Using the Digital I/O interface of STMicroelectronics STM32 Microcontrollers

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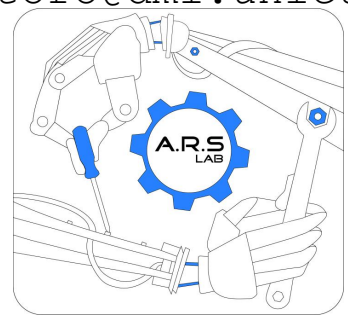

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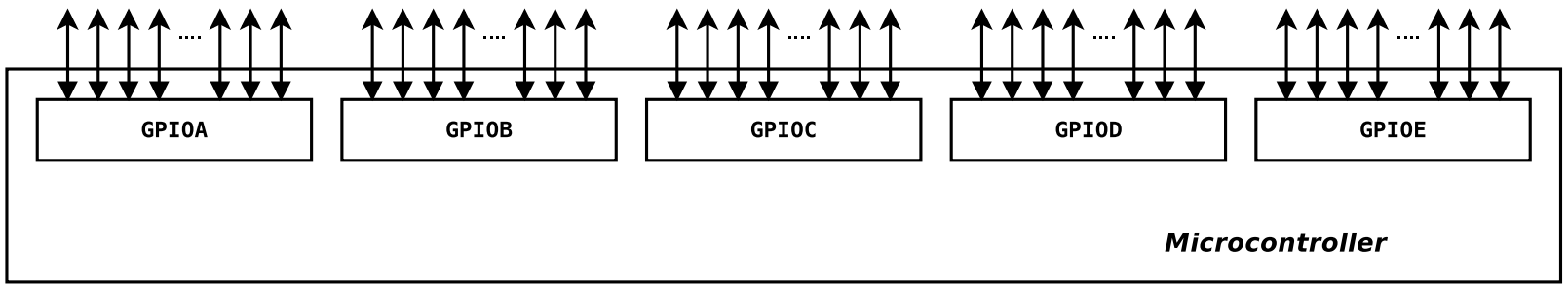
What is a “digital I/O interface”?

- It is an interface in which each electrical pin may have two states:
  - Logical `0` (it means 0V);
  - Logical `1` (it means 5V or 3.3V on the basis of the VDD);
- Each line can be programmer as:
  - an **output** (it “generates” current and can be used, for example, to lit a LED)
  - an **input** (it “receives” current and can be used, for example, to read a pushbutton)

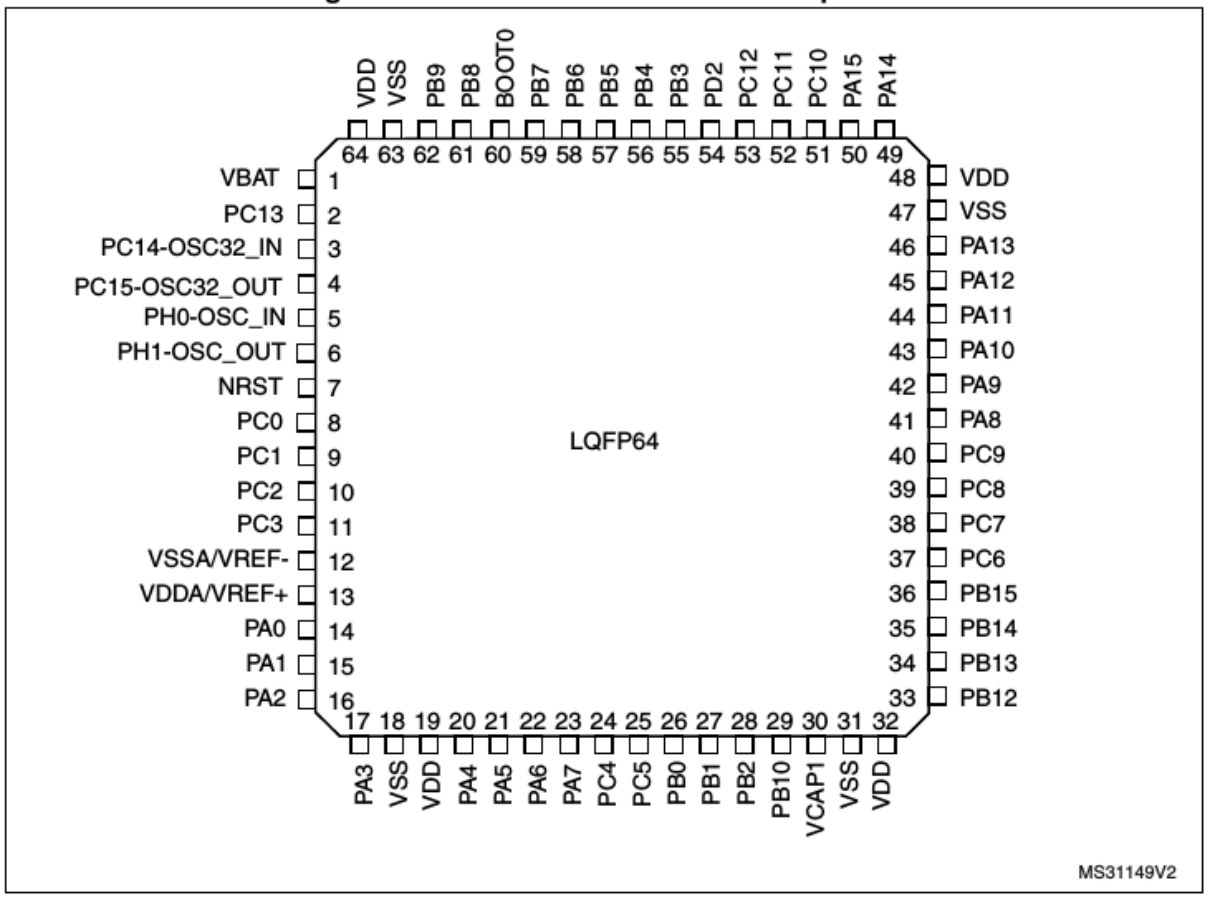
The General Purpose I/O (GPIO) Interface of STM32



