Additional Timer Functionalities Capture, Compare and PWM

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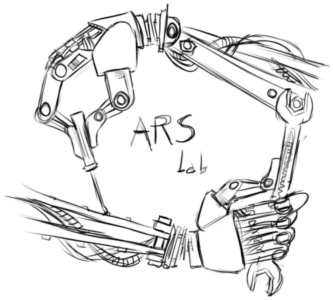

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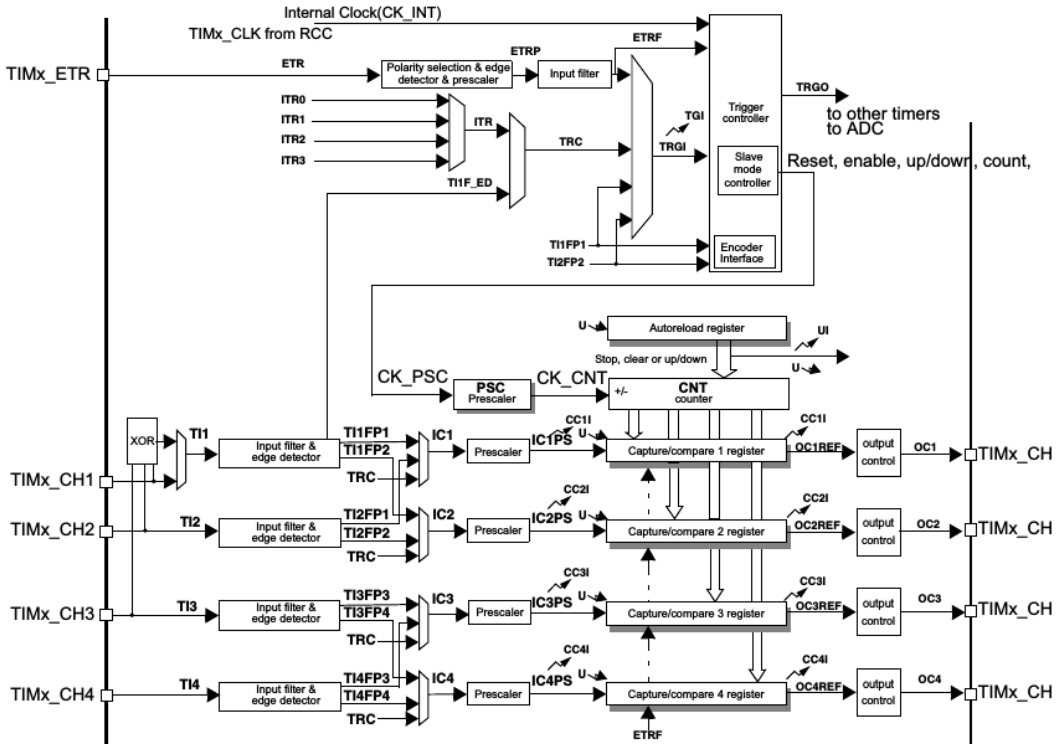
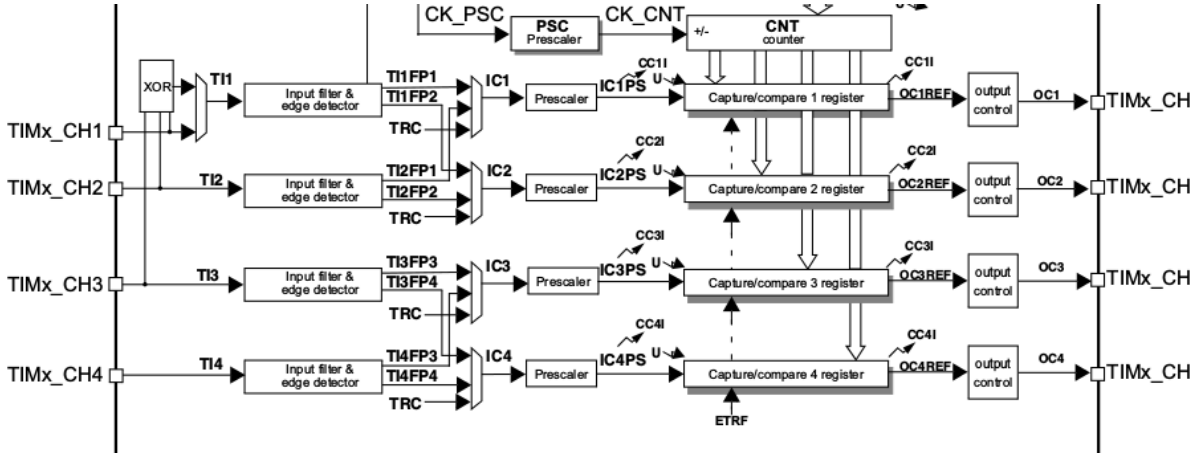
Timer Slave Circuits



