



## PWM overview



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# PWM overview

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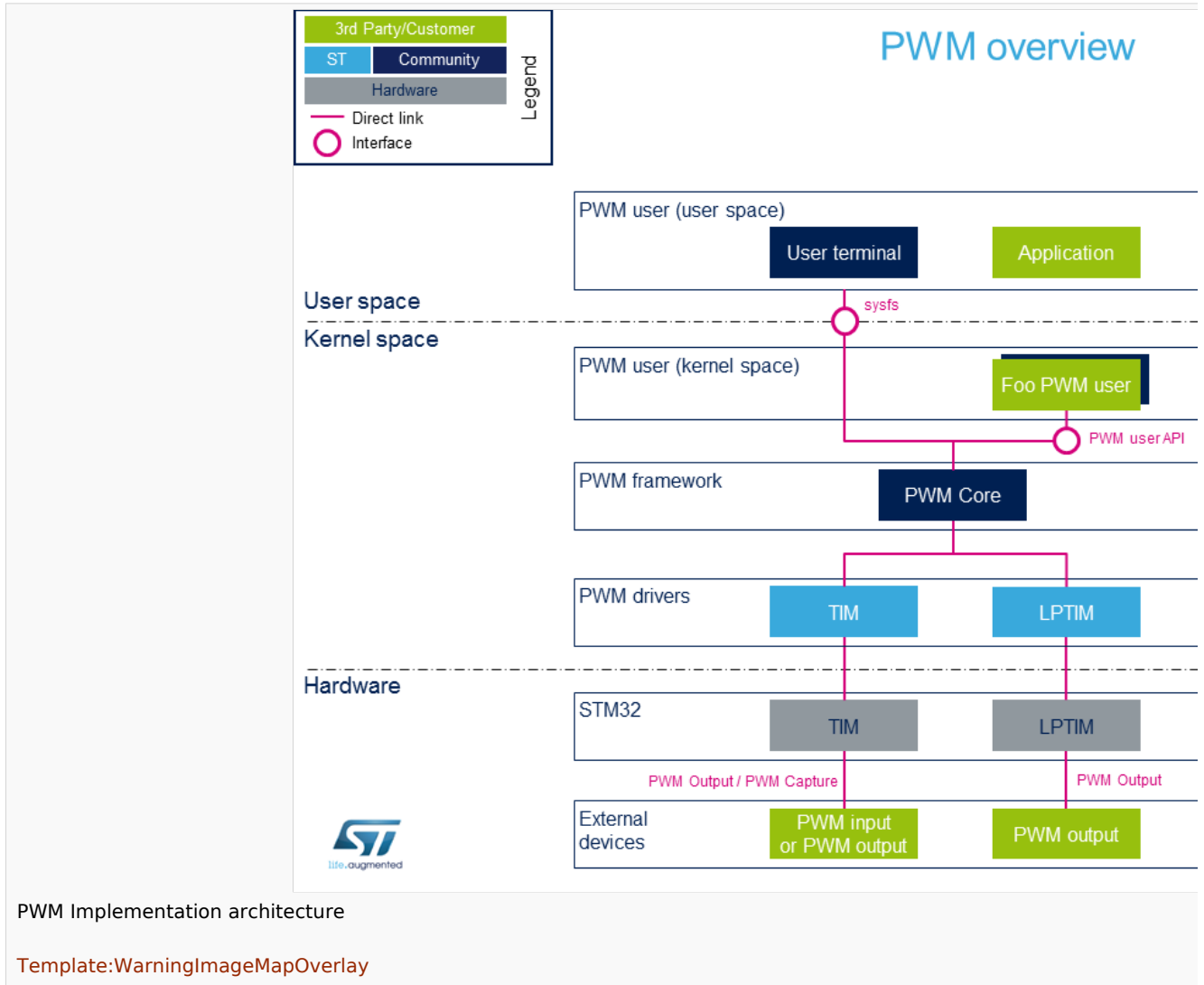
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## 1 Article purpose

The purpose of this article is the following:

- introduce PWM (pulse width modulation) Linux<sup>®</sup> Framework
- provide general information of PWM
- describe the main components and stakeholders
- give examples of PWM usage:
  - user space (sysfs) usage
  - kernel space (API) usage

## 2 PWM overview



### 2.1 Component description

- **PWM user** (User space)

The user can use PWM sysfs interface, from a user terminal or a custom application, to control PWM device(s) from user space.

- **PWM user** (Kernel space)

User drivers can use PWM API to control PWM external device(s) from kernel space (such as back-light, vibrator, LED or fan drivers).

- **PWM framework** (Kernel space)



The PWM core provides sysfs interface and PWM API. They can be used to implement PWM user and PWM controller drivers.

- **PWM drivers** (Kernel space)

Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

## 2.2 API description

Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
- **pwm\_init\_state()**, **pwm\_get\_state()**, **pwm\_apply\_state()**: this API is used to initialize, retrieve and apply the current PWM device state.
- **pwm\_config()**: this API updates the PWM device configuration (period and duty cycle).
- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

## 3 PWM configuration

### 3.1 Kernel configuration

Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

### 3.2 Device tree configuration

- PWM generic DT bindings:



[PWM DT bindings documentation](#)<sup>[5]</sup> describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

- Detailed DT configuration for STM32 internal peripherals:

[TIM device tree configuration](#) and/or [LPTIM device tree configuration](#)

## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device export npwm power pwm0 subsystem uevent unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 60000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```



## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
- pwm-vibrator: *drivers/input/misc/pwm-vibra.c*<sup>[7]</sup> driver, [Documentation/devicetree/bindings/input/pwm-vibrator.txt](#) DT binding documentation.

## 5 How to trace and debug the framework

### 5.1 How to monitor with debugfs

PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
$ cat pwm
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devices # <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
pwm-2 ((null) ): period: 0 ns duty: 0 ns polarity:
normal # <-- Other channels aren't used currently
pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
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## 6 References

- 1.01.1 TIM internal peripheral
- LPTIM internal peripheral
- Documentation/pwm.txt, Linux PWM interface overview
- Documentation/ABI/testing/sysfs-class-pwm, Linux PWM Application binary interface
- Documentation/devicetree/bindings/pwm/pwm.txt, PWM DT bindings documentation
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Pulse Width Modulation

System File System (See <https://en.wikipedia.org/wiki/Sysfs> for more details)

Application programming interface

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low-power timer (STM32 specific)

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Debug File System (See <https://en.wikipedia.org/wiki/Debugfs> for more details)

