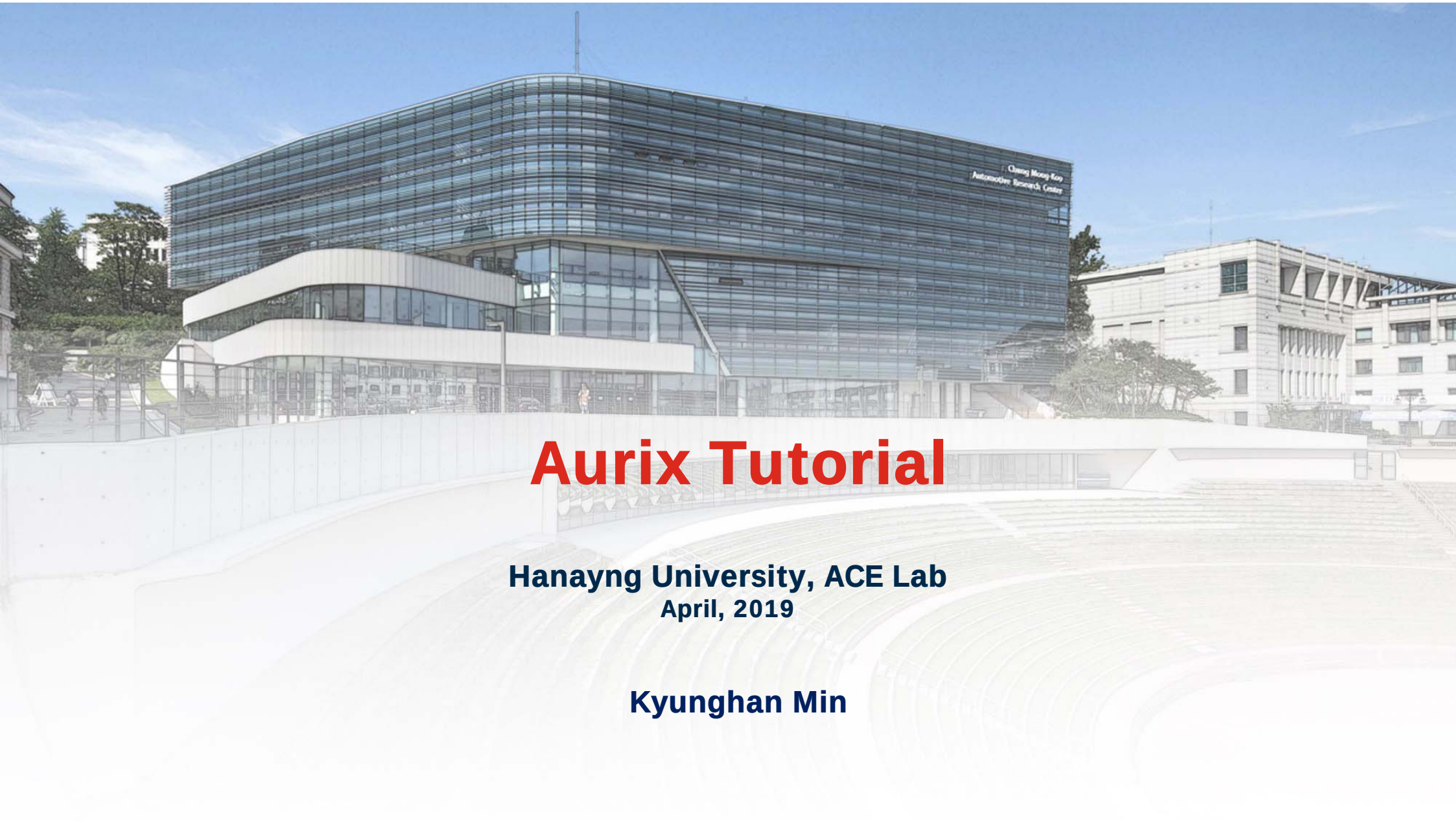


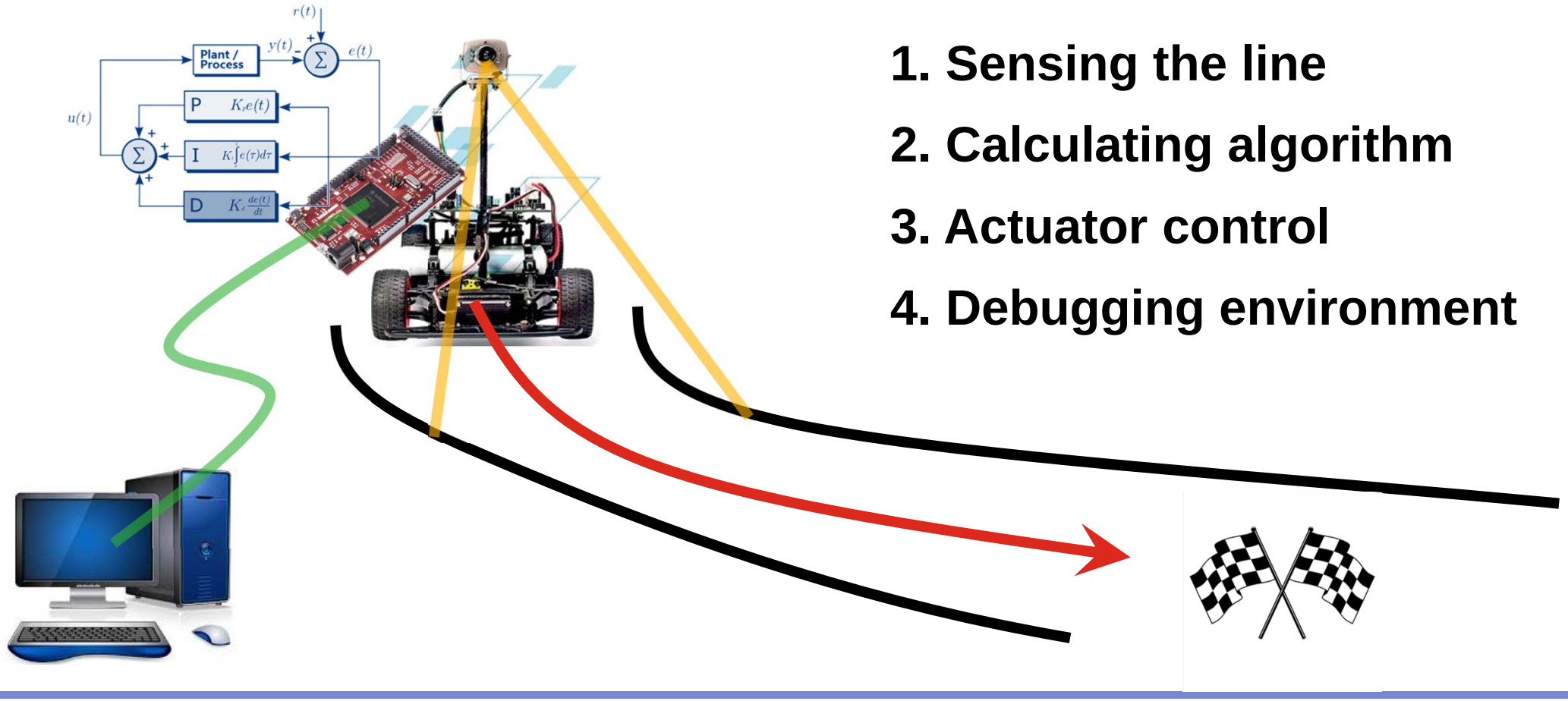
Aurix Tutorial

Hanayng University, ACE Lab
April, 2019

Kyunghan Min

Course overview