- Timers has **slave circuits** that can be used
  - to generate particular periodic signals
  - to measure the period or pulse of input signals

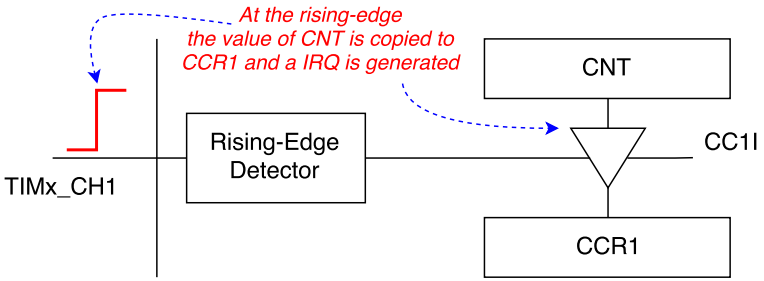
Timer Slave Circuits

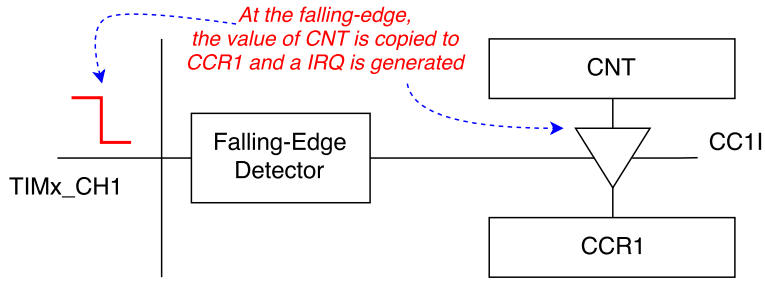


- Each STM32 timer has **four slave channels**
- Each channel can be **connected to a GPIO line** and can be programmed for:
  - input capture
  - PWM input measurement
  - output compare
  - PWM output generation
  - Each channel as an additional register **CCRy** (y is the channel number) that has the same size of the counter register

Input Capture

Input Capture





- When a channel **y** is configured as **input capture** the relevant GPIO line must be configured as **input**
- The capture circuit is able to **detect an edge (rising or falling)** in the input signal, according to configuration
- Then the **edge occurs** the value of the **CNT** is copied to **CCRy**
- A **capture-event interrupt** is generated

stm32_unict_lib Functions for Input Capture

- Configure the channel:

```
void TIM_config_IC(TIM_TypeDef * tim,
                   int channel, IC_Mode mode)
```

  - **tim**, the Timer
  - **channel**, the slave channel, from 1 to 4
  - **mode**, the capture mode, `IC_RISING_EDGE`, `IC_FALLING_EDGE`, `IC_BOTH_EDGES`

- Check a capture event:

```
int TIM_cc_check(TIM_TypeDef * tim, int channel)
```

  - **tim**, the Timer
  - **channel**, the slave channel, from 1 to 4
  - returns “true” or “false”

- Clear a capture event:

```
void TIM_cc_clear(TIM_TypeDef * tim, int channel)
```