## PWM overview

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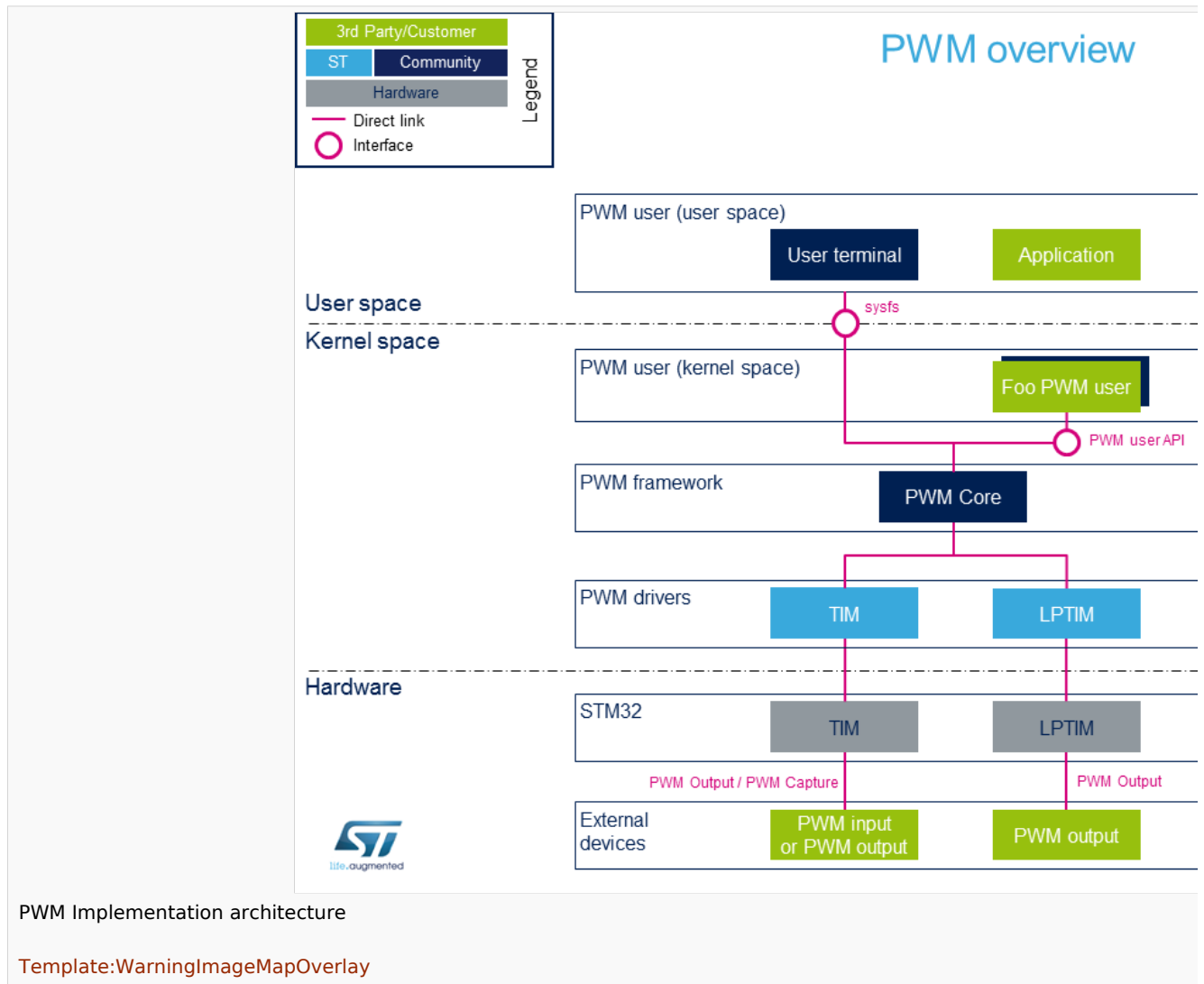
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Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

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Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

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- **pwm\_config()**: this API updates the PWM device configuration (period and duty cycle).
- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

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```
Device Drivers --->
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```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

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- PWM generic DT bindings:



[PWM DT bindings documentation<sup>\[5\]</sup>](#) describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

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```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm  power  pwm0  subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```



## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
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```
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pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
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## PWM overview

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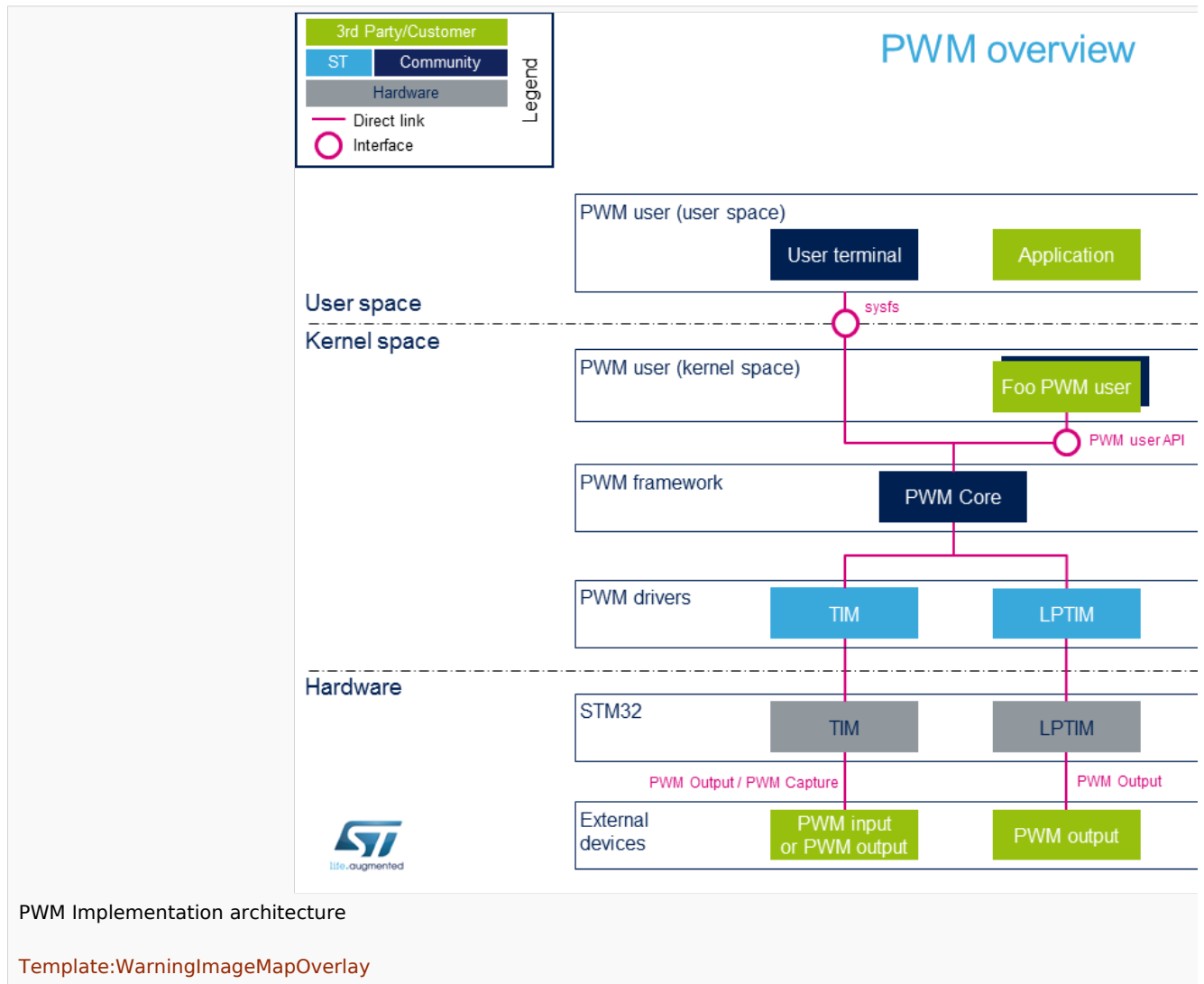
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Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

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Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

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- ...

