIO4_C6	13	14		GND		
149		SPDIF_TX	GPIO4_C5	15	16	GPIO4_D2			154
		+3.3V		17	18	GPIO4_D4			156
40	UART4_TXD	SPI1_TXD	GPIO1_B0	19	20		GND		
39	UART4_RXD	SPI1_RXD	GPIO1_A7	21	22	GPIO4_D5			157
41		SPI1_CLK	GPIO1_B1	23	24	GPIO1_B2	SPI1_CSn		42
		GND		25	26		ADC_IN0		
64		I2C2_SDA	GPIO2_A0	27	28	GPIO2_A1	I2C2_CLK		65
74	I2C6_SCL	SPI2_TXD	GPIO2_B2	29	30		GND		
73	I2C6_SDA	SPI2_RXD	GPIO2_B1	31	32	GPIO3_C0	SPDIF_TX	UART3_CTSn	112
76		SPI2_CSn	GPIO2_B4	33	34		GND		
133		I2S1_LRCK_TX	GPIO4_A5	35	36	GPIO4_A4	I2S1_LRCK_RX		132
158			GPIO4_D6	37	38	GPIO4_A6	I2S1_SDI		134
		GND		39	40	GPIO4_A7	I2S1_SDO		135

PWM Sub System

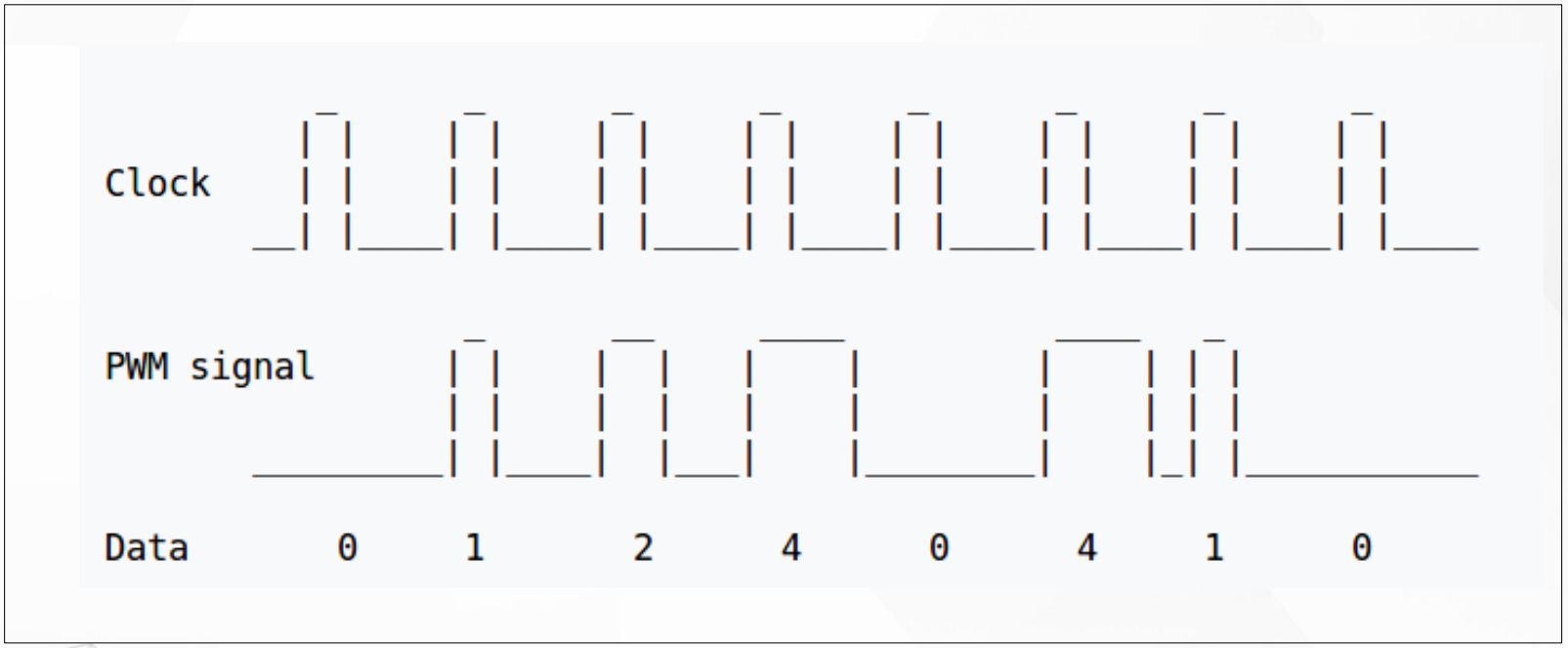
PWM

- PWM : Pulse Width Modulation



https://circuitdigest.com/tutorial/what-is-pwm-pulse-width-modulation

PWM



https://en.wikipedia.org/wiki/Pulse-width_modulation

PWM Parameter in Linux

- Period
  - The total period of the PWM signal
  - Value is in nanoseconds
  - sum of the active and inactive time of the PWM
- duty_cycle
  - The active time of the PWM signal
  - Value is in nanoseconds
  - must be less than the period.