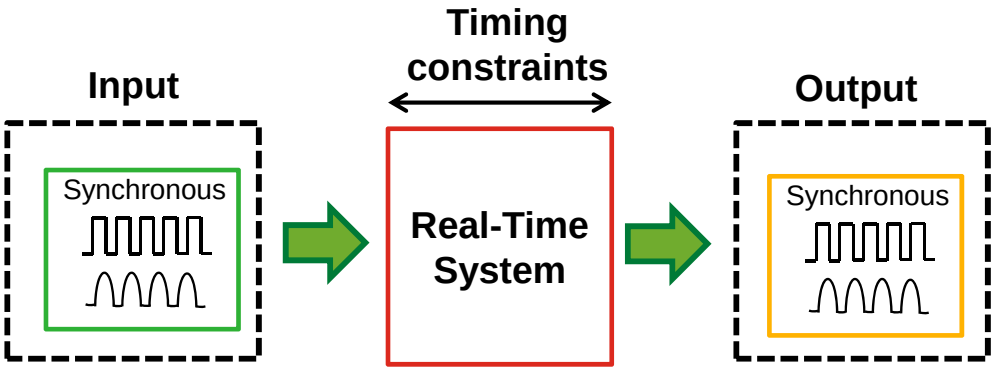
- What are need to complete the racing??



1. Sensing the line
2. Calculating algorithm
3. Actuator control
4. Debugging environment