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Device Drivers --->
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As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device export npwm power pwm0 subsystem uevent unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
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$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```



## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

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10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
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## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

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PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
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devices # <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
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normal <-- Other channels aren't used currently
pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
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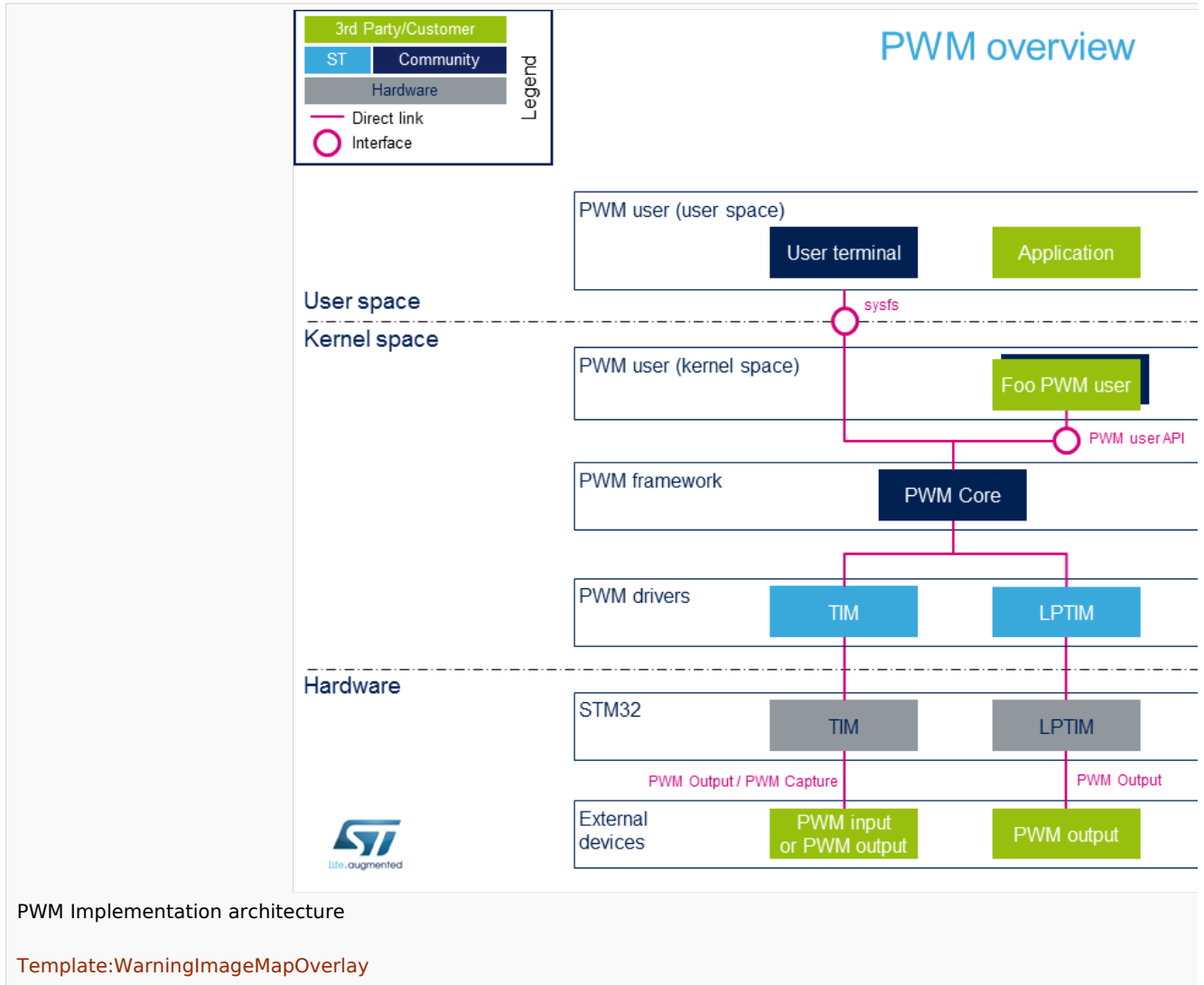
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### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
- **pwm\_init\_state()**, **pwm\_get\_state()**, **pwm\_apply\_state()**: this API is used to initialize, retrieve and apply the current PWM device state.
- **pwm\_config()**: this API updates the PWM device configuration (period and duty cycle).
- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

## 3 PWM configuration

### 3.1 Kernel configuration

Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

### 3.2 Device tree configuration

- PWM generic DT bindings:



[PWM DT bindings documentation](#)<sup>[5]</sup> describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

- Detailed DT configuration for STM32 internal peripherals:

[TIM device tree configuration](#) and/or [LPTIM device tree configuration](#)

## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm  power  pwm0  subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```





## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
- pwm-vibrator: *drivers/input/misc/pwm-vibra.c*<sup>[7]</sup> driver, [Documentation/devicetree/bindings/input/pwm-vibrator.txt](#) DT binding documentation.