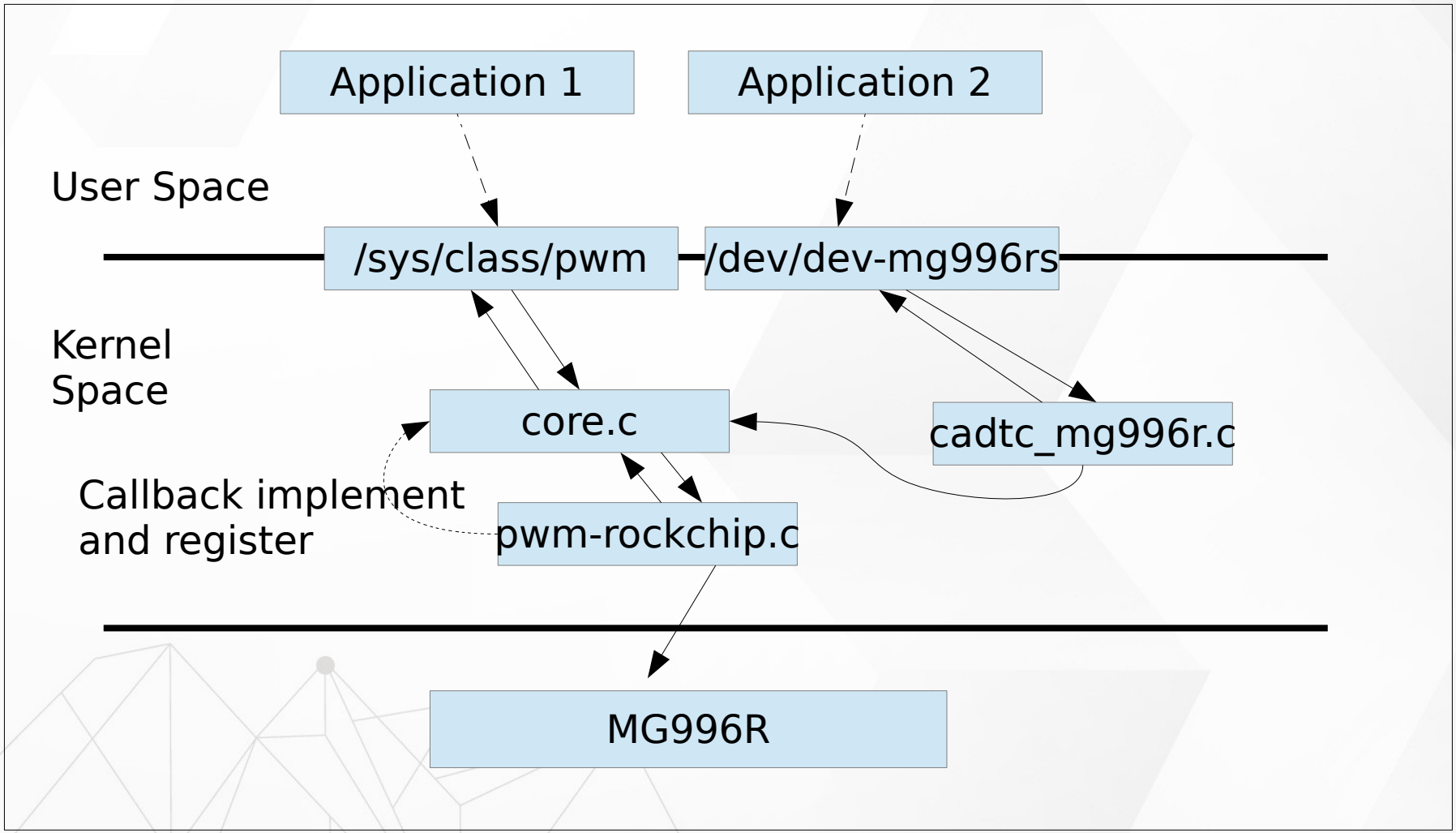
PWM Parameter in Linux

- Polarity
  - The polarity of the PWM signal
- Enable

PWM Driver

- $(KERNEL_SRC)/Documentation/pwm.txt
- Platform Driver
  - drivers/pwm/
  - drivers/pwm/core.c
  - drivers/pwm/pwm-rockchip.c

PWM Subsystem



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72		I2C7_SCL	GPIO2_B0	5	6		GND		
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133		I2S1_LRCK_TX	GPIO4_A5	35	36	GPIO4_A4	I2S1_LRCK_RX		132
158			GPIO4_D6	37	38	GPIO4_A6	I2S1_SDI		134
		GND		39	40	GPIO4_A7	I2S1_SDO		135

PWM SYSFS

```
/sys/class/pwm/pwmchip0
device    export    npwm    power    subsystem  uevent    unexport
```

```
echo 0 > export
capture    enable    polarity    uevent    duty_cycle  period    power
```