Course overview

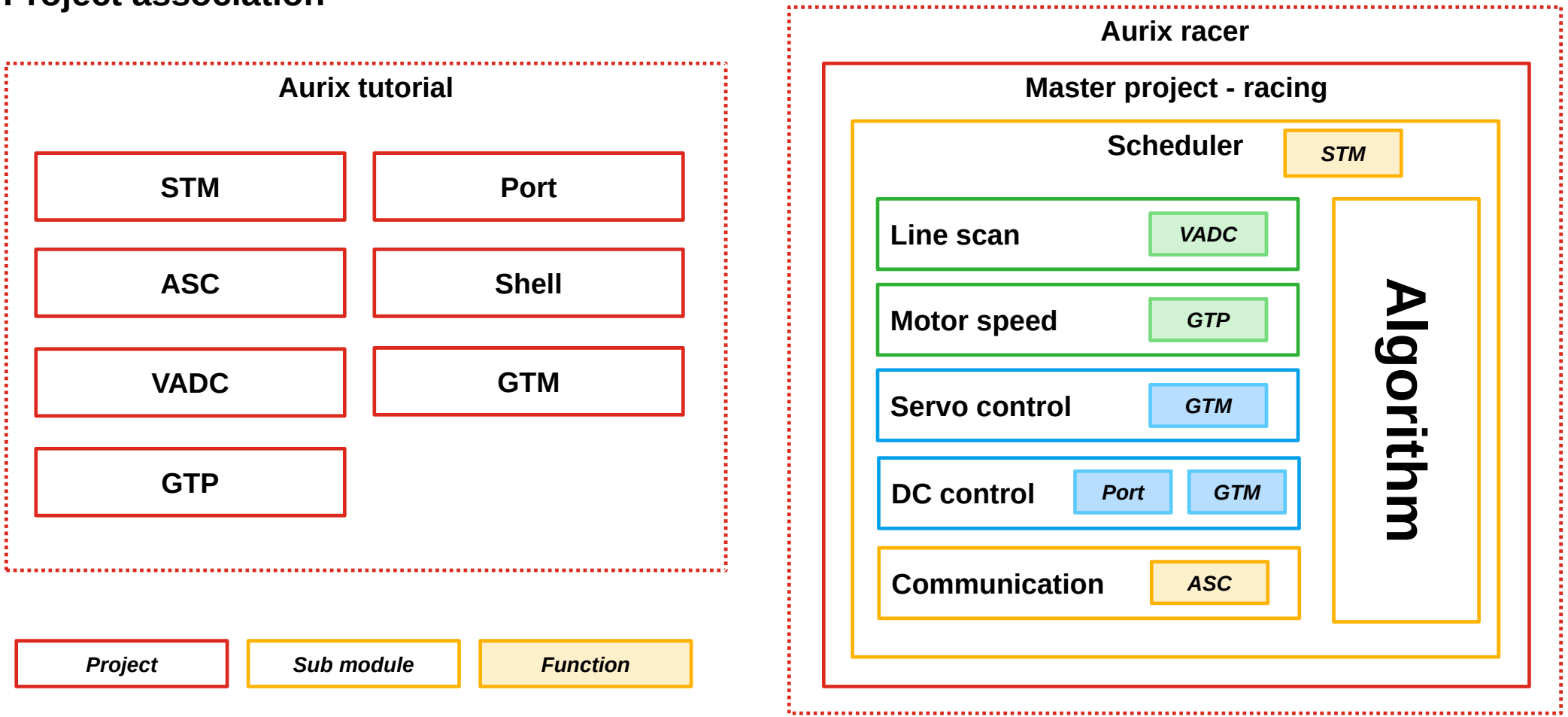
- Calculating algorithm: Determination of correct value within timing constraints
  - Interrupt, System timer module