## 5 How to trace and debug the framework

### 5.1 How to monitor with debugfs

PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
$ cat pwm
platform/44000000.timer:pwm, 4 PWM
devices # <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
pwm-2 ((null) ): period: 0 ns duty: 0 ns polarity:
normal <-- Other channels aren't used currently
pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
```



## 6 References

- 1.01.1 TIM internal peripheral
- LPTIM internal peripheral
- Documentation/pwm.txt, Linux PWM interface overview
- Documentation/ABI/testing/sysfs-class-pwm, Linux PWM Application binary interface
- Documentation/devicetree/bindings/pwm/pwm.txt, PWM DT bindings documentation
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Pulse Width Modulation

System File System (See <https://en.wikipedia.org/wiki/Sysfs> for more details)

Application programming interface

Light-emitting diode

low-power timer (STM32 specific)

Application binary interface. ( In computer software, an application binary interface (ABI) describes the low-level interface between a computer program and the operating system or another program.)

Device Tree

Debug File System (See <https://en.wikipedia.org/wiki/Debugfs> for more details)

## PWM overview

Stable: 06.02.2020 - 15:04 / Revision: 06.02.2020 - 15:02

Template:ArticleMainWriter Template:ArticleApprovedVersion

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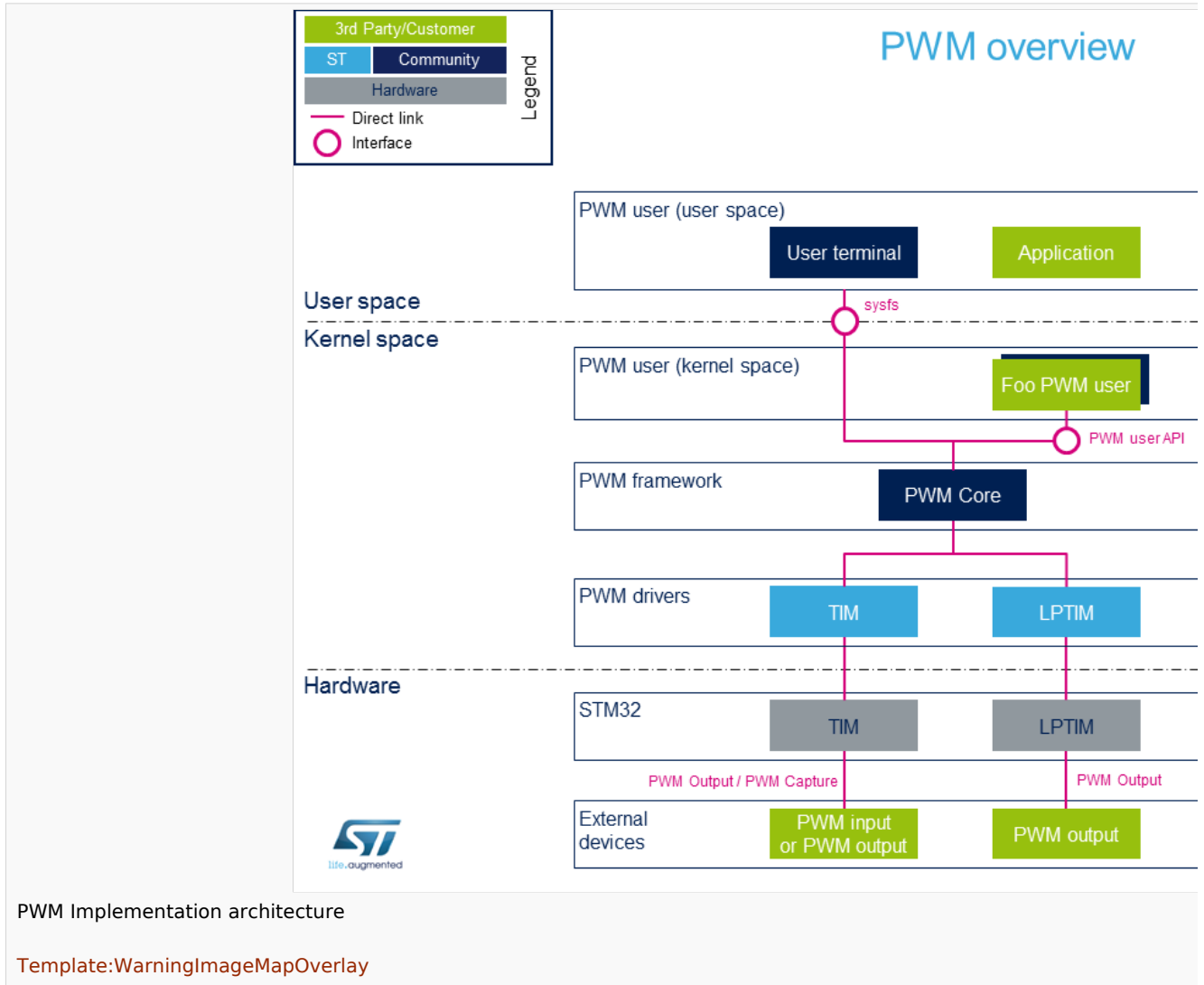
# 1 Article purpose

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The purpose of this article is the following:

- introduce PWM (pulse width modulation) Linux® Framework
- provide general information of PWM
- describe the main components and stakeholders
- give examples of PWM usage:
  - user space (sysfs) usage
  - kernel space (API) usage

## 2 PWM overview



### 2.1 Component description

- **PWM user** (User space)

The user can use PWM sysfs interface, from a user terminal or a custom application, to control PWM device(s) from user space.

- **PWM user** (Kernel space)

User drivers can use PWM API to control PWM external device(s) from kernel space (such as back-light, vibrator, LED or fan drivers).

- **PWM framework** (Kernel space)



The PWM core provides sysfs interface and PWM API. They can be used to implement PWM user and PWM controller drivers.

- **PWM drivers** (Kernel space)

Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

## 2.2 API description

Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
- **pwm\_init\_state()**, **pwm\_get\_state()**, **pwm\_apply\_state()**: this API is used to initialize, retrieve and apply the current PWM device state.
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- ...

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In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

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Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

### 3.2 Device tree configuration

- PWM generic DT bindings:



[PWM DT bindings documentation<sup>\[5\]</sup>](#) describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

- Detailed DT configuration for STM32 internal peripherals:

[TIM device tree configuration](#) and/or [LPTIM device tree configuration](#)

## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm  power  pwm0  subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```

## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002          # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
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## 5.1 How to monitor with debugfs

PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
$ cat pwm
platform/44000000.timer:pwm, 4 PWM
devices                                     <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
pwm-2 ((null) ): period: 0 ns duty: 0 ns polarity:
normal <-- Other channels aren't used currently
pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
```



## 6 References

- 1.01.1 TIM internal peripheral
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Pulse Width Modulation

System File System (See <https://en.wikipedia.org/wiki/Sysfs> for more details)

Application programming interface

Light-emitting diode

low-power timer (STM32 specific)

Application binary interface. ( In computer software, an application binary interface (ABI) describes the low-level interface between a computer program and the operating system or another program.)

Device Tree

Debug File System (See <https://en.wikipedia.org/wiki/Debugfs> for more details)

## PWM overview

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Template:ArticleMainWriter Template:ArticleApprovedVersion