  - **tim**, the Timer
  - **channel**, the slave channel, from 1 to 4

Case-Study: a “Reaction Test” Game

- We want to measure the **reaction time** of a person
- We lit a LED and wait for the person to press a button
- We mesure the **time** between LED lighting and button press
- After 5 secs, we notify a **timeout**

Case-Study: a “Reaction Test” Game

- We want to measure the **reaction time** of a person
  - We use a timer with a “capture” function
- We lit a LED
  - We set to “1” the GPIO and reset the timer
- and wait for the person to press a button
  - We wait for capture interrupt
- We mesure the **time** between LED lighting and button press
  - We read the capture-compare register
- After 5 secs, we notify a **timeout**
  - We use the “period match” (ARR)

Case-Study: a “Reaction Test” Game (1)

```
#include "stm32_unict_lib.h"

int main()
{
  DISPLAY_init();
  GPIO_init(GPIOB);
  GPIO_config_output(GPIOB, 0); // the LED
  GPIO_config_alternate(GPIOB, 4, 2); // button "Y" as AF2 --> TIM3,CH1

  TIM_init(TIM3);
  TIM_config_timebase(TIM3, 8400, 50000); // prescaler at 100us timeout of 5 secs
  TIM_config_IC(TIM3, 1, IC_FALLING_EDGE); // capture on falling-edge (pushbutton)
  TIM_set(TIM3, 0);
  TIM_on(TIM3);
  TIM_enable_irq(TIM3, IRQ_UPDATE | IRQ_CC_1);

  ...
}
```

Case-Study: a “Reaction Test” Game (2)

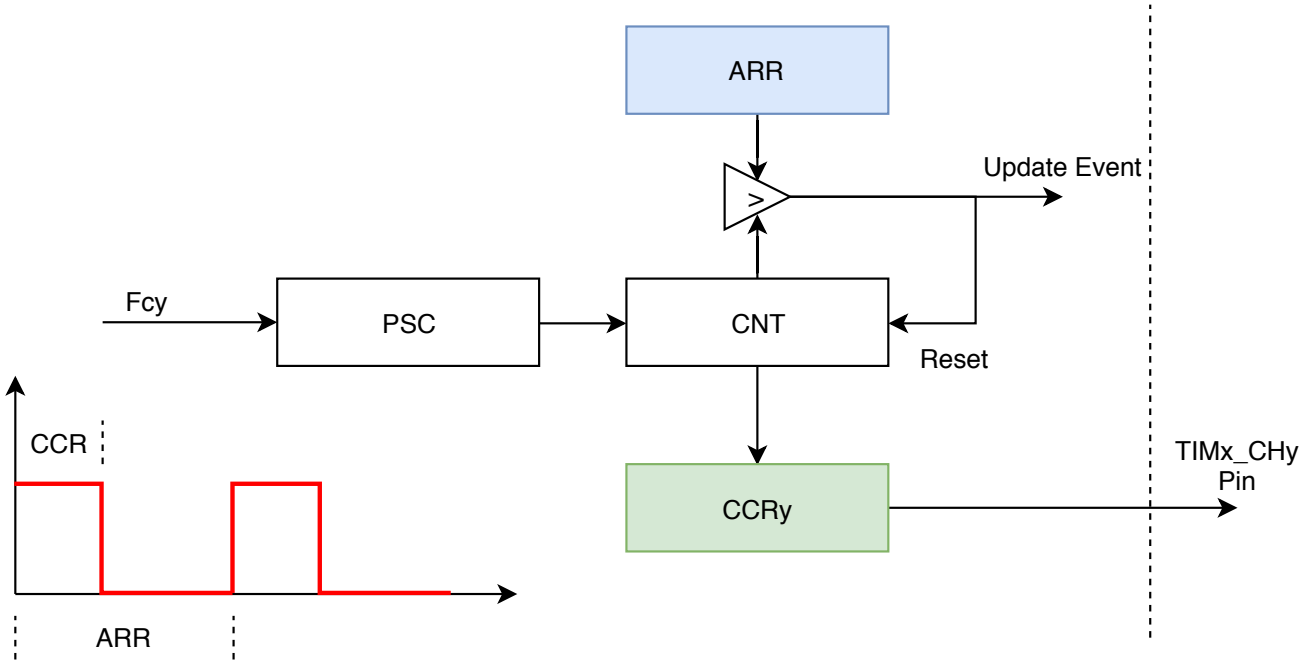
```
int main()
{
  ...
  for (;;) {
    delay_ms(3000); // wait 3 seconds to start the game
    TIM_set(TIM3, 0); // clear timer and flags
    measure_done = 0;
    timeout = 0;
    GPIO_write(GPIOB, 0, 1); // turn on LED
    DISPLAY_puts(0, "␣␣␣␣");
    while (!measure_done && !timeout) ;  // wait for capture or timeout
    if (measure_done) {
      // capture OK!
      int ms = TIM3->CCR1 / 10;
      char s[4];
      sprintf(s,"%4d", ms);
      DISPLAY_puts(0, s);
    }
    else {
      // timeout
      DISPLAY_puts(0, "tout");
    }
  }
}

...
```