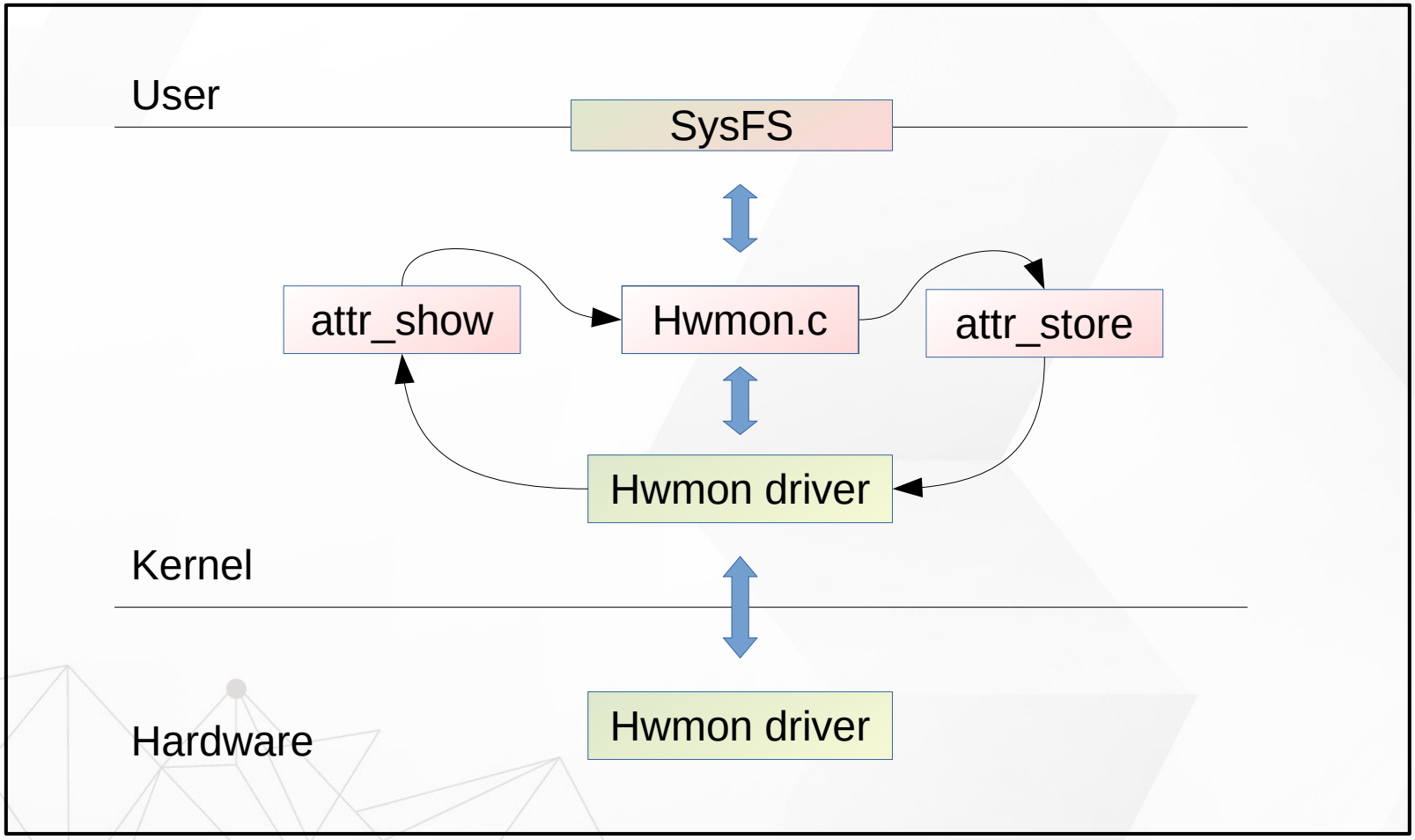
```
echo “20000000” > period          //20ms, 50 Hz
echo "2000000" > duty_cycle      //2ms
echo 1 > enable                   //Enable
```

PWM DoReMi

	Frequency (Hz)
C4	261.63
C4#	277.18
D4	293.66
D4#	311.13
E4	329.63
F4	349.23
F4#	369.99
G4	392.00
G4#	415.30