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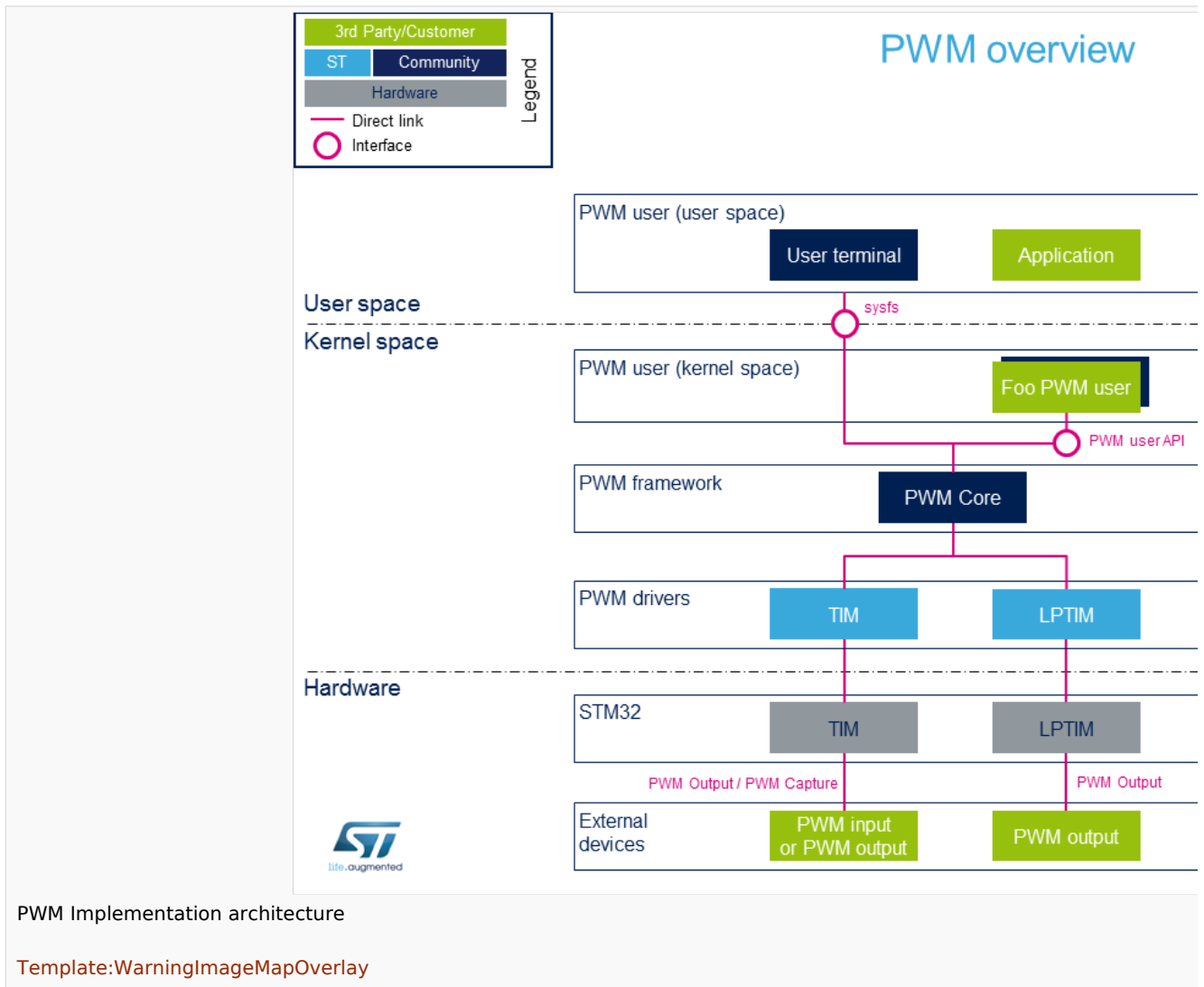
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- give examples of PWM usage:
  - user space (sysfs) usage
  - kernel space (API) usage

## 2 PWM overview



### 2.1 Component description

- **PWM user** (User space)

The user can use PWM sysfs interface, from a user terminal or a custom application, to control PWM device(s) from user space.

- **PWM user** (Kernel space)

User drivers can use PWM API to control PWM external device(s) from kernel space (such as back-light, vibrator, LED or fan drivers).

- **PWM framework** (Kernel space)



The PWM core provides sysfs interface and PWM API. They can be used to implement PWM user and PWM controller drivers.

- **PWM drivers** (Kernel space)

Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

## 2.2 API description

Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
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- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

## 3 PWM configuration

### 3.1 Kernel configuration

Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

### 3.2 Device tree configuration

- PWM generic DT bindings:



[PWM DT bindings documentation](#)<sup>[5]</sup> describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

- Detailed DT configuration for STM32 internal peripherals:

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## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm    power  pwm0    subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```

## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture  duty_cycle  enable  period  polarity  power  uevent

$ cat capture
10000 1002          # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
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PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
$ cat pwm
platform/44000000.timer:pwm, 4 PWM
devices                                     <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
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- 1.01.1 TIM internal peripheral
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Device Tree

Debug File System (See <https://en.wikipedia.org/wiki/Debugfs> for more details)

## PWM overview

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A [quality version](#) of this page, [accepted](#) on 11 February 2019, was based off this revision.

Template:ArticleMainWriter Template:ArticleApprovedVersion

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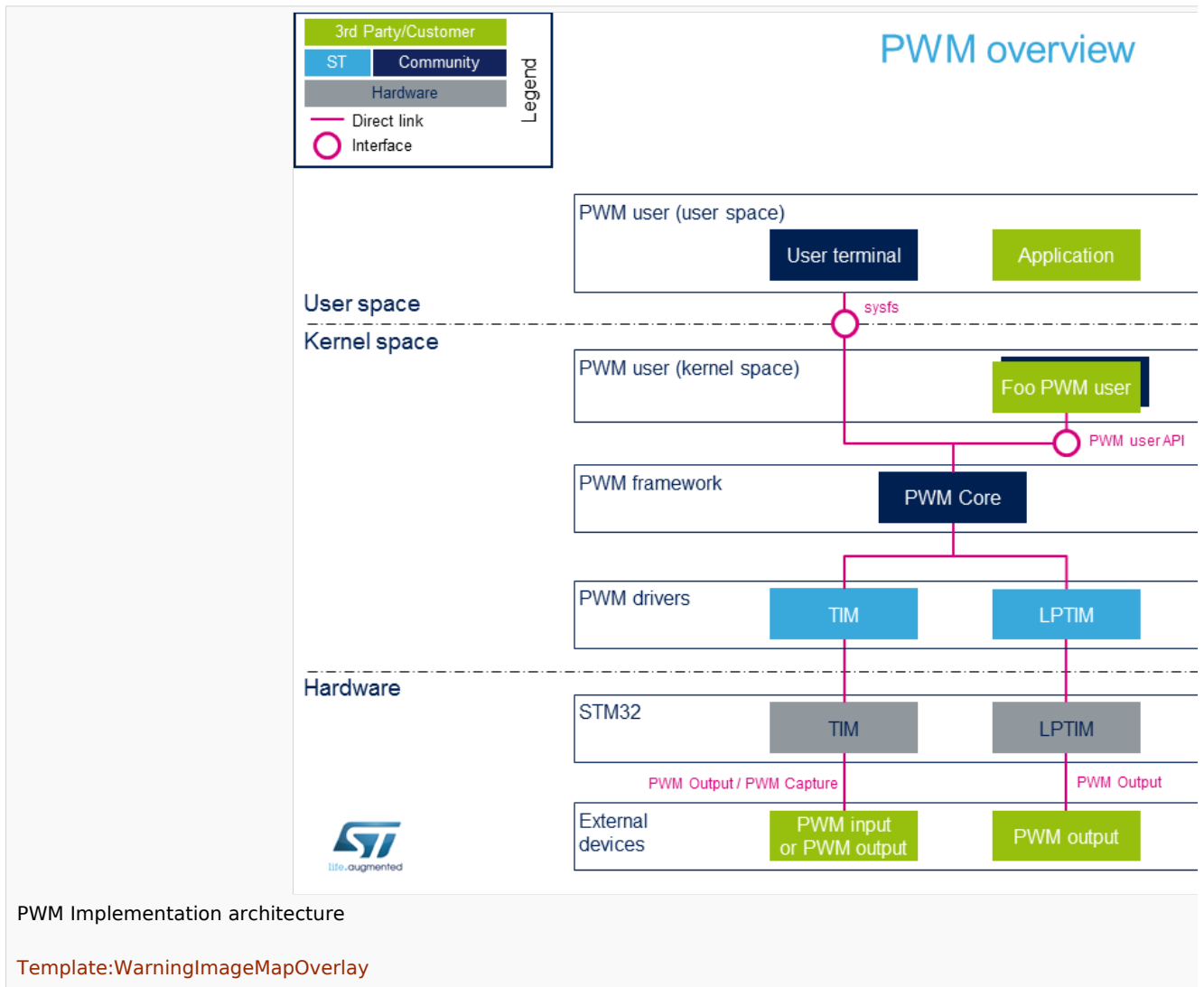
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The number of channels per controller can be read in npwm (read-only)

```
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```
$ echo 0 > export
$ ls
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```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```



## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
- pwm-vibrator: *drivers/input/misc/pwm-vibra.c*<sup>[7]</sup> driver, [Documentation/devicetree/bindings/input/pwm-vibrator.txt](#) DT binding documentation.

## 5 How to trace and debug the framework

### 5.1 How to monitor with debugfs

PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
$ cat pwm
platform/44000000.timer:pwm, 4 PWM
devices # <-- One timer
instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
pwm-2 ((null) ): period: 0 ns duty: 0 ns polarity:
normal <-- Other channels aren't used currently
pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
```