- MCUs of the STM32 family have several **digital ports**, called **GPIOA**, **GPIOB**, **GPIOC**, **...**,
- Each port has **16 bits** and thus **16 electrical pins**
- Pins are referred as **P*xy***, where *x* is the port name (A, B, ..., E) and *y* is the bit (0, 1, ..., 15).
- As an example, the pin `PC3` is the bit 3 of the port C.
- Each PIN has also an **alternate function**, related to a peripheral e.g. Timer, UART, SPI, etc.
- According to the MCU package, not all bits are mapped to electrical pins. This is a choice “by-design”.

The General Purpose I/O (GPIO) Interface of STM32

Figure 12. STM32F401xD/xE LQFP64 pinout



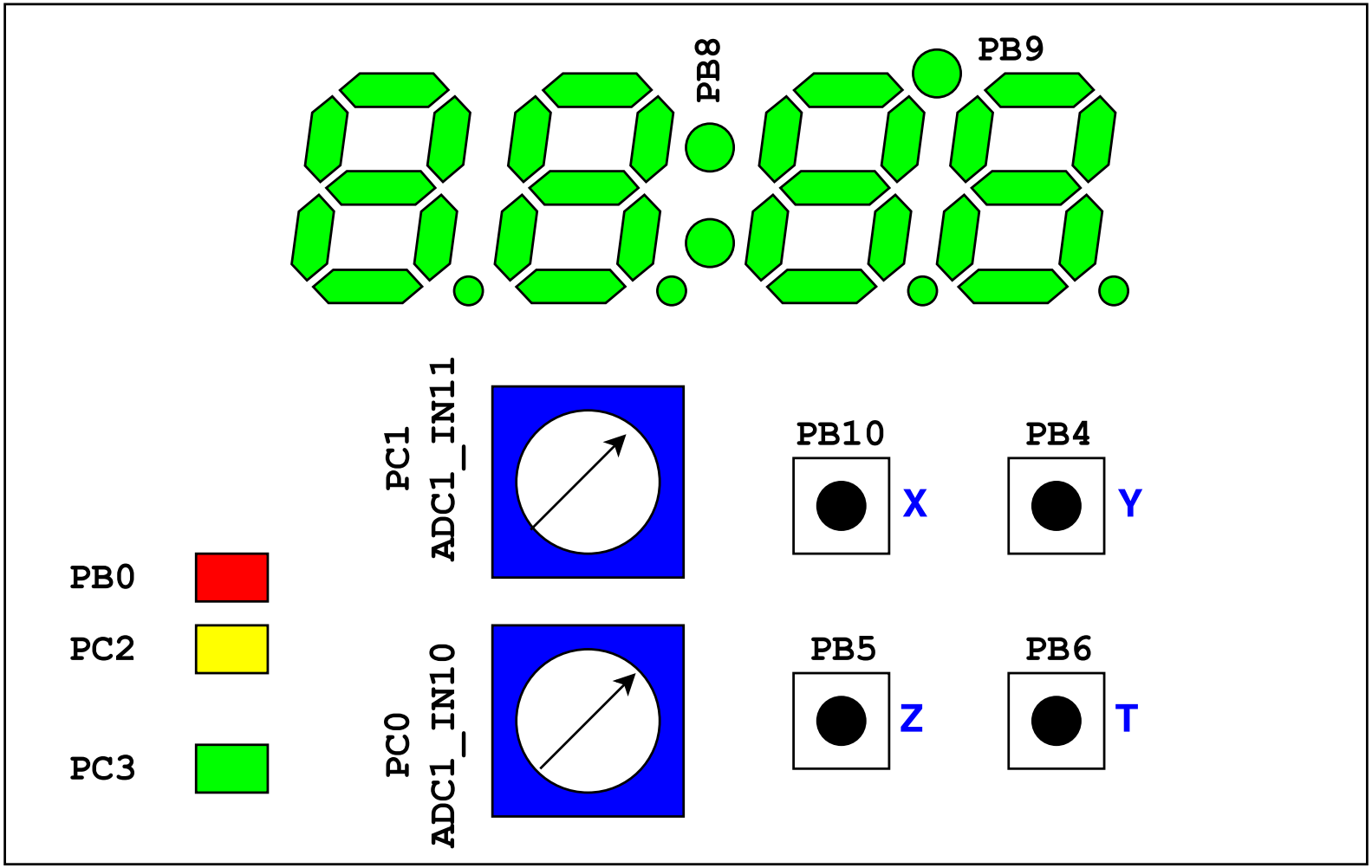
Using the GPIO Interface

- To use a specific GPIO line (pin), the following operations are needed:
- **Set-up**
  1. Initialize the whole GPIO port (this operation basically enables the clock line to the GPIO port)
  2. Set the direction (input or output) of the pin you intend to use
- **Operate**
  - Read the GPIO pin, if it is programmed as “input”, or
  - Write the GPIO pin, if it is programmed as “output”
- These operations are made really simple using the stm32_unict_lib

Using the GPIO Interface with stm32_unict_lib

- Example: setting **PA5** as output and using it
- **Set-up**
  1. Initialize the whole GPIO port (this operation basically enables the clock line to the GPIO port)
     ```
     GPIO_init(GPIOA);
     ```
  2. Set the direction of the pin you intend to use
     ```
     GPIO_config_output(GPIOA, 5);
     ```
- **Operate**
  - Write “0” to PA5:
    ```
    GPIO_write(GPIOA, 5, 0);
    ```
  - Write “1” to PA5:
    ```
    GPIO_write(GPIOA, 5, 1);
    ```

The Nucleo64 Addon Board



First Example: Flashing a LED

```
#include "stm32_unict_lib.h"

void setup(void)
{
    GPIO_init(GPIOB);  // initialize port B
    GPIO_config_output(GPIOB, 0); // configure pin PB0 as output
}

void loop(void)
{
    GPIO_write(GPIOB, 0, 1);  // set PB0 to 1
    delay_ms(500);            // wait 0.5 secs
    GPIO_write(GPIOB, 0, 0);  // set PB0 to 0
    delay_ms(500);            // wait 0.5 secs
}

int main()
{
    setup();
    // infinite loop
    for (;;) {
        loop();
    }
}
```

Using the GPIO Interface with stm32_unict_lib