A4	440.00
A4#	466.16
B4	493.88
C5	523.25

Hwmon Subsystem

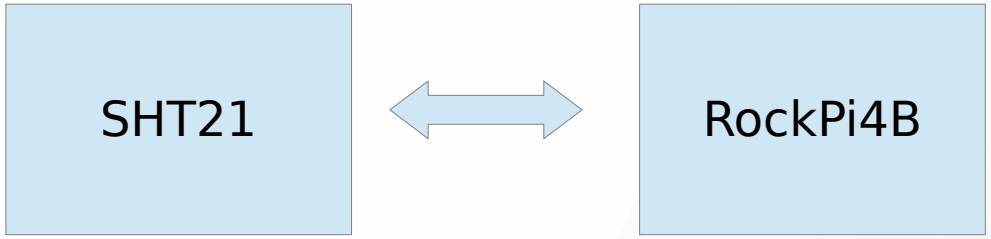
Hwmon Subsystem



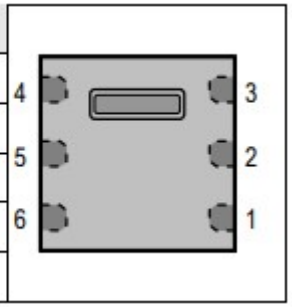
SHT21

- Simple interface
- Bus interface
  - I2C, GPIO, SPI
- Sensors
  - Temperature
  - Voltage
  - Humidity
  - Fan speed
  - PWM control

