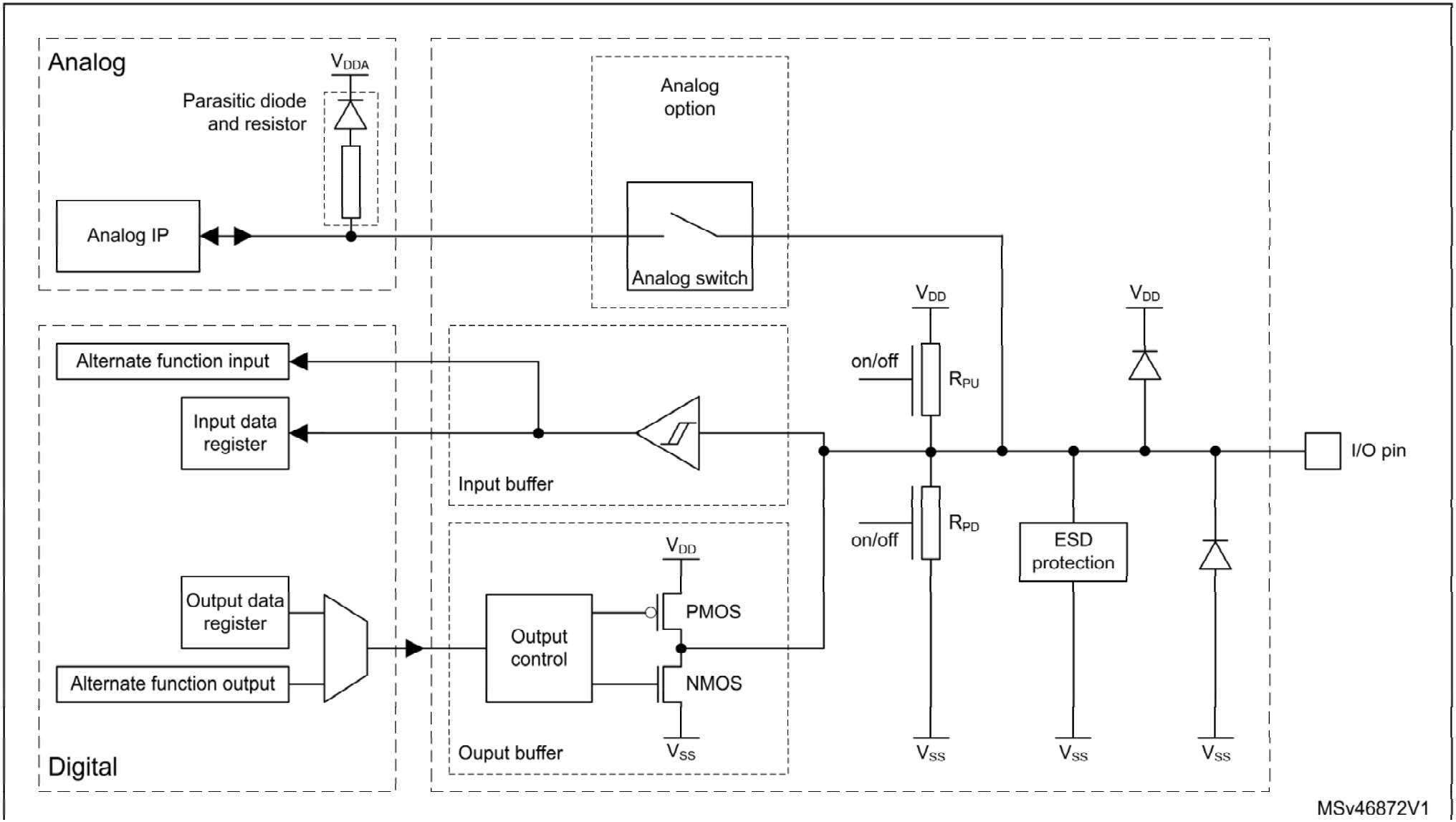
General Purpose Input/Output (GPIO)

Multifunction Pins

- A pin in the microcontroller can have multiple functions:
  - Digital I/O pin (input or output)
  - Specific peripheral function pin (for example the output of a hardware timer or an input clock signal) (Alternate function)
  - Analog input to connect to an ADC or DAC
  - The pin can be configured in Open Drain, Pull-up or pull-down, high speed or low speed.