Case-Study: a “Reaction Test” Game (3)

```
void TIM3_IRQHandler(void)
{
  if (TIM_update_check(TIM3)) {
    // period match, timeout
    GPIO_write(GPIOB, 0, 0);
    timeout = 1;
    TIM_update_clear(TIM3);
  }
  if (TIM_cc_check(TIM3,1)) {
    // capture
    GPIO_write(GPIOB, 0, 0);
    measure_done = 1;
    TIM_cc_clear(TIM3,1);
  }
}
```

PWM Output

PWM Output



- A channel **y** can be configured to generate a **PWM Signal** with specific **frequency/period and duty cycle**
- the **period** is given in terms of **count units** and the value must be assigned to **ARR** register
- the duty cycle is specified as the duration of **positive part**, it is given in terms of **count units** and the value must be assigned to **CCRy** register

stm32_unict_lib Functions for PWM Output

- To configure a channel in PWM mode the following function is provided:
  `void TIM_config_PWM(TIM_TypeDef * tim, int channel)`
  - **tim**, the Timer
  - **channel**, the slave channel, from 1 to 4
- The **period** is set as the "autoreload" parameter in the `TIM_config_timebase` function
- The **duty cycle** is set by assiging the **CCRy** register

Case-Study: LED intensity control using PWM

```
#include <stdio.h>
#include "stm32_unict_lib.h"

#define PERIOD_PWM   1000

int main(void)
{
  DISPLAY_init();
  GPIO_init(GPIOB);
  GPIO_config_alternate(GPIOB, 0, 2); // AF2 --> TIM3_CH3

  ADC_init(ADC1, ADC_RES_8, ADC_ALIGN_RIGHT);
  ADC_channel_config(ADC1, GPIOC, 0, 10);
  ADC_on(ADC1);
  ADC_sample_channel(ADC1, 10);

  TIM_init(TIM3);
  TIM_config_timebase(TIM3, 420, PERIOD_PWM);
  TIM_set(TIM3, 0);
  TIM_config_PWM(TIM3, 3); // channel 3
  TIM_on(TIM3);

  for (;;) {
    ADC_start(ADC1);
    while (!ADC_completed(ADC1)) {}
    int t_on = (ADC_read(ADC1) * 1000)/255;
    TIM3->CCR3 = t_on;
    char s[4];
    sprintf(s, "%4d", t_on);
    DISPLAY_puts(0,s);
  }
  return 0;
}
```

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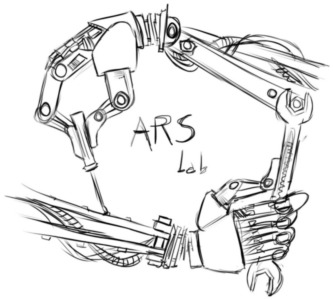

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