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## GPIOLib overview



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## Contents

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1. GPIOLib overview .....	42
2. Debugfs .....	12
3. GPIO device tree configuration .....	22
4. GPIO internal peripheral .....	32
5. How to control a GPIO in kernel space .....	52
6. How to control a GPIO in userspace .....	62
7. How to use the kernel dynamic debug .....	72
8. Overview of GPIO pins .....	82
9. Pinctrl overview .....	92
10. STM32CubeMX .....	102



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## SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	44
2 System overview .....	45
2.1 Component description .....	45
2.2 API description .....	46
3 Configuration .....	47
3.1 Kernel configuration .....	47
3.2 Device tree configuration .....	47
4 How to use framework .....	48
4.1 How to configure a new board .....	48
4.2 How to toggle a GPIO in user space .....	48
4.3 How to toggle a GPIO in kernel space .....	48
4.4 Tools .....	48
5 How to trace and debug the framework .....	49
5.1 How to monitor .....	49
5.1.1 How to monitor with debugfs .....	49
5.1.2 Other ways to monitor .....	49
5.2 How to trace .....	49
6 Source code location .....	50
7 To go further .....	51
8 References .....	52



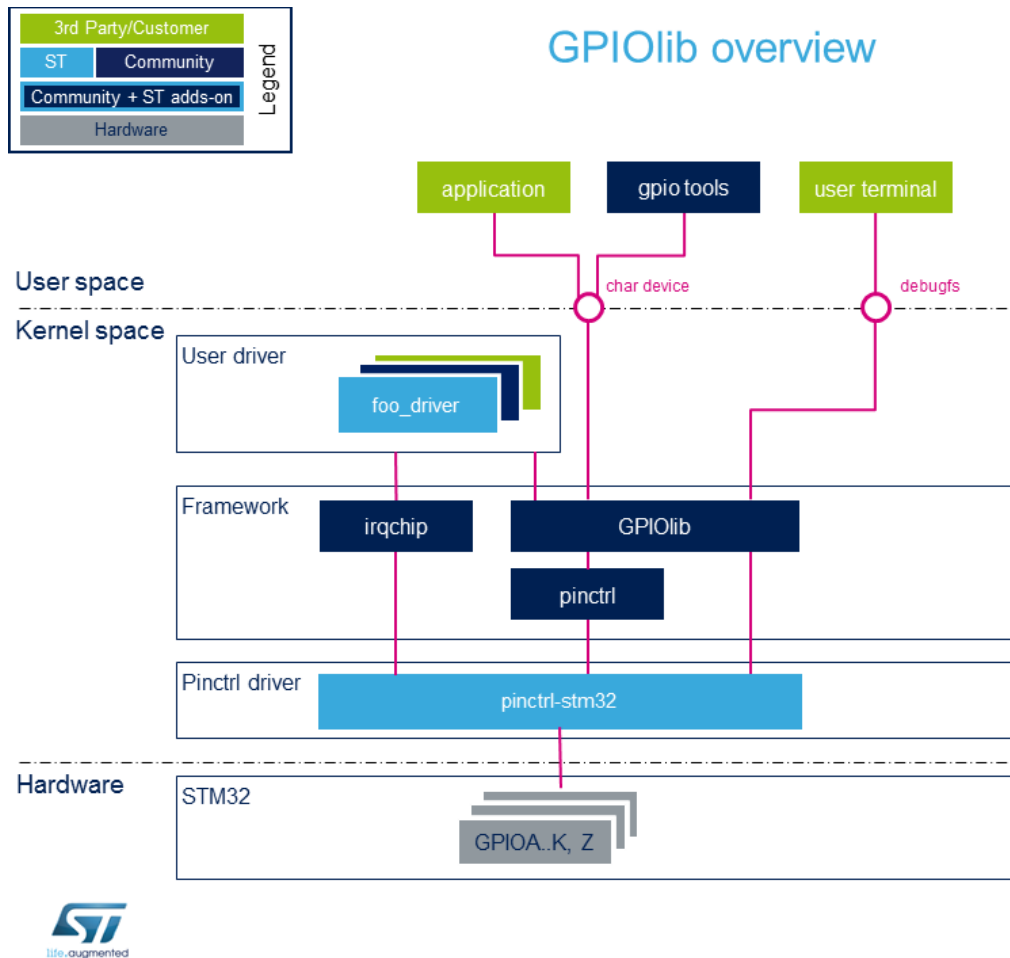
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## 1 Framework purpose

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As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
  - Refer to [GNU documentation](#) for file manipulation.
  - See example [How to control a GPIO in userspace](#)
- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt"<sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt"<sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



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## 3 Configuration

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### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



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## 4 How to use framework

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### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)





## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

### 5.2 How to trace

By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
Board $> dmesg -n8
Board $> echo "file drivers/pinctrl/* +p" > /sys/kernel/debug/dynamic_debug/control
Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
```



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## 6 Source code location

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The source files are located inside the Linux kernel.

- **GPIOLib:** `gpiolib.c`<sup>[6]</sup> and `gpiolib-of.c`<sup>[7]</sup>
- **GPIO tools:** folder `tools/gpio` in Kernel<sup>[8]</sup>
- **Pinctrl core part:** generic core<sup>[9]</sup>, generic `pinconf`<sup>[10]</sup> and generic `pinmux`<sup>[11]</sup>
- **STM32 pinctrl vendor part:** folder to STM32 dedicated pinctrl functions<sup>[12]</sup>



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## 7 To go further

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GPIOLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



## 8 References

- Kernel documentation - gpio.txt, GPIO Kernel documentation
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Application programming interface

foo\_driver could be any driver that needs to control a GPIO

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

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### Contents

1 Framework purpose .....	14
2 System overview .....	15
2.1 Component description .....	15
2.2 API description .....	16
3 Configuration .....	17
3.1 Kernel configuration .....	17
3.2 Device tree configuration .....	17
4 How to use framework .....	18
4.1 How to configure a new board .....	18
4.2 How to toggle a GPIO in user space .....	18
4.3 How to toggle a GPIO in kernel space .....	18
4.4 Tools .....	18



---

5 How to trace and debug the framework .....	19
5.1 How to monitor .....	19
5.1.1 How to monitor with debugfs .....	19
5.1.2 Other ways to monitor .....	19
5.2 How to trace .....	19
6 Source code location .....	20
7 To go further .....	21
8 References .....	22



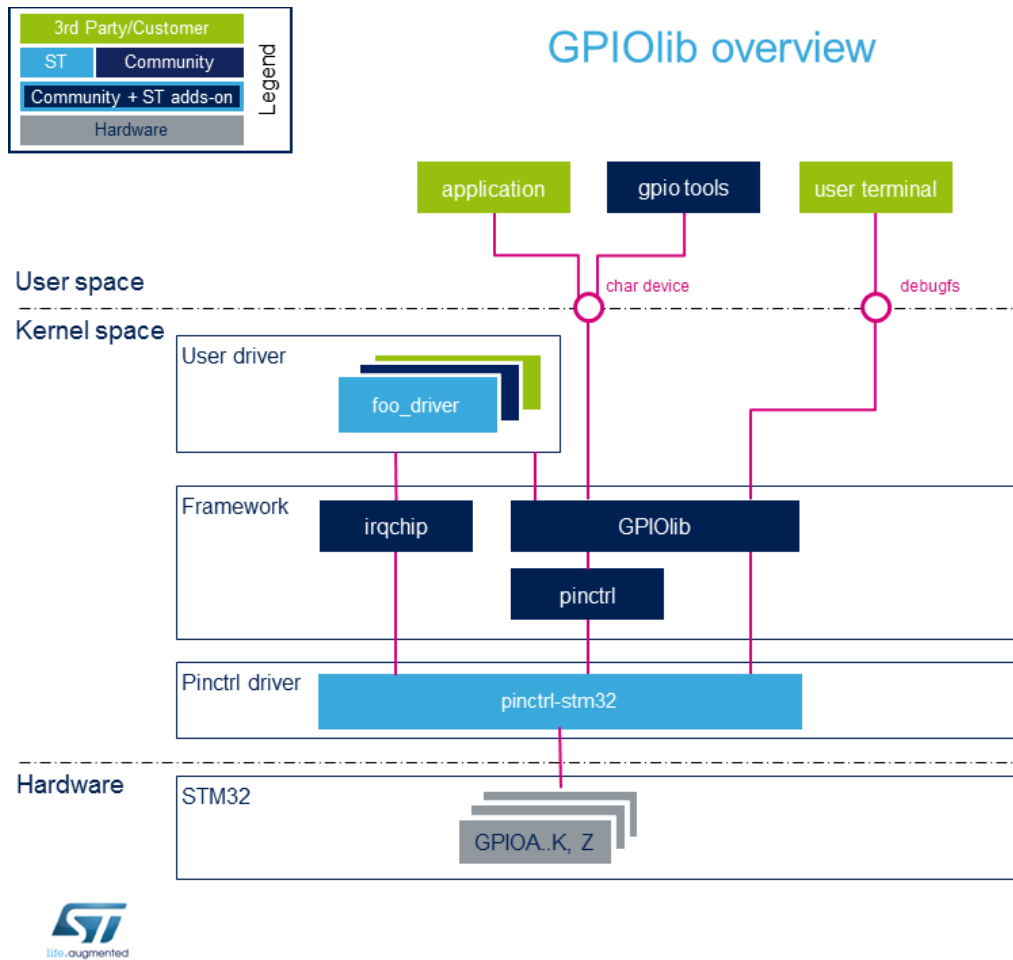
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Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

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  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).





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## 3 Configuration

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### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

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A detailed device tree configuration is described in [GPIO device tree configuration](#).



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## 4 How to use framework

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### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

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[How to control a GPIO in userspace](#)

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## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

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By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

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GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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### Contents

1 Framework purpose .....	24
2 System overview .....	25
2.1 Component description .....	25
2.2 API description .....	26
3 Configuration .....	27
3.1 Kernel configuration .....	27
3.2 Device tree configuration .....	27
4 How to use framework .....	28
4.1 How to configure a new board .....	28
4.2 How to toggle a GPIO in user space .....	28
4.3 How to toggle a GPIO in kernel space .....	28
4.4 Tools .....	28



---

5 How to trace and debug the framework .....	29
5.1 How to monitor .....	29
5.1.1 How to monitor with debugfs .....	29
5.1.2 Other ways to monitor .....	29
5.2 How to trace .....	29
6 Source code location .....	30
7 To go further .....	31
8 References .....	32



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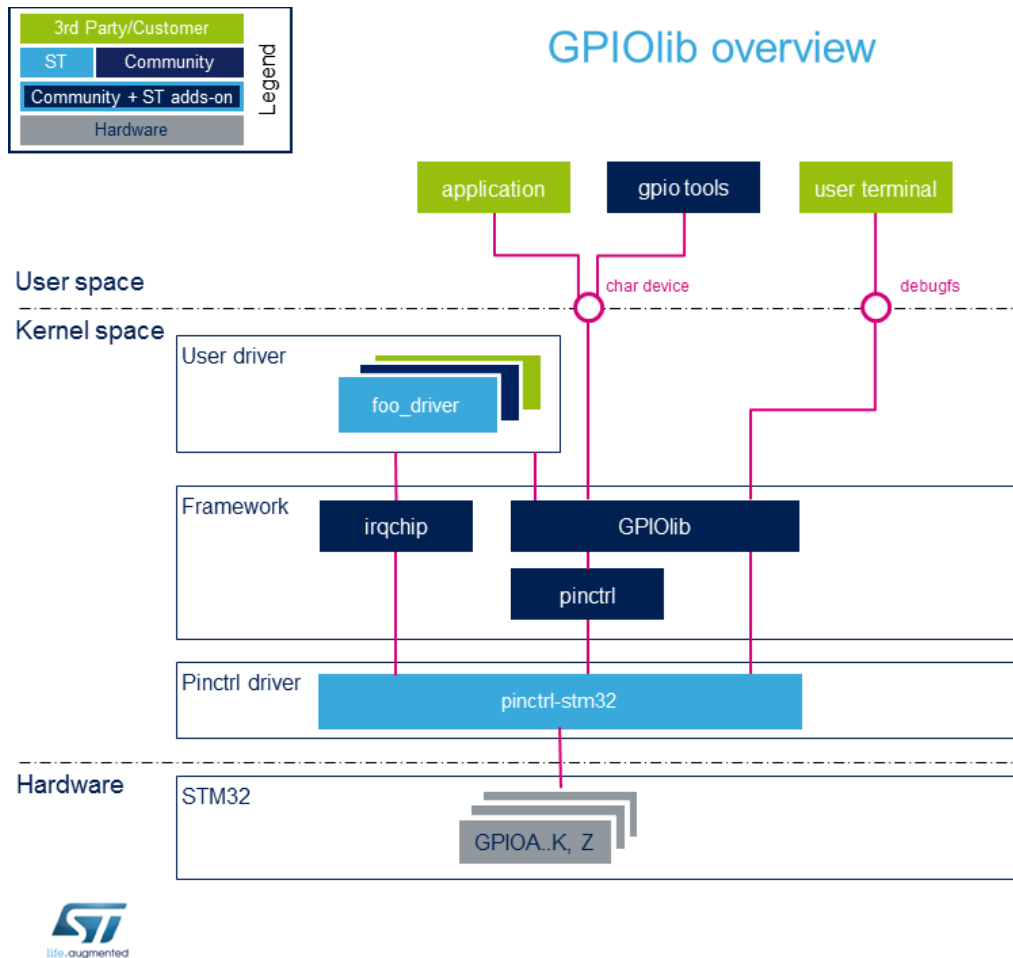
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### Contents

1 Framework purpose .....	34
2 System overview .....	35
2.1 Component description .....	35
2.2 API description .....	36
3 Configuration .....	37
3.1 Kernel configuration .....	37
3.2 Device tree configuration .....	37
4 How to use framework .....	38
4.1 How to configure a new board .....	38
4.2 How to toggle a GPIO in user space .....	38
4.3 How to toggle a GPIO in kernel space .....	38
4.4 Tools .....	38





---

5 How to trace and debug the framework .....	39
5.1 How to monitor .....	39
5.1.1 How to monitor with debugfs .....	39
5.1.2 Other ways to monitor .....	39
5.2 How to trace .....	39
6 Source code location .....	40
7 To go further .....	41
8 References .....	42



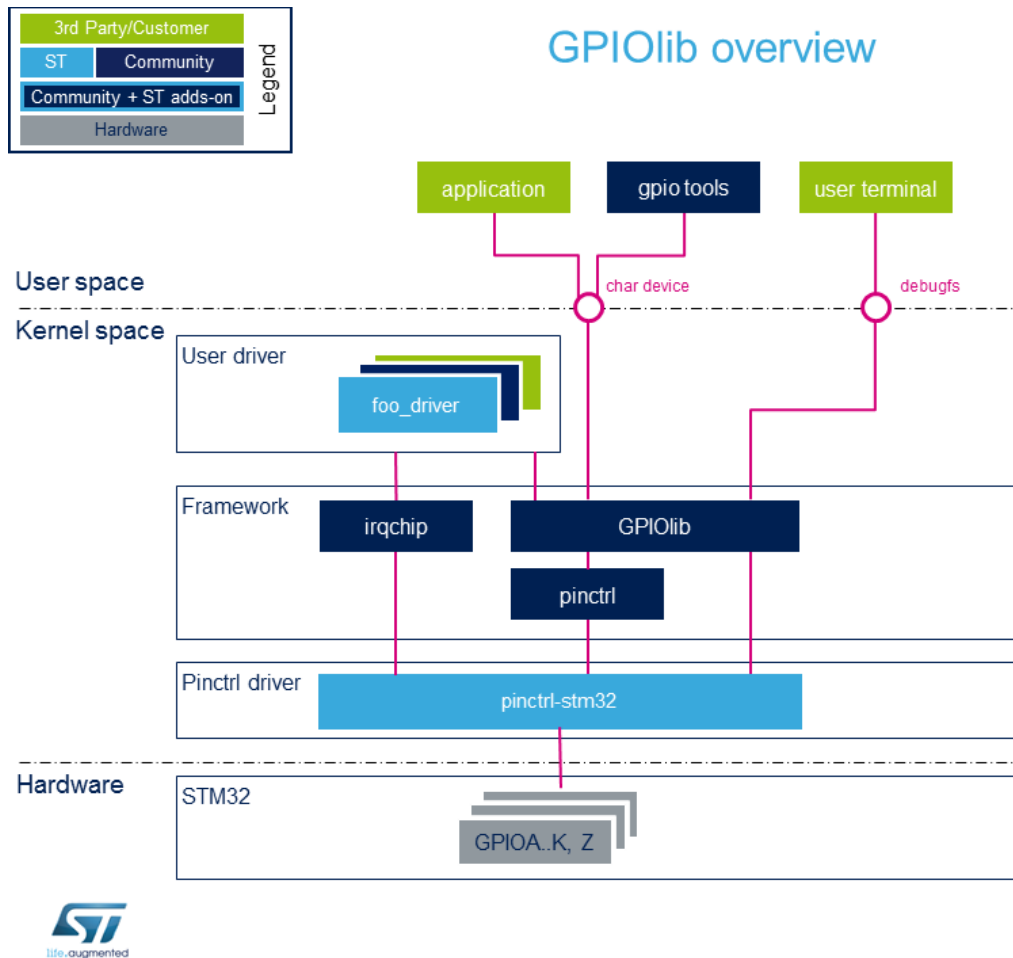
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  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** `foo_driver` could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
  - Refer to [GNU documentation](#) for file manipulation.
  - See example [How to control a GPIO in userspace](#)
- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt"<sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt"<sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)



## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

### 5.2 How to trace

By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
Board $> dmesg -n8
Board $> echo "file drivers/pinctrl/* +p" > /sys/kernel/debug/dynamic_debug/control
Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
```



