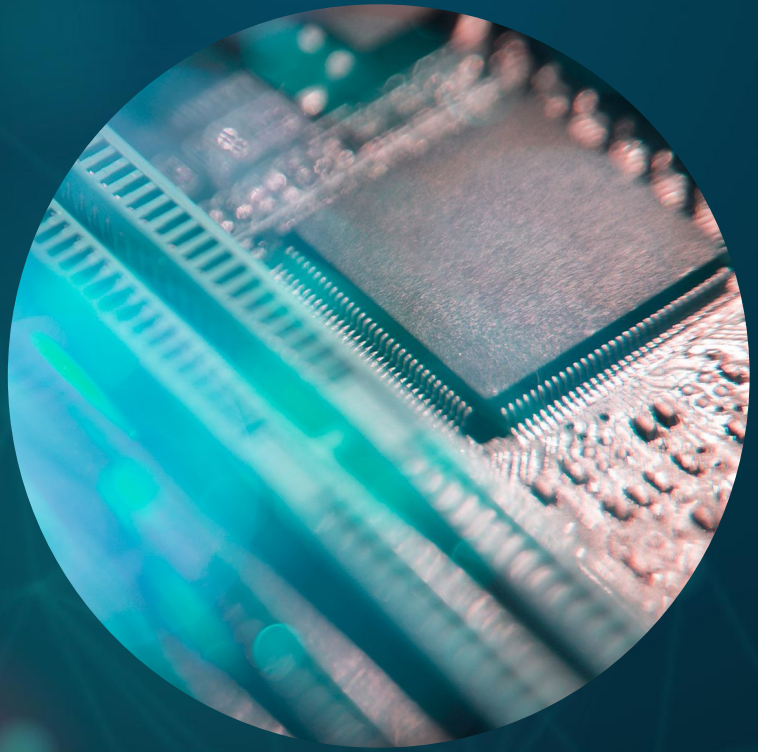
ARM Based Microcontroller

GPIO

Lecture 3



Advanced RISC Machines

IMT SCHOOL

Introduction 01

General Purpose Input Output

IMT SCHOOL

GPIO

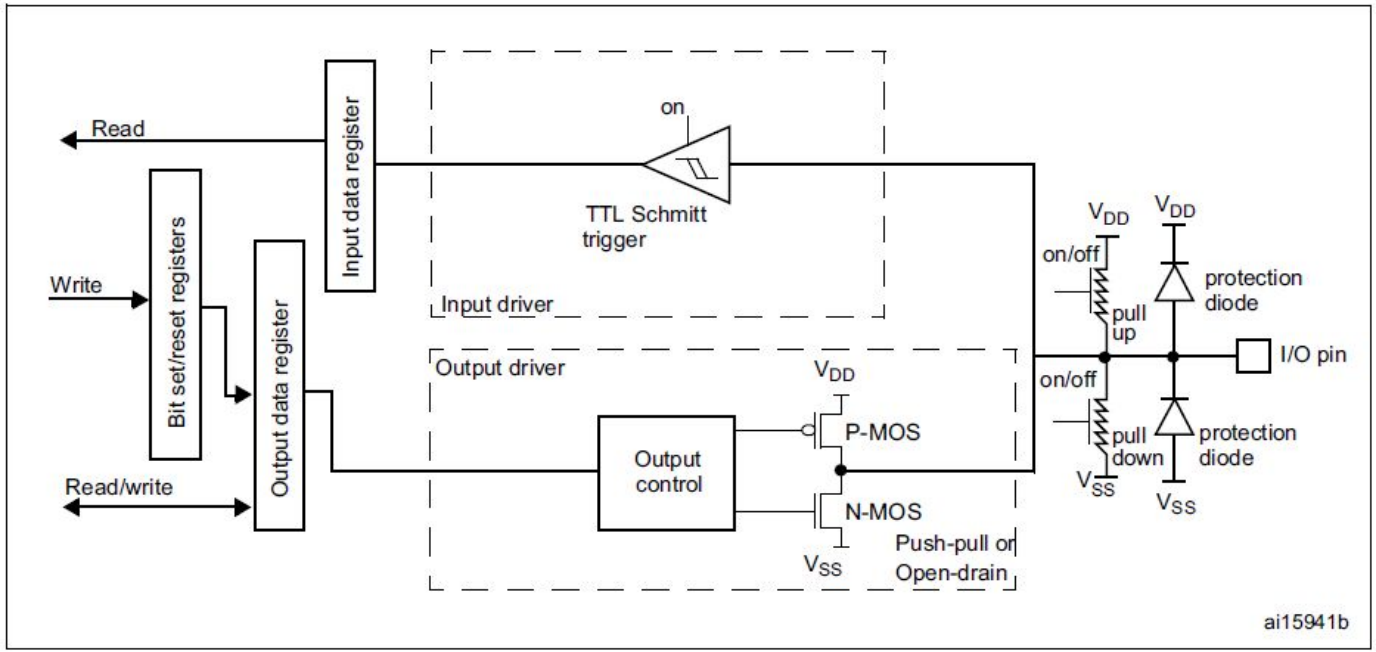
GPIO (General Purpose Input/Output):

GPIO stands for General Purpose Input/Output. It's a standard interface used to connect microcontrollers to other electronic devices. For example, it can be used with sensors, diodes, displays, and System-on-Chip modules.