- Example: setting **PC3** as input and using it
- **Set-up**
  1. Initialize the whole GPIO port (this operation basically enables the clock line to the GPIO port)
     ```
     GPIO_init(GPIOC);
     ```
  2. Set the direction of the pin you intend to use
     ```
     GPIO_config_input(GPIOC, 3);
     ```
- **Operate**
  - Read PC3 pin:
    ```
    int pinval = GPIO_read(GPIOC, 3);
    ```
  - "pinval" can be "0" or "1"

First Example: Read a Pushbutton and lit the LED

```
#include "stm32_unict_lib.h"

void setup(void)     // pushbutton on PB10; LED on PC2
{
    GPIO_init(GPIOB);    // initialize ports
    GPIO_init(GPIOC);
    GPIO_config_input(GPIOB, 10); // pin PB10 as input
    GPIO_config_output(GPIOC, 2); // pin PC2 as output
}

void loop(void)
{
    int pinval = GPIO_read(GPIOB, 10);
    GPIO_write(GPIOC, 2, !pinval);
}

int main()
{
    setup();
    // infinite loop
    for (;;) {
        loop();
    }
}
```

Inside the code....

- What are the GPIOA, GPIOB, ... variables?
- What are the prototypes of the GPIO functions?

- GPIOA, GPIOB, ... are **global variables** defined in CMSIS libraries as:

```
GPIO_TypeDef * GPIOA;
GPIO_TypeDef * GPIOB;
...;
```

- `GPIO_TypeDef` is a structure whose fields are the special-function-registers (SFRs) of a GPIO port
- Each GPIOA, GPIOB, ... variable is a **pointer** to a `GPIO_TypeDef` and represents the **address** of the memory holding the SFRs of that port

The GPIO function prototypes

- Initialize a GPIO port:

```
void GPIO_init(GPIO_TypeDef * port);
```

- Configure a GPIO pin as input:

```
void GPIO_configure_input(GPIO_TypeDef * port,
                          int pin_num);
```

- Configure a GPIO pin as output:

```
void GPIO_configure_output(GPIO_TypeDef * port,
                           int pin_num);
```

- Write to an output pin:

```
void GPIO_write(GPIO_TypeDef * port, int pin_num,
                int pin_val);
```

- Read from an input pin:

```
int GPIO_read(GPIO_TypeDef * port, int pin_num);
```

- Change the state of an output pin:

```
void GPIO_toggle(GPIO_TypeDef * port, int pin_num);
```

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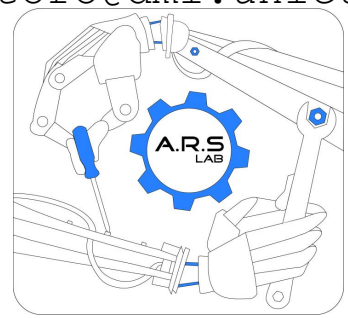

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