---

## 6 Source code location

---

The source files are located inside the Linux kernel.

- **GPIOLib:** gpiolib.c<sup>[6]</sup> and gpiolib-of.c<sup>[7]</sup>
- **GPIO tools:** folder tools/gpio in Kernel<sup>[8]</sup>
- **Pinctrl core part:** generic core<sup>[9]</sup>, generic pinconf<sup>[10]</sup> and generic pinmux<sup>[11]</sup>
- **STM32 pinctrl vendor part:** folder to STM32 dedicated pinctrl functions<sup>[12]</sup>





---

## 7 To go further

---

GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



## 8 References

- Kernel documentation - gpio.txt, GPIO Kernel documentation
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Application programming interface

foo\_driver could be any driver that needs to control a GPIO

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

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### SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	44
2 System overview .....	45
2.1 Component description .....	45
2.2 API description .....	46
3 Configuration .....	47
3.1 Kernel configuration .....	47
3.2 Device tree configuration .....	47
4 How to use framework .....	48
4.1 How to configure a new board .....	48
4.2 How to toggle a GPIO in user space .....	48
4.3 How to toggle a GPIO in kernel space .....	48
4.4 Tools .....	48



---

5 How to trace and debug the framework .....	49
5.1 How to monitor .....	49
5.1.1 How to monitor with debugfs .....	49
5.1.2 Other ways to monitor .....	49
5.2 How to trace .....	49
6 Source code location .....	50
7 To go further .....	51
8 References .....	52