SHT21



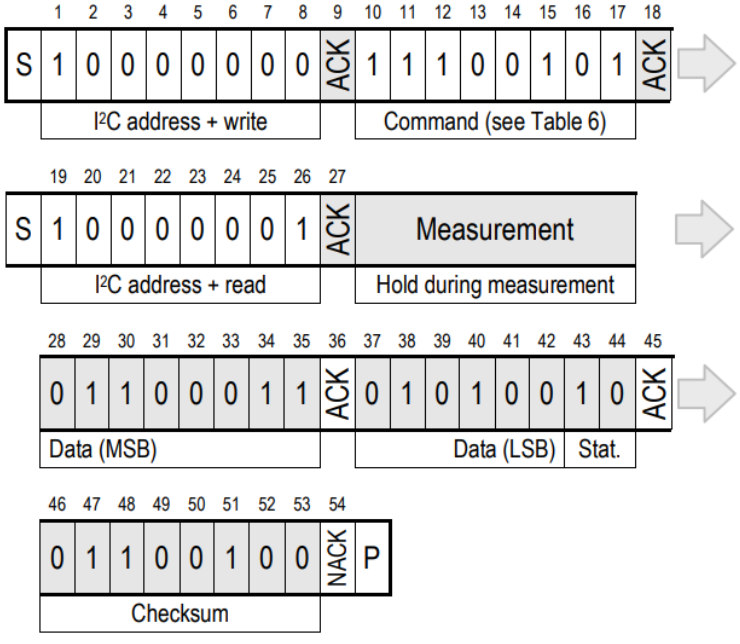
Pin	Name	Comment
1	SDA	Serial Data, bidirectional
2	VSS	Ground
5	VDD	Supply Voltage
6	SCL	Serial Clock, bidirectional
3,4	NC	Not Connected



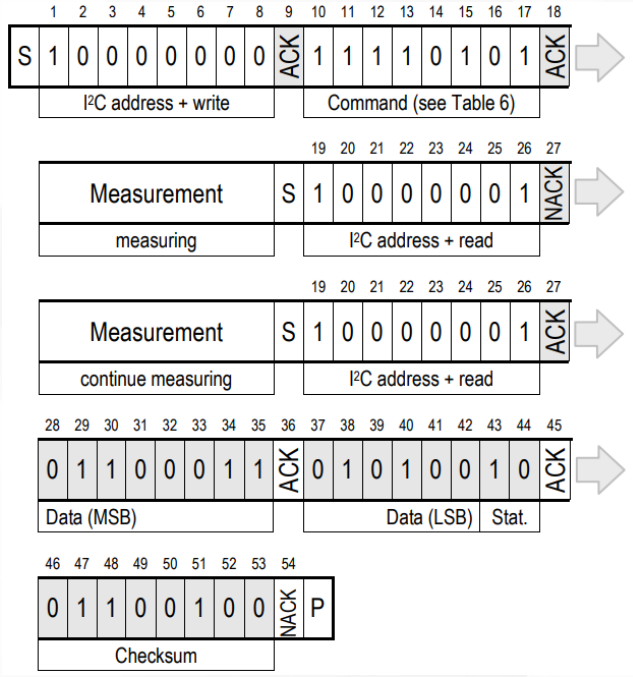
Command	Comment	Code
Trigger T measurement	hold master	1110'0011
Trigger RH measurement	hold master	1110'0101
Trigger T measurement	no hold master	1111'0011
Trigger RH measurement	no hold master	1111'0101
Write user register		1110'0110
Read user register		1110'0111
Soft reset		1111'1110