## 6 References

- 1.01.1 TIM internal peripheral
- LPTIM internal peripheral
- Documentation/pwm.txt, Linux PWM interface overview
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Pulse Width Modulation

System File System (See <https://en.wikipedia.org/wiki/Sysfs> for more details)

Application programming interface

Light-emitting diode

low-power timer (STM32 specific)

Application binary interface. ( In computer software, an application binary interface (ABI) describes the low-level interface between a computer program and the operating system or another program.)

Device Tree

Debug File System (See <https://en.wikipedia.org/wiki/Debugfs> for more details)

## PWM overview

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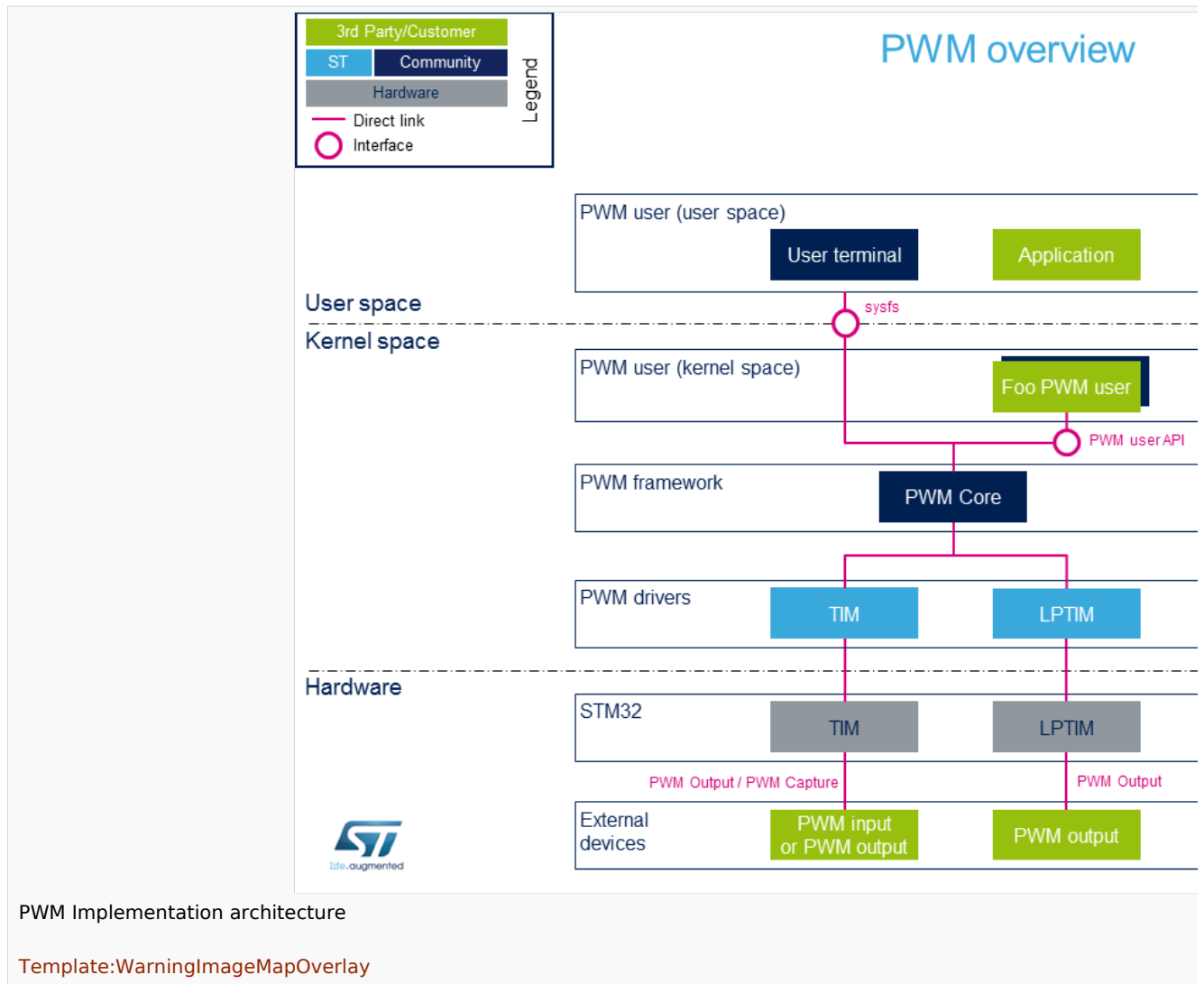
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---

The purpose of this article is the following:

- introduce PWM (pulse width modulation) Linux® Framework
- provide general information of PWM
- describe the main components and stakeholders
- give examples of PWM usage:
  - user space (sysfs) usage
  - kernel space (API) usage

## 2 PWM overview



### 2.1 Component description

- **PWM user** (User space)

The user can use PWM sysfs interface, from a user terminal or a custom application, to control PWM device(s) from user space.

- **PWM user** (Kernel space)

User drivers can use PWM API to control PWM external device(s) from kernel space (such as back-light, vibrator, LED or fan drivers).

- **PWM framework** (Kernel space)



The PWM core provides sysfs interface and PWM API. They can be used to implement PWM user and PWM controller drivers.