Multifunction PINs



Configuration (using registers)

a.- Configuration process

1.- GPIO port mode register (GPIOx_MODER)
2.- GPIO port output type register (GPIOx_OTYPER)
3.- GPIO port output speed register (GPIOx_OSPEEDR)
4.- GPIO port pull-up/pull-down register (GPIOx_PUPDR)

MODER(i) [1:0]	OTYPER(i)	OSPEEDR(i) [B:A]	PUPDR(i) [1:0]	I/O configuration	
01	0	SPEED [B:A]	0 0	GP output	PP
	0		0 1	GP output	PP + PU
	0		1 0	GP output	PP + PD
	0		1 1	Reserved	
	1		0 0	GP output	OD
	1		0 1	GP output	OD + PU
	1		1 0	GP output	OD + PD
	1		1 1	Reserved (GP output OD)	
10	0	SPEED [B:A]	0 0	AF	PP
	0		0 1	AF	PP + PU
	0		1 0	AF	PP + PD
	0		1 1	Reserved	
	1		0 0	AF	OD
	1		0 1	AF	OD + PU
	1		1 0	AF	OD + PD
	1		1 1	Reserved	
00	x	x x	0 0	Input	Floating
	x	x x	0 1	Input	PU
	x	x x	1 0	Input	PD
	x	x x	1 1	Reserved (input floating)	
11	x	x x	0 0	Input/output	Analog
	x	x x	0 1	Reserved	
	x	x x	1 0		
	x	x x	1 1		

Source: ST. RM0090 Reference manual

Direct Programming of GPIO

This code shows how manage I/O access using pointers.

```
volatile uint32_t *pGPIOA_MODER = 0;
volatile uint32_t *pGPIOA_ODR = 0;

pGPIOA_MODER = (uint32_t*)0x48000000; // Address of the GPIOA MODER register
pGPIOA_ODR = (uint32_t*)(0x48000000 + 0x14); // Address of the GPIOA ODR register

// Before use a peripheral, it must be enabled and connected to the AHB1 bus
// This will be done using the HAL

*pGPIOA_MODER = *pGPIOA_MODER | 0x04; // Sets MODER[3:2] = 0x1 and configure like Output
*pGPIOA_ODR = *pGPIOA_ODR | 0x02; // Sets PA1 high
```

Pointer declaration and initialization

Assign pointer specific peripheral address

Access peripheral:
a.- Configure pin.
b.- Access pin.

Programming GPIO

- Using HAL to manage the I/O peripheral.

```
GPIO_InitTypeDef GPIO_InitStruct = {0};

/* GPIO Port A Clock Enable */
__HAL_RCC_GPIOA_CLK_ENABLE();

/*Configure PA5 and PA2 like output */
GPIO_InitStruct.Pin = GPIO_PIN_5 | GPIO_PIN_2;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);

/*Set GPIO pin Output Level to LOW */
HAL_GPIO_WritePin(GPIOA, GPIO_PIN_5, GPIO_PIN_RESET);
```

a.- Configuration process

b.- Read/Write the I/O pins

IMPORTANT
Before use **any** peripheral, the peripheral clock must be **ENABLE**

Fill in the handler and initialize the HAL

Handler initialization

HAL initialization **must be done** before using it.

HAL GPIOFunctions and Handlers

- Initialization and de-initialization

```
void              HAL_GPIO_Init(GPIO_TypeDef  *GPIOx, GPIO_InitTypeDef *GPIO_Init);
void              HAL_GPIO_DeInit(GPIO_TypeDef  *GPIOx, uint32_t GPIO_Pin);
```

```
GPIO_PinState     HAL_GPIO_ReadPin(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin);
void              HAL_GPIO_WritePin(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin, GPIO_PinState PinState);
void              HAL_GPIO_TogglePin(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin);
HAL_StatusTypeDef HAL_GPIO_LockPin(GPIO_TypeDef* GPIOx, uint16_t GPIO_Pin);
void              HAL_GPIO_EXTI_IRQHandler(uint16_t GPIO_Pin);
void              HAL_GPIO_EXTI_Callback(uint16_t GPIO_Pin);
```