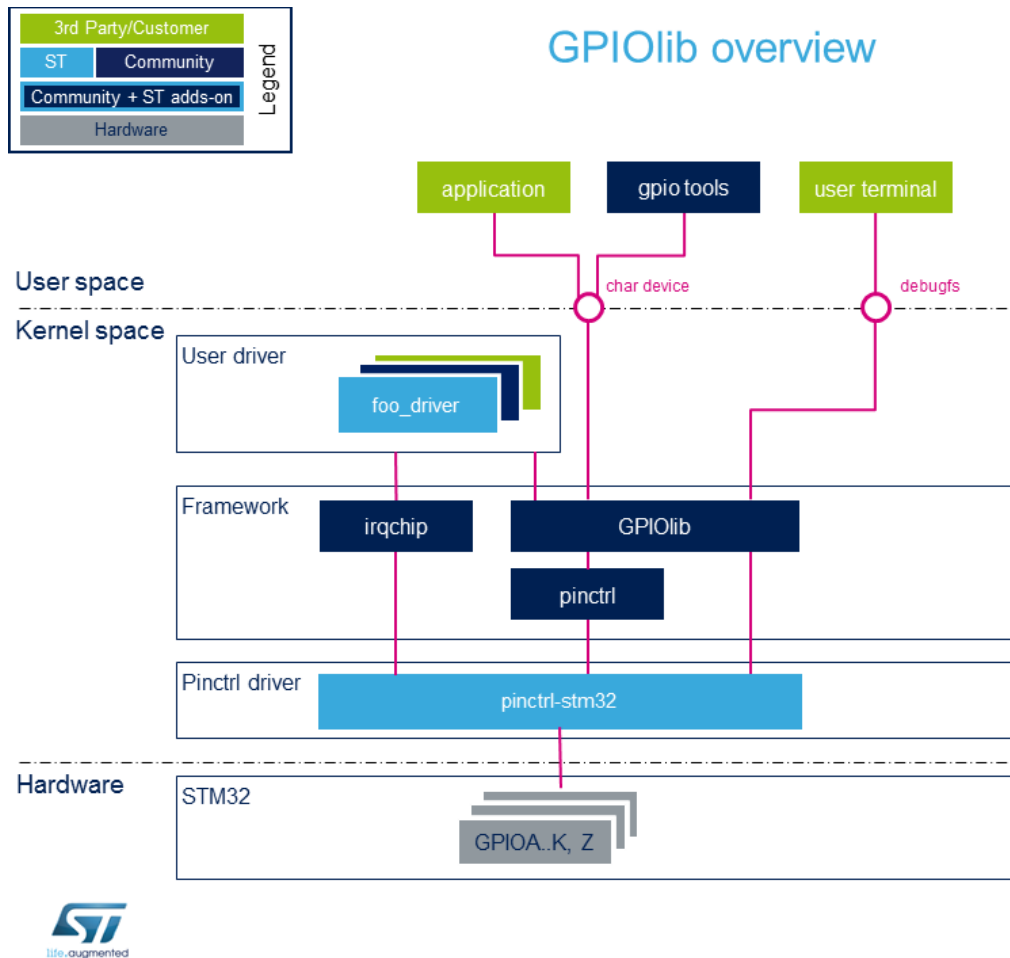
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## 1 Framework purpose

---

As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
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- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
  - Refer to [GNU documentation](#) for file manipulation.
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- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt"<sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt"<sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



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## 3 Configuration

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### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)





## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

### 5.2 How to trace

By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
Board $> dmesg -n8
Board $> echo "file drivers/pinctrl/* +p" > /sys/kernel/debug/dynamic_debug/control
Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
```



---

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---

The source files are located inside the Linux kernel.

- **GPIOLib:** gpiolib.c<sup>[6]</sup> and gpiolib-of.c<sup>[7]</sup>
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- **STM32 pinctrl vendor part:** folder to STM32 dedicated pinctrl functions<sup>[12]</sup>



---

## 7 To go further

---

GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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### SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	54
2 System overview .....	55
2.1 Component description .....	55
2.2 API description .....	56
3 Configuration .....	57
3.1 Kernel configuration .....	57
3.2 Device tree configuration .....	57
4 How to use framework .....	58
4.1 How to configure a new board .....	58
4.2 How to toggle a GPIO in user space .....	58
4.3 How to toggle a GPIO in kernel space .....	58
4.4 Tools .....	58



---

5 How to trace and debug the framework .....	59
5.1 How to monitor .....	59
5.1.1 How to monitor with debugfs .....	59
5.1.2 Other ways to monitor .....	59
5.2 How to trace .....	59
6 Source code location .....	60
7 To go further .....	61
8 References .....	62



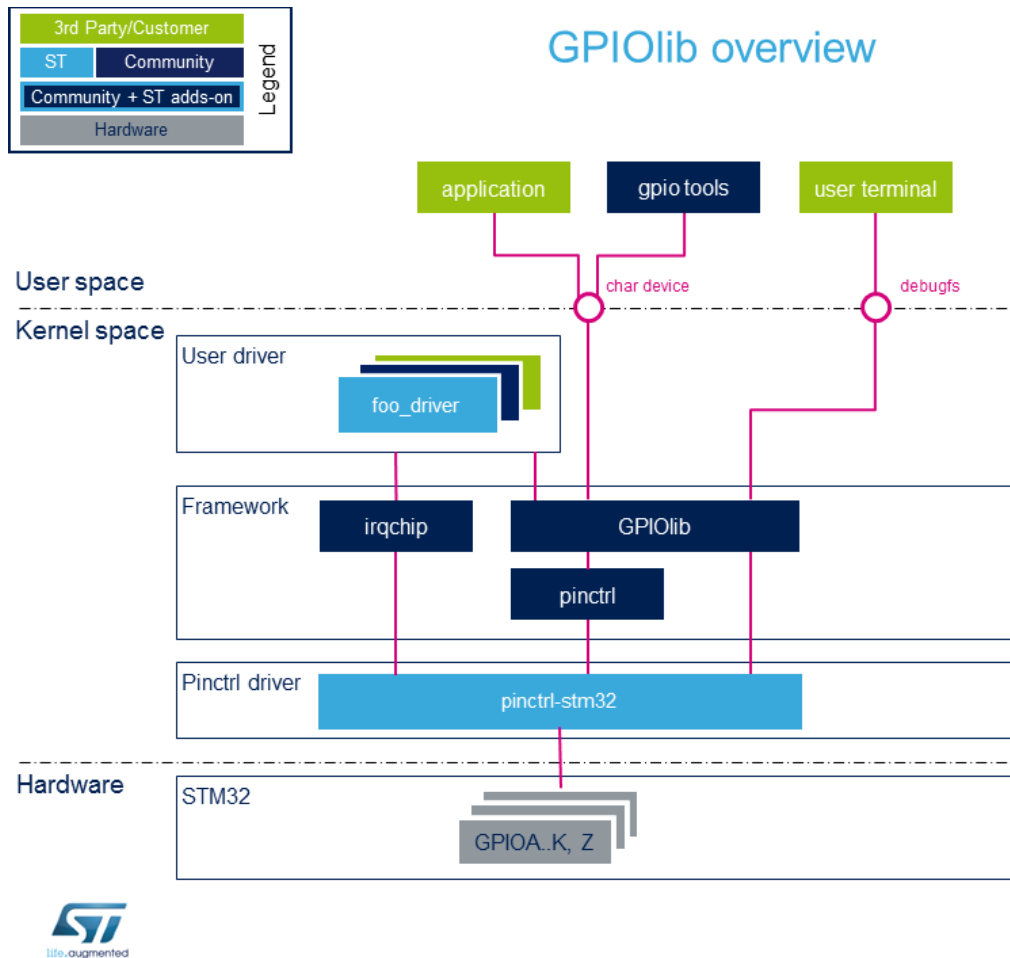
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## 1 Framework purpose

---

As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
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  - See example [How to control a GPIO in userspace](#)
- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt"<sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt"<sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).





---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)



## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
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```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

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You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

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## 7 To go further

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GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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Template:ArticleMainWriter Template:ArticleApprovedVersion

### SUMMARY

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### Contents

1 Framework purpose .....	64
2 System overview .....	65
2.1 Component description .....	65
2.2 API description .....	66
3 Configuration .....	67
3.1 Kernel configuration .....	67
3.2 Device tree configuration .....	67
4 How to use framework .....	68
4.1 How to configure a new board .....	68
4.2 How to toggle a GPIO in user space .....	68
4.3 How to toggle a GPIO in kernel space .....	68
4.4 Tools .....	68



---

5 How to trace and debug the framework .....	69
5.1 How to monitor .....	69
5.1.1 How to monitor with debugfs .....	69
5.1.2 Other ways to monitor .....	69
5.2 How to trace .....	69
6 Source code location .....	70
7 To go further .....	71
8 References .....	72



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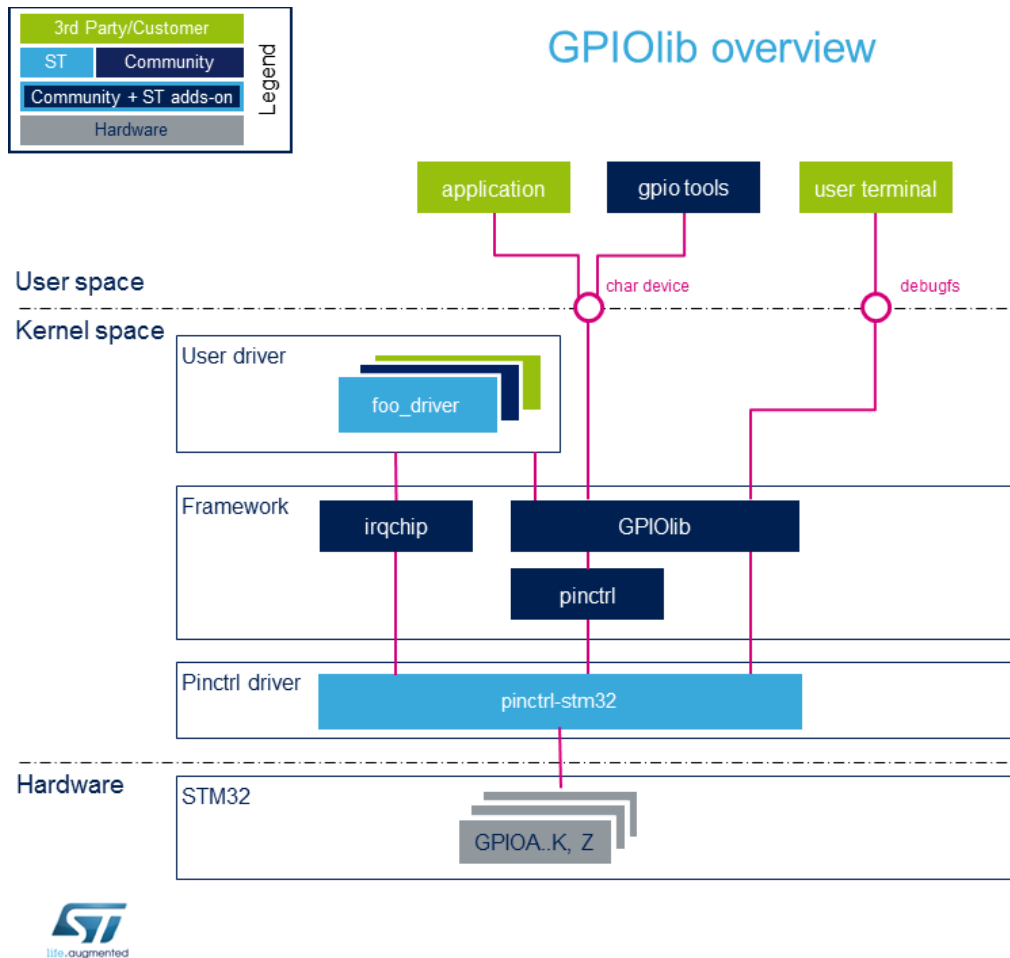
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As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>



## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
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Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

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  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

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### 4.3 How to toggle a GPIO in kernel space

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### 4.4 Tools

[Control GPIO through libgpiod](#)



## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

### 5.2 How to trace

By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
Board $> dmesg -n8
Board $> echo "file drivers/pinctrl/* +p" > /sys/kernel/debug/dynamic_debug/control
Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
```