- **PWM drivers** (Kernel space)

Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

## 2.2 API description

Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
- **pwm\_init\_state()**, **pwm\_get\_state()**, **pwm\_apply\_state()**: this API is used to initialize, retrieve and apply the current PWM device state.
- **pwm\_config()**: this API updates the PWM device configuration (period and duty cycle).
- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

## 3 PWM configuration

### 3.1 Kernel configuration

Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

### 3.2 Device tree configuration

- PWM generic DT bindings:



[PWM DT bindings documentation](#)<sup>[5]</sup> describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

- Detailed DT configuration for STM32 internal peripherals:

[TIM device tree configuration](#) and/or [LPTIM device tree configuration](#)

## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm  power  pwm0  subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```





## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002 # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
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```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
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instance exposes 4 PWM channels.
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```



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Device Tree

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## PWM overview

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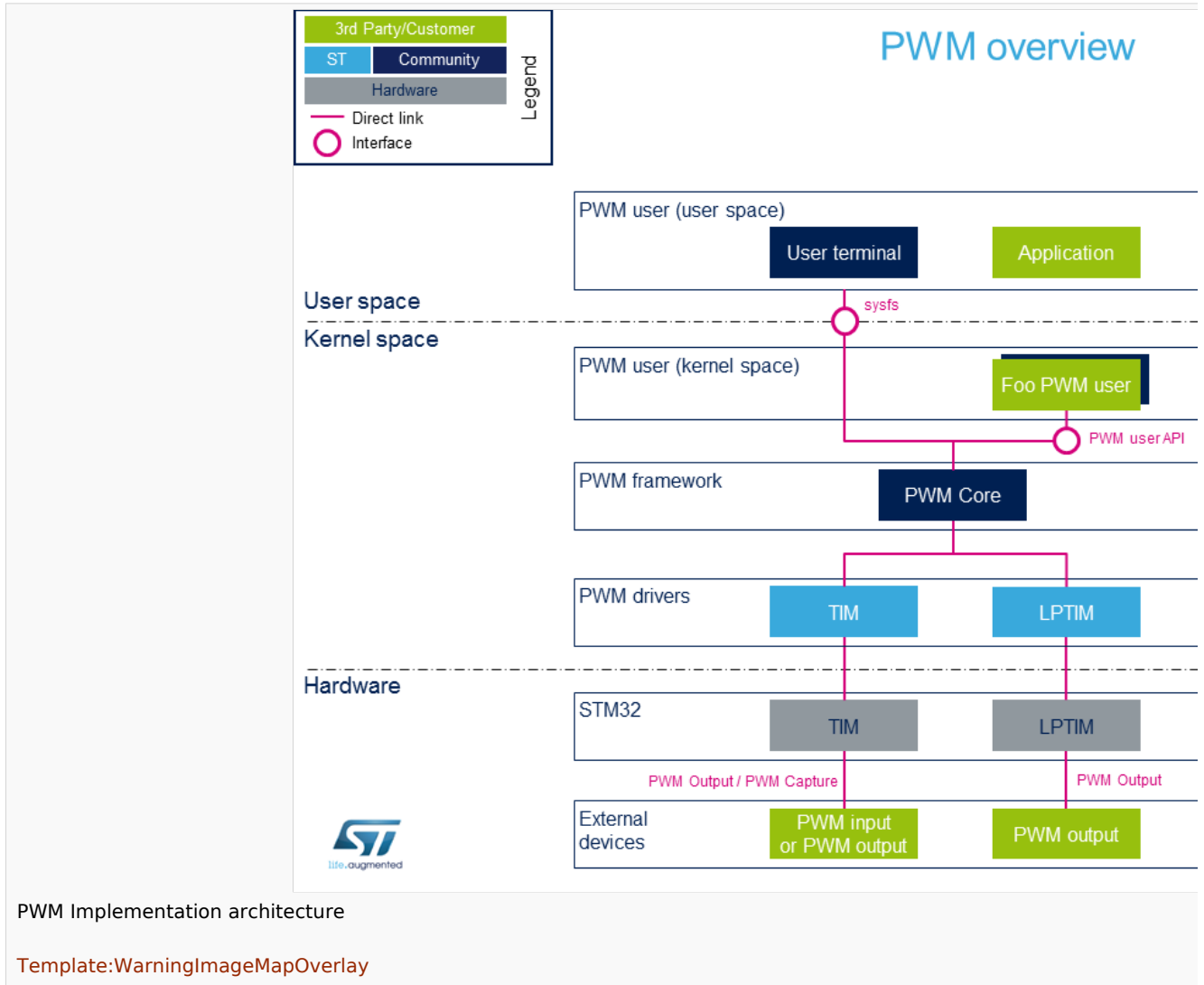
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- describe the main components and stakeholders
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  - kernel space (API) usage

## 2 PWM overview



### 2.1 Component description

- **PWM user** (User space)

The user can use PWM sysfs interface, from a user terminal or a custom application, to control PWM device(s) from user space.

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User drivers can use PWM API to control PWM external device(s) from kernel space (such as back-light, vibrator, LED or fan drivers).

- **PWM framework** (Kernel space)



The PWM core provides sysfs interface and PWM API. They can be used to implement PWM user and PWM controller drivers.

- **PWM drivers** (Kernel space)

Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

- **PWM hardware**

PWM controller(s) such as *TIM internal peripheral*<sup>[1]</sup> and *LPTIM internal peripheral*<sup>[2]</sup> used to drive external PWM controlled devices.

## 2.2 API description

Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

### 2.2.1 Kernel PWM API

The main useful user API are the following:

- **devm\_pwm\_get()** or **pwm\_get()** / **pwm\_put()**: this API is used to look up, request, then free a PWM device.
- **pwm\_init\_state()**, **pwm\_get\_state()**, **pwm\_apply\_state()**: this API is used to initialize, retrieve and apply the current PWM device state.
- **pwm\_config()**: this API updates the PWM device configuration (period and duty cycle).
- ...

### 2.2.2 Sysfs interface

In addition to [Documentation/pwm.txt](#)<sup>[3]</sup> details on ABI are available in [Documentation/ABI/testing/sysfs-class-pwm](#)<sup>[4]</sup>.

## 3 PWM configuration

### 3.1 Kernel configuration

Activate PWM framework in the kernel configuration through the Linux menuconfig tool, [Menuconfig](#) or [how to configure kernel](#) (CONFIG\_PWM=y):

```
Device Drivers --->
[*] Pulse-Width Modulation (PWM) Support --->
```

Activate PWM drivers for STM32 PWM drivers: [STM32 TIM Linux driver](#) and/or [STM32 LPTIM Linux driver](#)

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- PWM generic DT bindings:



[PWM DT bindings documentation](#)<sup>[5]</sup> describes device tree properties related to standard **PWM user nodes** and **PWM controller nodes**.

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## 4 How to use PWM

PWM can be used either from the user or the kernel space.