See: stm32l4xx_hal_gpio.h

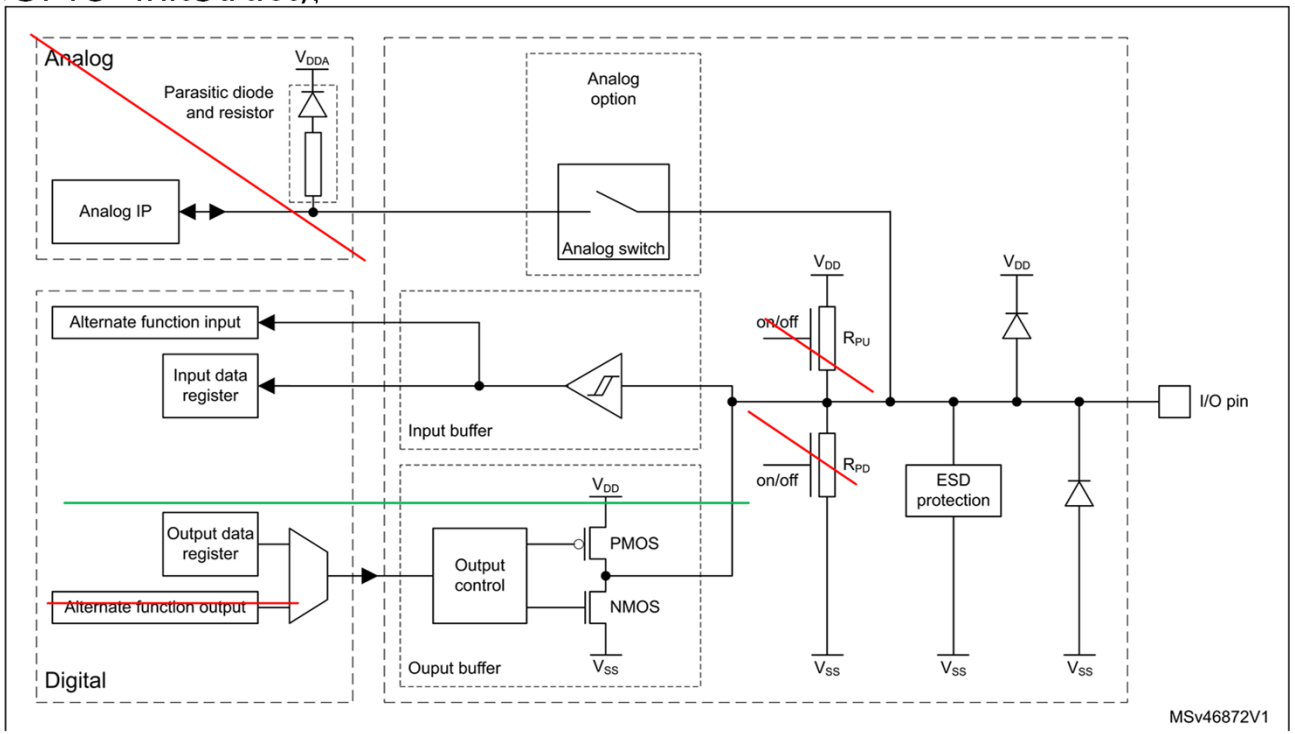
```
typedef struct {
        volatile uint32_t MODER;
        volatile uint32_t OTYPER;
        volatile uint32_t OSPEEDR;
        volatile uint32_t PUPDR;
        volatile uint32_t IDR;
        volatile uint32_t ODR;
        volatile uint32_t BSRR;
        volatile uint32_t LCKR;
        volatile uint32_t AFR[2];
        volatile uint32_t BRR;
} GPIO_TypeDef;
```

```
typedef struct {
        uint32_t Pin;
        uint32_t Mode;
        uint32_t Pull;
        uint32_t Speed;
        uint32_t Alternate;
} GPIO_InitTypeDef;
```

```
typedef enum
{
  GPIO_PIN_RESET = 0U,
  GPIO_PIN_SET
}GPIO_PinState;
```

Examples (Digital output)

```
GPIO_InitTypeDef GPIO_InitStruct = {0};
__HAL_RCC_GPIOB_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_0;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
HAL_GPIO_Init(GPIOB, &GPIO_InitStruct);
```



Examples (digital input - interrupt)

```
GPIO_InitTypeDef GPIO_InitStruct = {0};
__HAL_RCC_GPIOF_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_6;
GPIO_InitStruct.Mode = GPIO_MODE_INPUT;
GPIO_InitStruct.Pull = GPIO_PULLUP; //GPIO_PULLDOWN //GPIO_NOPULL
HAL_GPIO_Init(GPIOF, &GPIO_InitStruct);
```

```
GPIO_InitTypeDef GPIO_InitStruct = {0};
__HAL_RCC_GPIOC_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_13;
GPIO_InitStruct.Mode = GPIO_MODE_IT_RISING;
GPIO_InitStruct.Pull = GPIO_NOPULL;
HAL_GPIO_Init(GPIOC, &GPIO_InitStruct);
```