---

## 6 Source code location

---

The source files are located inside the Linux kernel.

- **GPIOLib:** gpiolib.c<sup>[6]</sup> and gpiolib-of.c<sup>[7]</sup>
- **GPIO tools:** folder tools/gpio in Kernel<sup>[8]</sup>
- **Pinctrl core part:** generic core<sup>[9]</sup>, generic pinconf<sup>[10]</sup> and generic pinmux<sup>[11]</sup>
- **STM32 pinctrl vendor part:** folder to STM32 dedicated pinctrl functions<sup>[12]</sup>



---

## 7 To go further

---

GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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foo\_driver could be any driver that needs to control a GPIO

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

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### SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	74
2 System overview .....	75
2.1 Component description .....	75
2.2 API description .....	76
3 Configuration .....	77
3.1 Kernel configuration .....	77
3.2 Device tree configuration .....	77
4 How to use framework .....	78
4.1 How to configure a new board .....	78
4.2 How to toggle a GPIO in user space .....	78
4.3 How to toggle a GPIO in kernel space .....	78
4.4 Tools .....	78





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5 How to trace and debug the framework .....	79
5.1 How to monitor .....	79
5.1.1 How to monitor with debugfs .....	79
5.1.2 Other ways to monitor .....	79
5.2 How to trace .....	79
6 Source code location .....	80
7 To go further .....	81
8 References .....	82



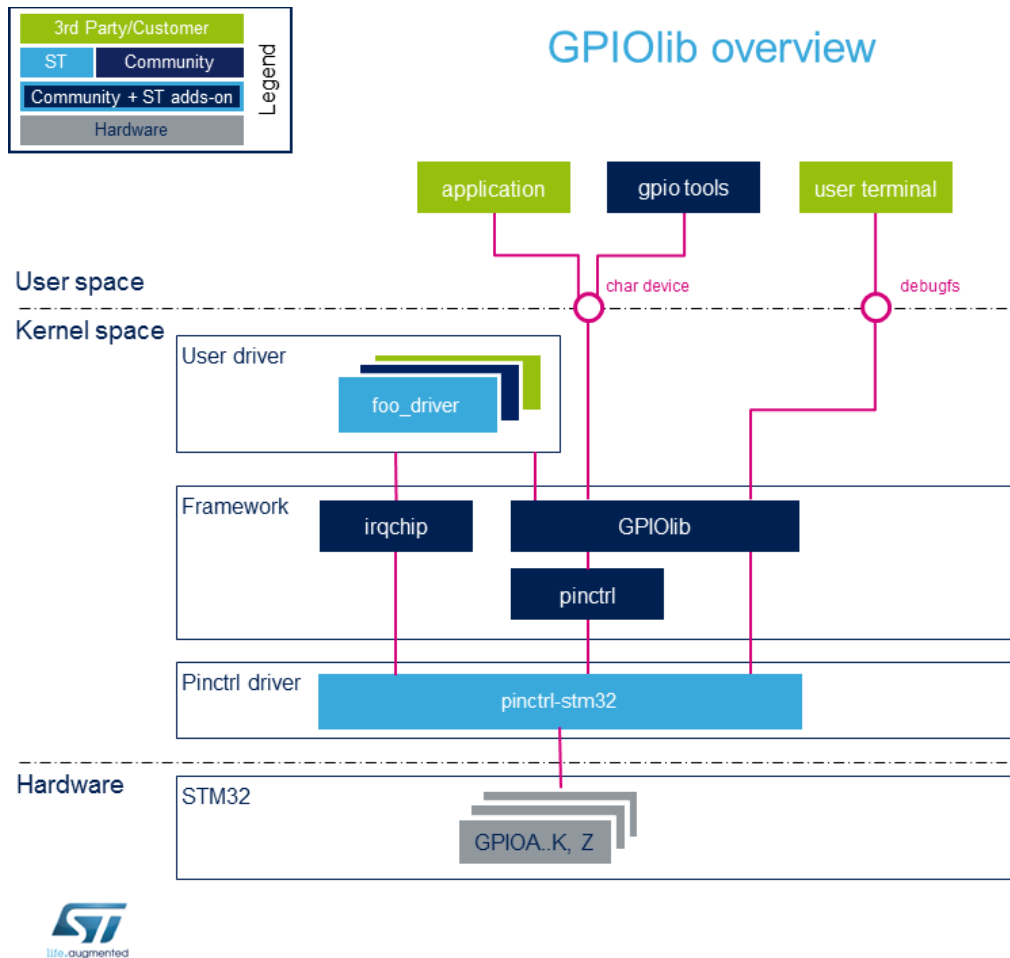
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## 1 Framework purpose