### 4.1 How to use PWM with sysfs interface

The available PWM controllers are listed in sysfs:

```
$ ls /sys/class/pwm
pwmchip0
```

The number of channels per controller can be read in npwm (read-only)

```
$ cd /sys/class/pwm/pwmchip0
$ cat npwm
4
```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

```
$ echo 0 > export
$ ls
device  export  npwm    power  pwm0    subsystem  uevent  unexport
```

The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

```
$ echo 100000000 > pwm0/period
$ echo 600000000 > pwm0/duty_cycle
$ echo 1 > pwm0/enable
```

The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
$ cat pwm0/polarity
inversed

$ echo "normal" > pwm0/polarity
$ cat pwm0/polarity
normal
```

## 4.2 How to use PWM capture with sysfs interface

PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
$ echo 0 > export

$ cd pwm0
$ ls
capture duty_cycle enable period polarity power uevent

$ cat capture
10000 1002          # capture result is in nano-seconds, e.g.: 100KHz, 10% duty
cycle
```

## 4.3 Example of PWM usage with kernel PWM API

Several in-kernel drivers use kernel PWM API. Below a few examples:

- pwm-beeper: *drivers/input/misc/pwm-beeper.c*<sup>[6]</sup> driver, [Documentation/devicetree/bindings/input/pwm-beeper.txt](#) DT binding documentation.
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# 5 How to trace and debug the framework

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PWM usage can be monitored from debugfs 'pwm' entry. For example:

```
$ cd /sys/kernel/debug/
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platform/44000000.timer:pwm, 4 PWM
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instance exposes 4 PWM channels.
pwm-0 (sysfs ): requested enabled period: 1000000 ns duty: 500000 ns
polarity: normal <-- Channel 0 has been exported, enabled and configured via sysfs
pwm-1 ((null) ): period: 0 ns duty: 0 ns polarity: normal
pwm-2 ((null) ): period: 0 ns duty: 0 ns polarity:
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pwm-3 ((null) ): period: 0 ns duty: 0 ns polarity: normal
```



## 6 References

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Device Tree

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## PWM overview

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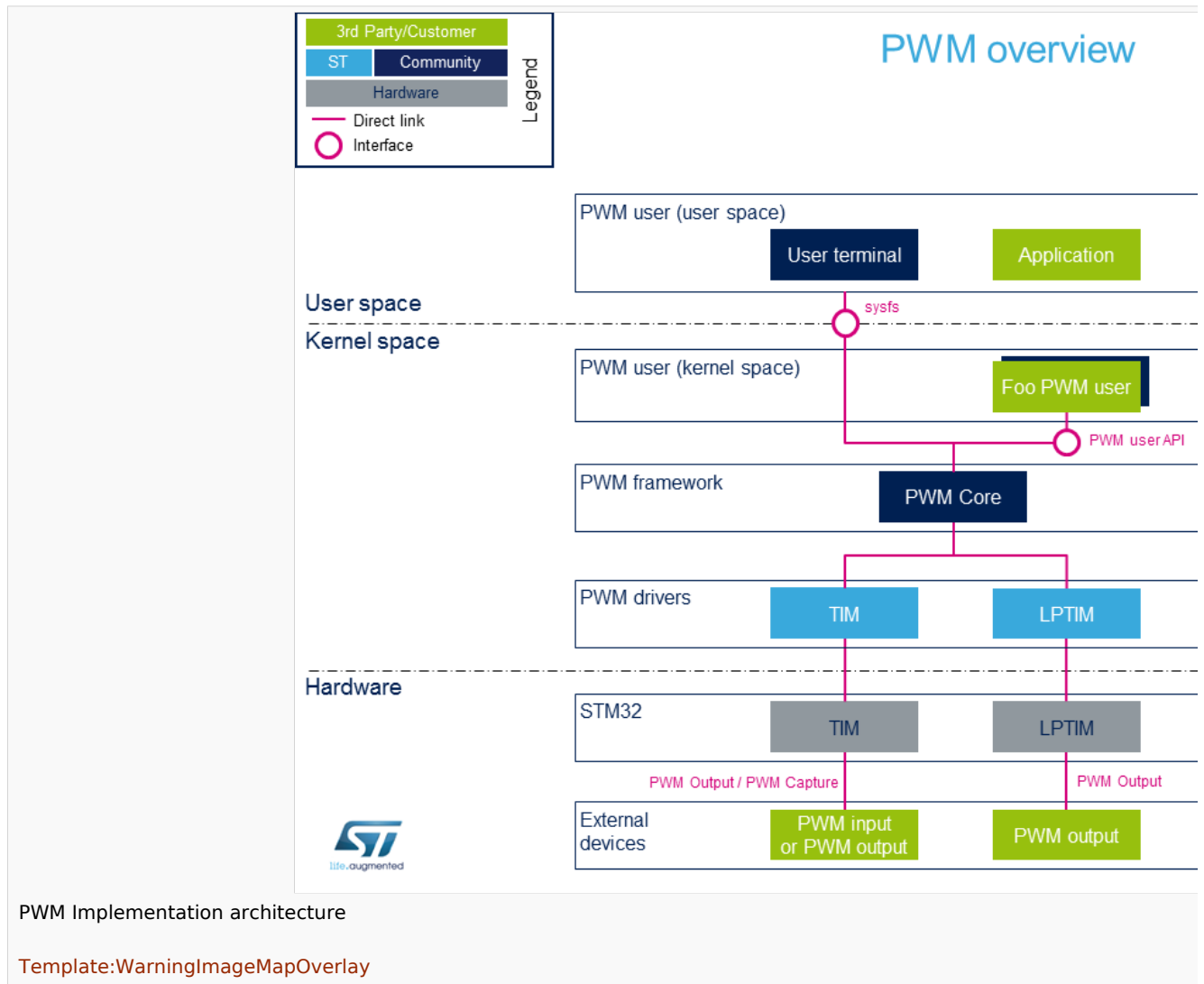
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Provider drivers such as [STM32 TIM Linux driver](#) and [STM32 LPTIM Linux driver](#) that expose PWM controller(s) to the core.

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Documentation on PWM interface can be found under kernel [Documentation/pwm.txt](#)

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- ...

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[*] Pulse-Width Modulation (PWM) Support --->
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```
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The number of channels per controller can be read in npwm (read-only)

```
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$ cat npwm
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```

Each channel is exported (requested for sysfs activation) by writing the corresponding number in 'export'.

As an example, proceed as follows to export the first channel (e.g. channel 0):

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$ echo 0 > export
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The period and duty cycle must be configured before enabling any channel.

As an example, proceed as follows to set a period of 100 ms with a duty cycle of 60% on channel 0:

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The polarity can be inverted or set to normal by using the polarity entry:

```
$ echo "inversed" > pwm0/polarity
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PWM capture is available on some PWM controllers such as *TIM internal peripheral*<sup>[1]</sup> (see TIM configured in PWM input capture mode).

```
# First export a channel (e.g. 0), then capture PWM input on it:
$ cd /sys/class/pwm/pwmchip0
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Several in-kernel drivers use kernel PWM API. Below a few examples:

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PWM usage can be monitored from debugfs 'pwm' entry. For example:

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---

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