The GPIO peripheral is used to configure the device IO ports, also called pins or pads. Each GPIO instance controls 8 pins (for GPIOK and GPIOZ) or 16 pins (for GPIOA to GPIOJ).

Every IO port implements the logic shown in the image below.

GPIO


Read
Write
Read/write
Bit set/reset registers
Output data register
Input data register
on
TTL Schmitt trigger
Input driver
Output driver
Output control
P-MOS
N-MOS
Push-pull or Open-drain
VDD
VSS
on/off
pull up
pull down
protection diode
I/O pin
ai15941b

GPIO

the general-purpose I/O ports(GPIO), is a pin on an IC (Integrated Circuit). It can be used for driving loads, reading digital and analog signals, controlling external components, generating triggers for external devices etc. Each of the general-purpose I/O ports has two 32-bit configuration registers, two 32-bit data registers, a 32-bit set/reset register , a 16-bit reset register and a 32-bit locking register.

Each port bit of GPIOs can be individually configured by software in several modes:

- Input floating.
- Input pull-up.
- Input-pull-down.
- Analog.
- Output open-drain.
- Output push-pull.
- Alternate function push-pull.
- Alternate function open-drain.

GPIO Modes Description

02

General Purpose Input Output

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Input mode configuration

When a STM32 device I/O pin is configured as input, one of three options must be selected:

- Input with internal pull-up. Pull-up resistors are used in STM32 devices to ensure a well-defined logical level in case of floating input signal. Depending on application requirements, an external pull-up can be used instead.

- Input with internal pull-down. Pull-down resistors are used in STM32 devices to ensure a well-defined logical level in case of floating input signal. Depending on application requirements, an external pull-down can be used instead.

- Floating input. Signal level follows the external signal. When no external signal is present, the Schmitt trigger randomly toggles between the logical levels induced by the external noise. This increases the overall consumption.

Input mode configuration

Programmed as input, an I/O port exhibits the following characteristics:

- The output buffer is disabled
- The Schmitt trigger input is activated
- The pull-up or pull-down resistors are activated depending on the value in the GPIOx_PUPDR register
- The data present on the I/O pin is sampled into the input data register at each AHB clock cycle
- The I/O state is obtained by reading the GPIOx_IDR input data register

Output mode configuration

When a STM32 device I/O pin is configured as output, one of two options must be selected:
• Push-pull output mode:
The push-pull output actually uses two transistors: one PMOS and one NMOS. Each transistor is ON to drive the output to the appropriate level:

– The top transistor (PMOS) is ON when the output has to drive HIGH state

– The bottom transistor (NMOS) is ON when the output has to drive a LOW state
The control of the two transistors is done through the GPIO port output type register (GPIOx_OTYPER).
Writing the related bit of the output register (GPIOx_ODR) to 0 activates the NMOS transistor to force the I/O pin to ground.
Writing the related bit of the output register (GPIOx_ODR) to 1 activates the PMOS transistor to force the I/O pin to VDD.

Output mode configuration

• Open-drain output mode:
Open-drain output mode does not use the PMOS transistor and a pull-up resistor is required.
When the output has to go high, the NMOS transistor must be turned off, pulling the line high only by the pull-up resistor. This pull-up resistor could be internal with a typical value of 40 kOhm and activated through GPIO port pull-up / pull-down register (GPIOx_PUPDR).
Note: It is important to note that it is not possible to activate pull-up and pull-down at the same
time on the same I/O pin.
It is also possible to use an external pull-up or pull-down resistor instead of the internal resistor. In this case, the value must be adapted to be compliant with the GPIO output voltage and current characteristics.

Output mode configuration

Programmed as output, an I/O port exhibits the following characteristics:

- The output buffer can be configured in open-drain or push-pull mode
- The Schmitt trigger input is activated
- The internal pull-up and pull-down resistors are activated depending on the value in the GPIOx_PUPDR register.
- The written value into the output data register GPIOx_ODR sets the I/O pin state
- The written data on GPIOx_ODR can be read from GPIOx_IDR register that is updated every AHB clock cycle

Open-drain output is often used to control devices which operate at a different voltage supply than the STM32. Open-drain mode is also used to drive one or several I2C devices when specific pull-up resistors are required.

Alternate functions

On some STM32 GPIO pins, the user has the possibility to select alternate functions inputs / outputs. Each pin is multiplexed with up to sixteen peripheral functions such as communication interfaces (SPI, UART, I2C, USB, CAN, LCD and others), timers, debug interface, and others.
The alternate function of the selected pin is configured through two registers:

- GPIOx_AFRL (for pin 0 to 7)

- GPIOx_AFRH (for pin 8 to 15)

To know which functions are multiplexed on each GPIO pin, refer to the device datasheet.