---

As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
  - Refer to [GNU documentation](#) for file manipulation.
  - See example [How to control a GPIO in userspace](#)
- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt"<sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt"<sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)



## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

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By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
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Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
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---

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The source files are located inside the Linux kernel.

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---

## 7 To go further

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GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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### SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	84
2 System overview .....	85
2.1 Component description .....	85
2.2 API description .....	86
3 Configuration .....	87
3.1 Kernel configuration .....	87
3.2 Device tree configuration .....	87
4 How to use framework .....	88
4.1 How to configure a new board .....	88
4.2 How to toggle a GPIO in user space .....	88
4.3 How to toggle a GPIO in kernel space .....	88
4.4 Tools .....	88



---

5 How to trace and debug the framework .....	89
5.1 How to monitor .....	89
5.1.1 How to monitor with debugfs .....	89
5.1.2 Other ways to monitor .....	89
5.2 How to trace .....	89
6 Source code location .....	90
7 To go further .....	91
8 References .....	92



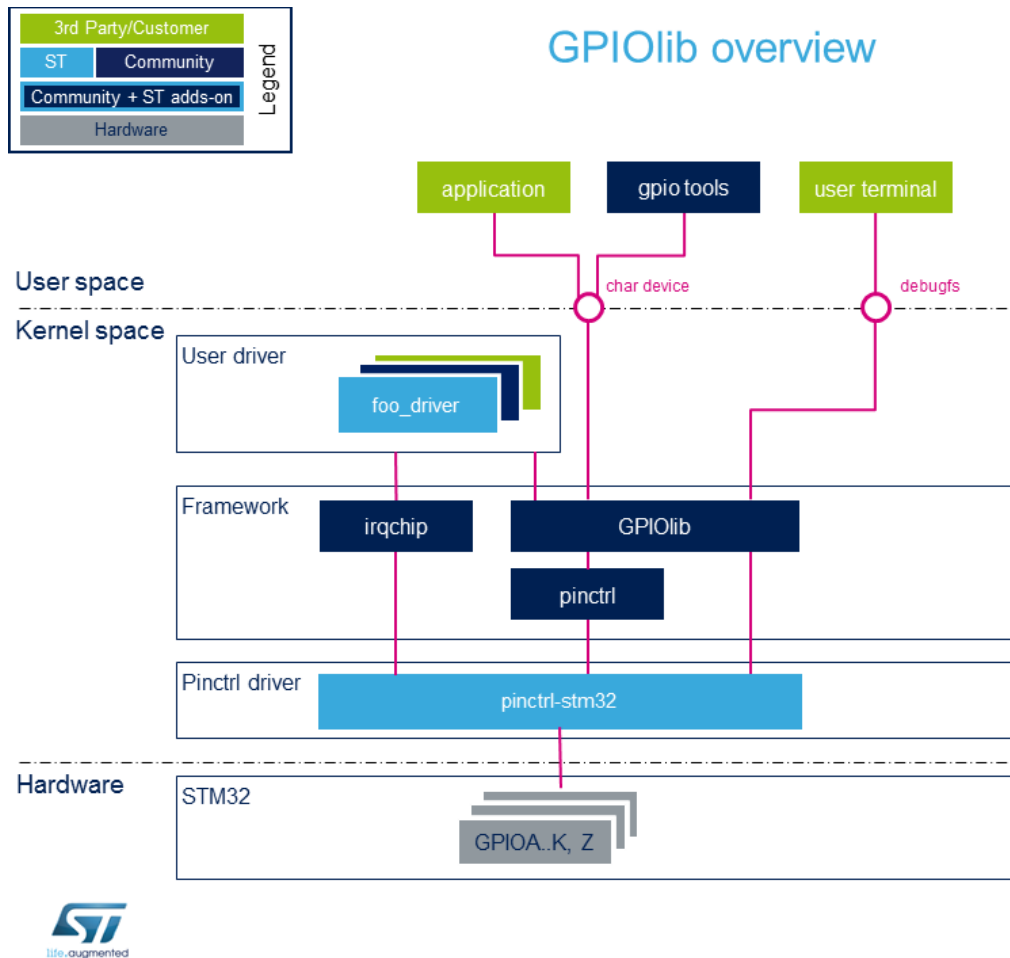
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## 1 Framework purpose

---

As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
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- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



---

## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
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  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)





## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (           |?           ) out hi
  gpio-95 (           |reset        ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

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By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

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The source files are located inside the Linux kernel.