SHT21

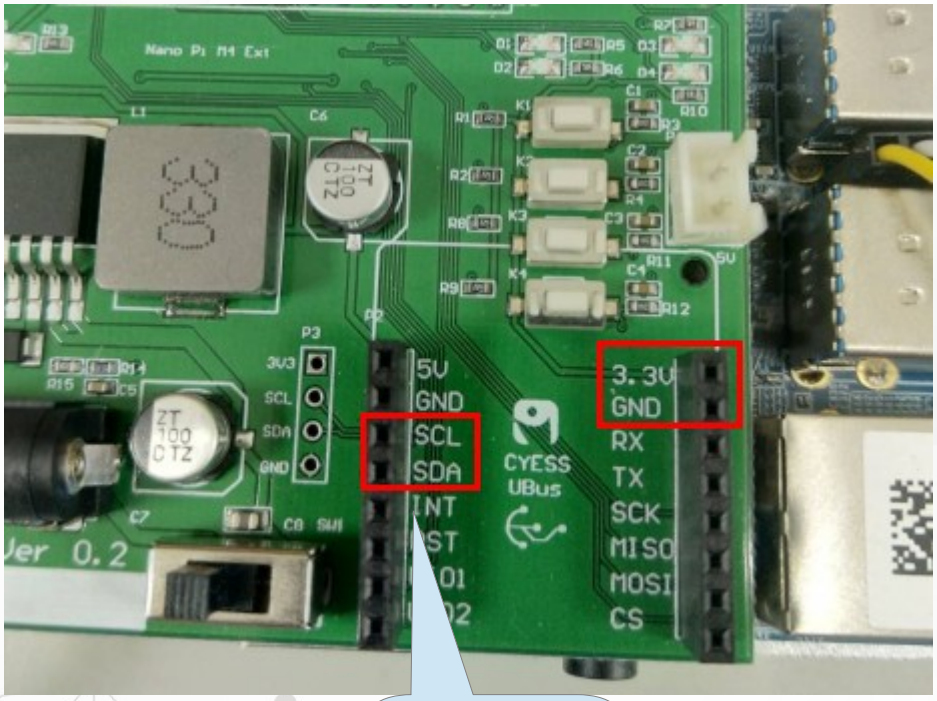
Hold master communication sequence



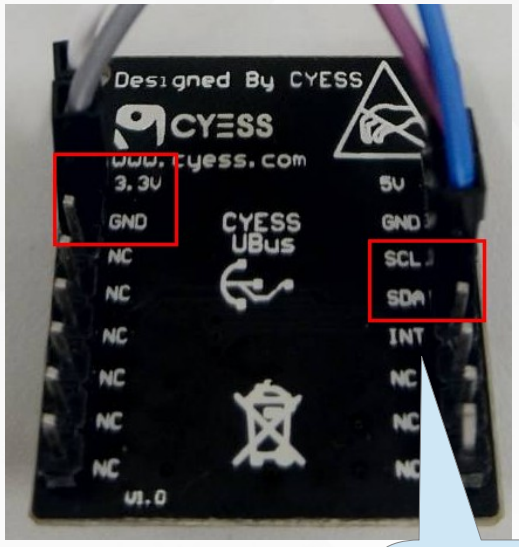
No Hold master communication sequence



SHT21



I2C



I2C

SHT21

Hwmon Sysfs

```
# ls /sys/class/hwmon/hwmon0
device           name   subsystem    uevent
humidity1_input  power  temp1_input
```