Alternate functions

When the I/O port is programmed as alternate function mode:

- The output buffer can be configured in open-drain or push-pull mode
- The output buffer is driven by the signals coming from the peripheral (transmitter enable and data)
- The Schmitt trigger input is activated
- The pull-up and pull-down resistors activations depend on the value in the register GPIOx_PUPDR

The data present on the I/O pin are sampled into the input data register at each AHB clock cycle.
A read access to the input data register provides the I/O state.
Alternate functions details are provided in the datasheet and the reference manual of the product.

Analog configuration

Few STM32 GPIO pins can be configured in analog mode which allows the use of ADC, DAC, OPAMP, and COMP internal peripherals. To use a GPIO pin in analog mode, the following register are considered:

• - GPIOx_MODER to select the mode (Input, Output, Alternate, Analog)
• - GPIOx_ASCR to select the required function ADC, DAC, OPAMP, or COMP

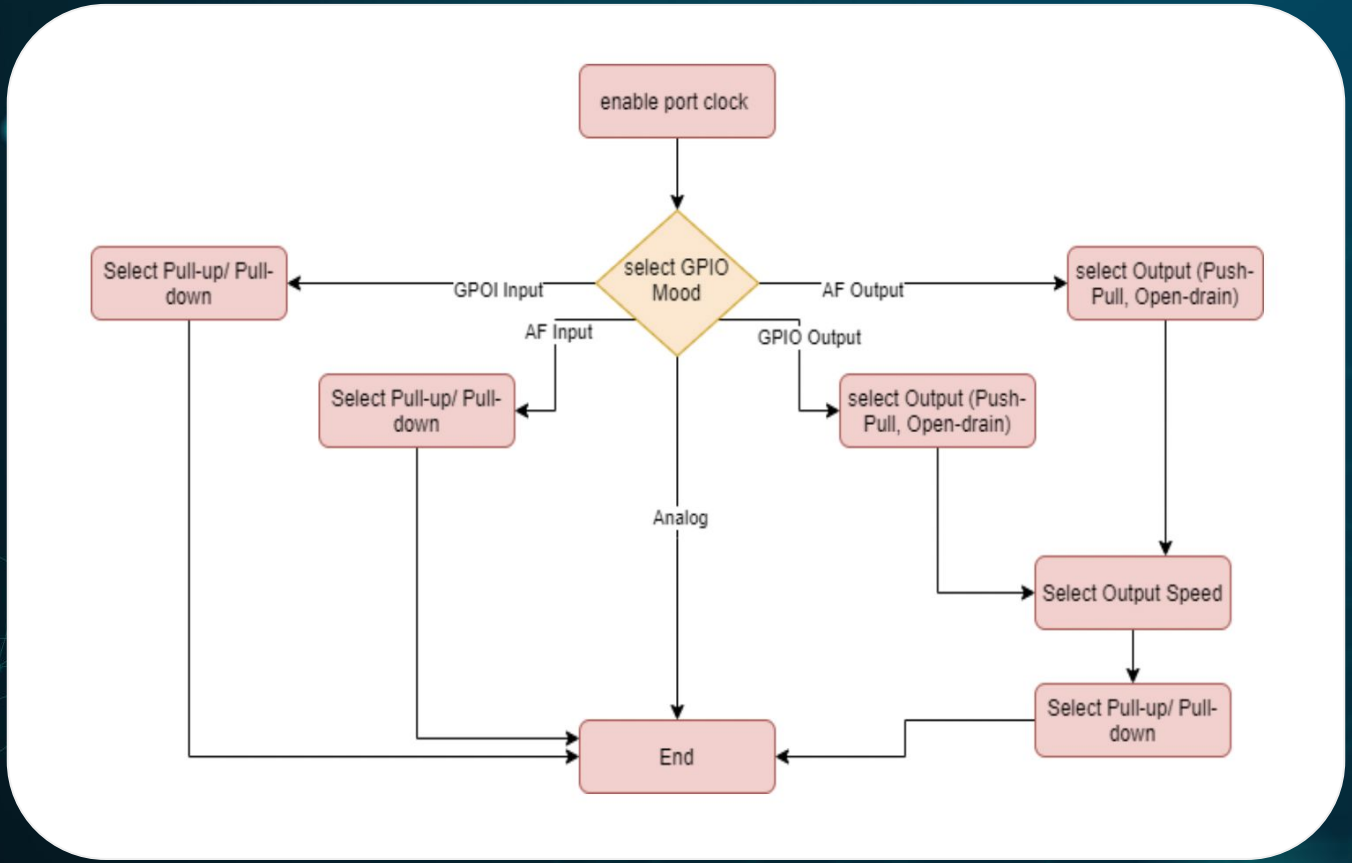
When the I/O port is programmed in an analog configuration:

• The output buffer is disabled
• The Schmitt trigger input is deactivated, providing zero consumption for every analog value of the I/O pin.The output of the Schmitt trigger is forced to a constant value (0).
• The pull-up and pull-down resistors are disabled by hardware

Read access to the input data register gets the value 0.

For details concerning ADC, DAC, OPAMP and COMP function and programming, refer to the datasheet and reference manual of the product.

GPIO Flowchart



STM32 Is AWESOME

Session LAb

THANKS!

Do you have any question?

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