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---

## 7 To go further

---

GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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Template:ArticleMainWriter Template:ArticleApprovedVersion

### SUMMARY

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### Contents

1 Framework purpose .....	94
2 System overview .....	95
2.1 Component description .....	95
2.2 API description .....	96
3 Configuration .....	97
3.1 Kernel configuration .....	97
3.2 Device tree configuration .....	97
4 How to use framework .....	98
4.1 How to configure a new board .....	98
4.2 How to toggle a GPIO in user space .....	98
4.3 How to toggle a GPIO in kernel space .....	98
4.4 Tools .....	98



---

5 How to trace and debug the framework .....	99
5.1 How to monitor .....	99
5.1.1 How to monitor with debugfs .....	99
5.1.2 Other ways to monitor .....	99
5.2 How to trace .....	99
6 Source code location .....	100
7 To go further .....	101
8 References .....	102



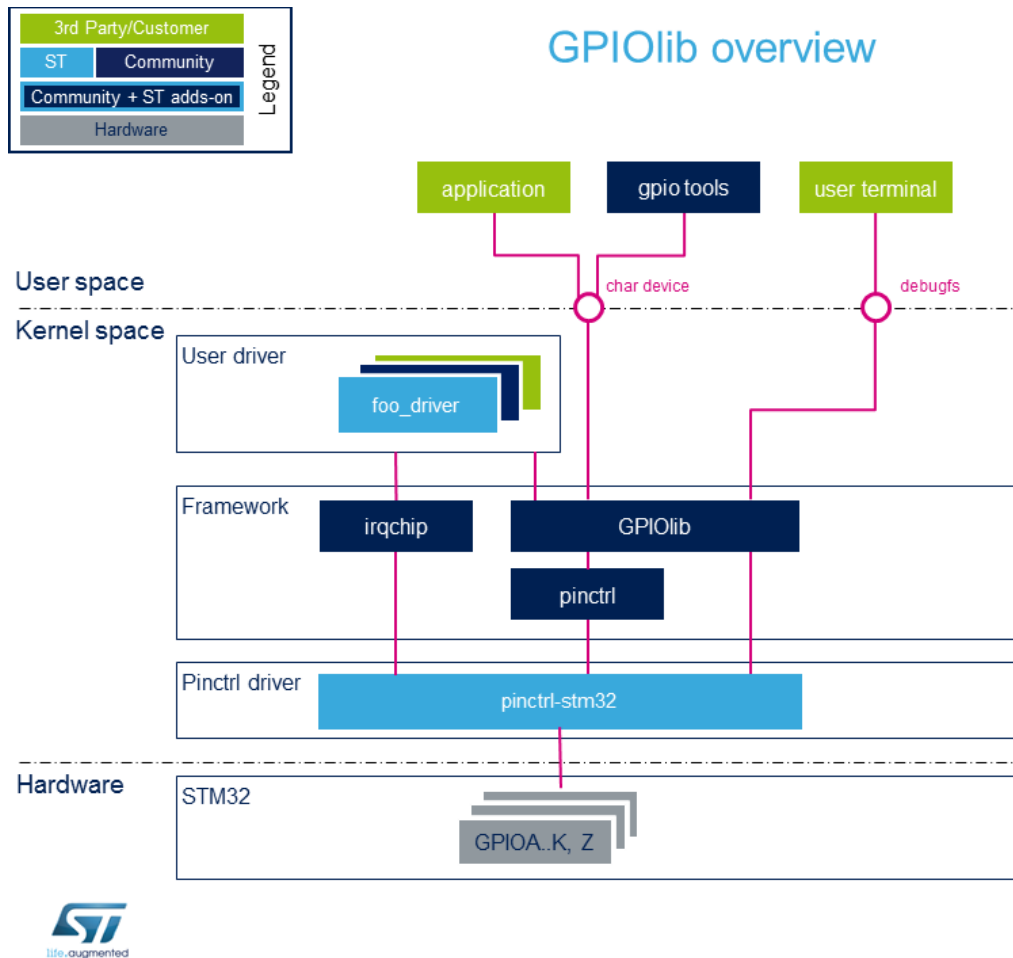
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## 1 Framework purpose

---

As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>

## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
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  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
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Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
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  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).





---

## 3 Configuration

---

### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



---

## 4 How to use framework

---

### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

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## 5 How to trace and debug the framework

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#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

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It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

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GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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Application programming interface

foo\_driver could be any driver that needs to control a GPIO

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

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### SUMMARY

The purpose of this article is to explain how the GPIOLib framework manages IOs/pins, how to configure it, and how to use it.

### Contents

1 Framework purpose .....	104
2 System overview .....	105
2.1 Component description .....	105
2.2 API description .....	106
3 Configuration .....	107
3.1 Kernel configuration .....	107
3.2 Device tree configuration .....	107
4 How to use framework .....	108
4.1 How to configure a new board .....	108
4.2 How to toggle a GPIO in user space .....	108
4.3 How to toggle a GPIO in kernel space .....	108
4.4 Tools .....	108



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5 How to trace and debug the framework .....	109
5.1 How to monitor .....	109
5.1.1 How to monitor with debugfs .....	109
5.1.2 Other ways to monitor .....	109
5.2 How to trace .....	109
6 Source code location .....	110
7 To go further .....	111
8 References .....	112



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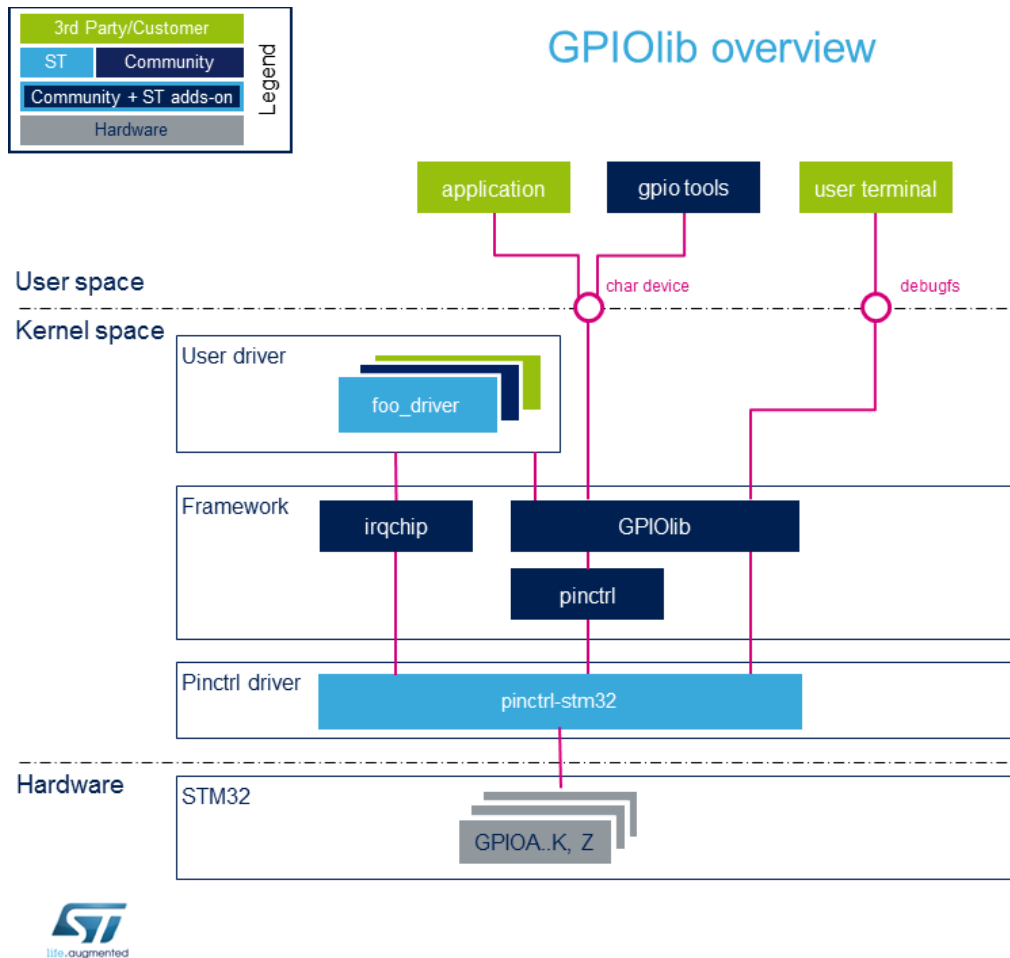
## 1 Framework purpose