Examples (Analog)

```
__HAL_RCC_GPIOA_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_3;
GPIO_InitStruct.Mode = GPIO_MODE_ANALOG;
GPIO_InitStruct.Pull = GPIO_NOPULL;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
```

Examples (Alternate Function)

Table 12. STM32F427xx and STM32F429xx alternate function mapping

Port		AF0	AF1	AF2	AF3	AF4	AF5	AF6	AF7	AF8	AF9	AF10	AF11	AF12	AF13	AF14	AF15
		SYS	TIM1/2	TIM3/4/5	TIM8/9/10/11	I2C1/2/3	SPI1/2/3/4/5/6	SPI2/3/SAI1	SPI3/USART1/2/3	USART6/UART4/5/7/8	CAN1/2/TIM12/13/14/LCD	OTG2_HS/OTG1_FS	ETH	FMC/SDIO/OTG2_FS	DCMI	LCD	SYS
Port A	PA0	-	TIM2_CH1/TIM2_ETR	TIM5_CH1	TIM8_ETR	-	-	-	USART2_CTS	UART4_TX	-	-	ETH_MII_CRS	-	-	-	EVENTOUT
	PA1	-	TIM2_CH2	TIM5_CH2	-	-	-	-	USART2_RTS	UART4_RX	-	-	ETH_MII_RX_CLK/ETH_RMII_REF_CLK	-	-	-	EVENTOUT
	PA2	-	TIM2_CH3	TIM5_CH3	TIM9_CH1	-	-	-	USART2_TX	-	-	-	ETH_MDIO	-	-	-	EVENTOUT
	PA3	-	TIM2_CH4	TIM5_CH4	TIM9_CH2	-	-	-	USART2_RX	-	-	OTG_HS_ULPI_D0	ETH_MII_COL	-	-	LCD_B5	EVENTOUT
	PA4	-	-	-	-	-	SPI1_NSS	SPI3_NSS/I2S3_WS	USART2_CK	-	-	-	-	OTG_HS_	DCMI_	LCD_	EVENTOUT
	PA5	-	TIM2_CH1/TIM2_ETR	-	TIM8_CH1N	-	SPI1_SCK	-	-	-	-	-	-	-	-	-	-
	PA6	-	TIM1_BKIN	TIM3_CH1	TIM8_BKIN	-	SPI1_MISO	-	-	-	-	-	-	-	-	-	-
	PA7	-	TIM1_CH1N	TIM3_CH2	TIM8_CH1N	-	SPI1_MOSI	-	-	-	-	-	-	-	-	-	-
	PA8	MCO1	TIM1_CH1	-	-	I2C3_SCL	-	-	USART1_CK	-	-	-	-	-	-	-	-
	PA9	-	TIM1_CH2	-	-	I2C3_SMBA	-	-	USART1_TX	-	-	-	-	-	-	-	-
	PA10	-	TIM1_CH3	-	-	-	-	-	USART1_RX	-	-	ID	-	-	D1	-	TOUT
	PA11	-	TIM1_CH4	-	-	-	-	-	USART1_CTS	-	CAN1_RX	OTG_FS_DM	-	-	-	LCD_R4	EVENTOUT
	PA12	-	TIM1_ETR	-	-	-	-	-	USART1_RTS	-	CAN1_TX	OTG_FS_	-	-	-	LCD_R5	EVEN

```
__HAL_RCC_GPIOA_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_0;
GPIO_InitStruct.Mode = GPIO_MODE_AF_PP;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
GPIO_InitStruct.Alternate = GPIO_AF1_TIM2;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
```

```
__HAL_RCC_GPIOA_CLK_ENABLE();
GPIO_InitStruct.Pin = GPIO_PIN_0;
GPIO_InitStruct.Mode = GPIO_MODE_AF_OD;
GPIO_InitStruct.Pull = GPIO_PULLUP;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
GPIO_InitStruct.Alternate = GPIO_AF1_TIM2;
HAL_GPIO_Init(GPIOA, &GPIO_InitStruct);
```

Conclusions

- Some STM32 microcontroller pins can be configured for different functions
  - Use HAL to configure the PIN in the initialization of your system
  - Check the reference manual to see the Alternate Functions (to be used for timers, SPI, I2C, etc)
  - Review the HAL_GPIO code in Keil environment