temperature

```
# cat /sys/class/hwmon/hwmon0/temp1_input
32279
```

humidity

```
# cat /sys/class/hwmon/hwmon0/humidity1_input
34512
```

IIO Subsystem

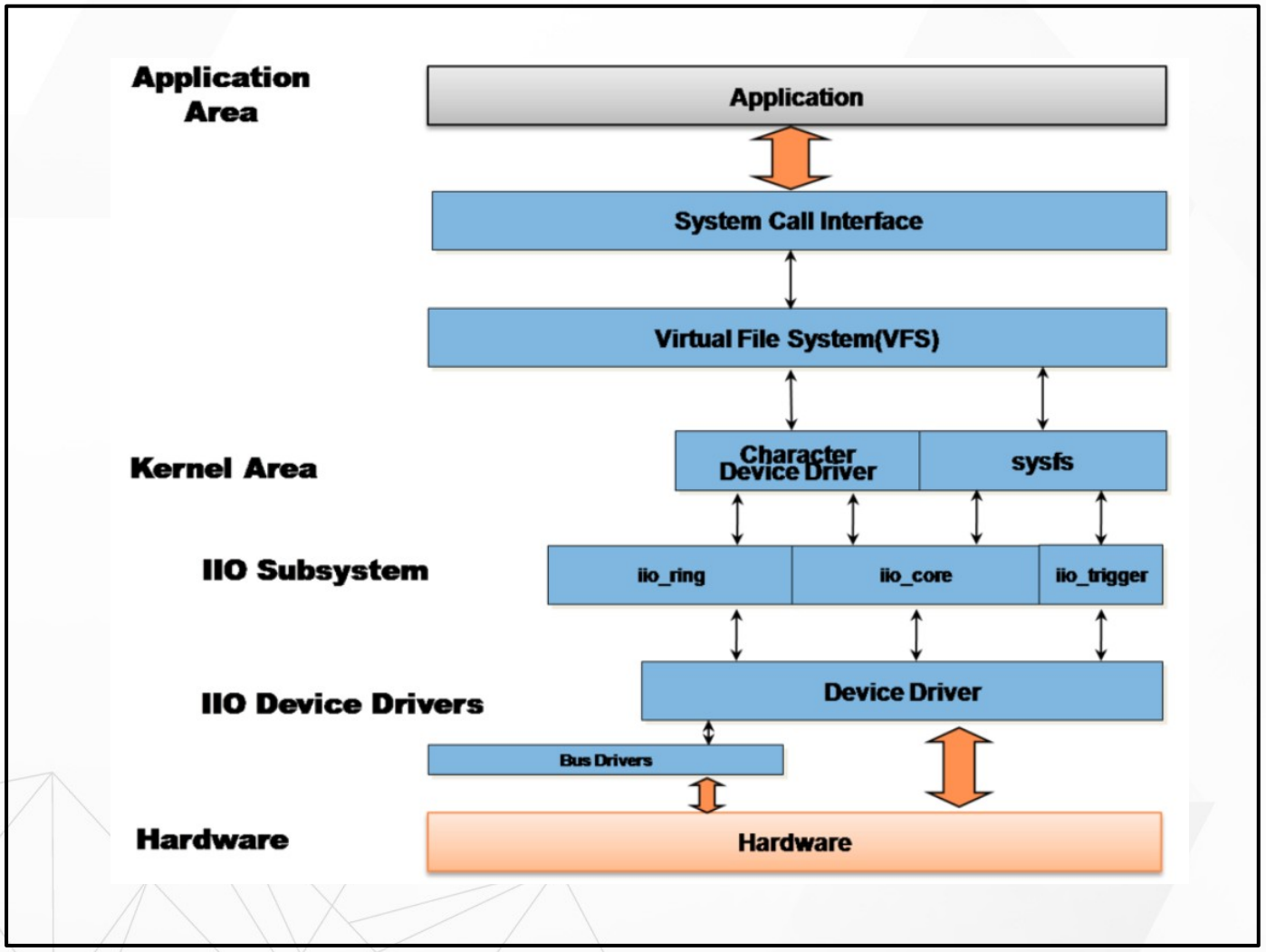
IIO Introduction

- IIO - The Industrial I/O
- support for devices that in some sense
  - analog to digital (ADC)
  - digital to analog converters (DAC)
- Devices that fall into this category are
  - ADCs
  - Accelerometers
  - Gyros
  - DAC
  - Pressure Sensors

IIO Introduction

- Fill the gap between the somewhat similar hwmon and input subsystems
- Hwmon is very much directed at low sample rate sensors used in applications
  - fan speed control
  - temperature measurement.
- Input is, as it's name suggests focused on human interaction input devices

IIO Introduction



IIO Interface

- There are 2 ways for a user space application to interact with an IIO driver
- **/sys/bus/iio/iio:deviceX/**
  - data channels
- **/dev/iio:deviceX**
  - buffered data transfer
  - events information

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