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As explain in [Overview of GPIO pins](#), the pins are multiplexed between "Alternate function", "ANALOG" and "GPIO" modes. The current article deals with the framework to use in order to manipulate GPIO: the GPIOLib framework. The GPIOLib framework is used when you want to control a pin directly in software, i.e. to set pin as output as a certain level (0/1), or to set pin in input configuration, or to configure the GPIO as an interrupt line. More details about GPIO in the kernel documentation are available in `gpio.txt` <sup>[1]</sup>



## 2 System overview



### 2.1 Component description

- **GPIOLib:**
  - provides the GPIOLib API to be used by a driver who wants to control a GPIO. See [API](#) for more details.
  - calls the pinctrl framework to manage/configure pins.
- **Pinctrl:** the pinctrl framework **core**. Its role is:
  - to call specific vendor callback for the pin configuration (muxing end setting).
  - to create the logical pin mapping and guarantee pin exclusivity for a device. See [Pinctrl overview](#)
- **Pinctrl-stm32:** microprocessor **specific** pinctrl driver, its role is:
  - to register the vendor specific function (callback) in the pinctrl framework.
  - to access to hardware registers to configure pins (muxing and all pin capabilities).
- **IRQ chip:** provides the API<sup>[2]</sup> to request an IRQ for a GPIO Line.
- **foo\_driver:** foo\_driver could be any driver that needs to control a GPIO.
- **debugfs:** provides a debug interface available from the user terminal. See [How to monitor with debugfs](#).
- **GPIO tools:** tools offered by the kernel to manipulate GPIOs. See [GPIO tools](#).



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## 2.2 API description

Depending on needs and the caller location (kernel space or user space), several APIs are available to control a pin:

- **User space API:** the Linux<sup>®</sup> standard character device driver interface<sup>[3]</sup> allows applications to manipulate all "system objects" with the standard file API (open, read, write, close, IOctl...). This is used to manipulate GPIO through user space, as gpio devices are seen as files.
  - Refer to [GNU documentation](#) for file manipulation.
  - See example [How to control a GPIO in userspace](#)
- **Kernel space API:** the GPIOLib API provides API to the user driver.
  - See in the Kernel documentation "consumer.txt" <sup>[4]</sup> to know how to obtain and use GPIO in a driver.
  - See in the Kernel documentation "board.txt" <sup>[5]</sup> to know how to assign GPIOs to a consumer device.
  - The GPIO descriptor acquisition is linked to a function label declared in the device tree. So there is a direct relationship between the driver and the device tree about this label, and the driver name (see sample code "dummy.c" below (ie "st, dummy" and "redled")).
  - See example [How to control a GPIO in kernel space](#)
- **Debugfs API:** provides only information about GPIO configuration. See [How to monitor with debugfs](#).



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## 3 Configuration

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### 3.1 Kernel configuration

GPIOLib is activated by default in ST deliveries.

### 3.2 Device tree configuration

A detailed device tree configuration is described in [GPIO device tree configuration](#).



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## 4 How to use framework

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### 4.1 How to configure a new board

If you have to declare a GPIO, please refer first to the hardware block GPIO page: [GPIO internal peripheral](#) and your board schematics. Then either you declare your GPIO directly in [device tree](#) or you declare it using the [STM32CubeMX](#).

### 4.2 How to toggle a GPIO in user space

[How to control a GPIO in userspace](#)

### 4.3 How to toggle a GPIO in kernel space

[How\\_to\\_control\\_a\\_GPIO\\_in\\_kernel\\_space](#)

### 4.4 Tools

[Control GPIO through libgpiod](#)



## 5 How to trace and debug the framework

### 5.1 How to monitor

#### 5.1.1 How to monitor with debugfs

Some information about gpio is available in [Debugfs](#) interface.

```
Board $> cat /sys/kernel/debug/gpio
```

Output:

```
gpiochip0: GPIOs 0-15, parent: platform/soc:pin-controller, GPIOA:
...
gpiochip1: GPIOs 16-31, parent: platform/soc:pin-controller, GPIOB:
...
gpiochip5: GPIOs 80-95, parent: platform/soc:pin-controller, GPIOF:
  gpio-94 (          |?          ) out hi
  gpio-95 (          |reset       ) out hi
  ...
```

It provides per gpiochip: requested GPIOs, the state of the GPIO and the gpio-controller parent.

#### 5.1.2 Other ways to monitor

You can also get GPIO information by using [gpiodetect](#) - [gpioinfo](#) tools

### 5.2 How to trace

By default there is no kernel trace to see the activity on GPIOs. However you could enable [dynamic debug](#) for the [gpiolib](#) and the [pinctrl](#).

```
Board $> dmesg -n8
Board $> echo "file drivers/pinctrl/* +p" > /sys/kernel/debug/dynamic_debug/control
Board $> echo "file drivers/gio/* +p" > /sys/kernel/debug/dynamic_debug/control
```



---

## 6 Source code location

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The source files are located inside the Linux kernel.

- **GPIOLib:** `gpiolib.c`<sup>[6]</sup> and `gpiolib-of.c`<sup>[7]</sup>
- **GPIO tools:** folder `tools/gpio` in Kernel<sup>[8]</sup>
- **Pinctrl core part:** generic core<sup>[9]</sup>, generic `pinconf`<sup>[10]</sup> and generic `pinmux`<sup>[11]</sup>
- **STM32 pinctrl vendor part:** folder to STM32 dedicated pinctrl functions<sup>[12]</sup>



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## 7 To go further

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GPIONLib is the main framework to handle a GPIO at run time. However, dedicated GPIO drivers already exist to control basic features (Leds, regulator, buttons, ...). You can find the list (and more details) inside the Kernel documentation <sup>[13]</sup>



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## 8 References

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- Kernel documentation - gpio.txt, GPIO Kernel documentation
- Interrupt Management training document, *Linux Kernel and Driver Development*
- character device interface, *Linux Kernel and Driver Development* training document, see **Kernel frameworks for device drivers** chapter
- Kernel gpio documentation - consumer.txt, to know how to obtain and use GPIO in a driver
- Kernel gpio documentation - board.txt, to know how to assign GPIOs to a consumer device and a function
- GPIOLib source - gpiolib.c Provides GPIOLib API
- GPIOLib source - gpiolib-of.c Provides OF-GPIOLib API
- gpio tools folder Provides all sources of GPIO tools
- Pinctrl framework source - core.c Sources of generic pinctrl framework
- Pinctrl framework source - pinconf.c Sources of generic pin configuration
- Pinctrl framework source - pinmux.c Sources of generic pin muxing
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