- Sensing
  - Line scan: Vadc
  - Motor speed: Gpt12
- Actuating
  - DC motor, Servo motor: GtmTom
- Debugging
  - ASC & Terminal

Course overview

Project association



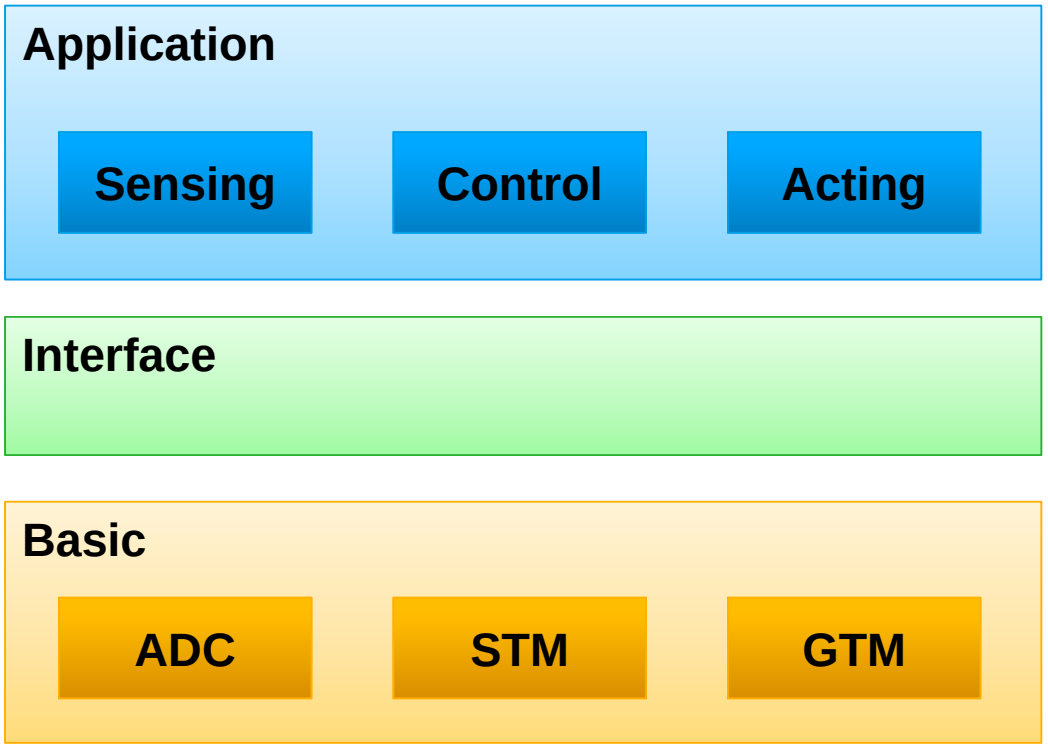
Contents

- System timer module
- iLLD (Infineon Low Level Driver)
- Communication
- Analog to digital converter
- Pulse width modulation
- Pulse accumulation

iLLD

Low level driver and its demo code by Infineon

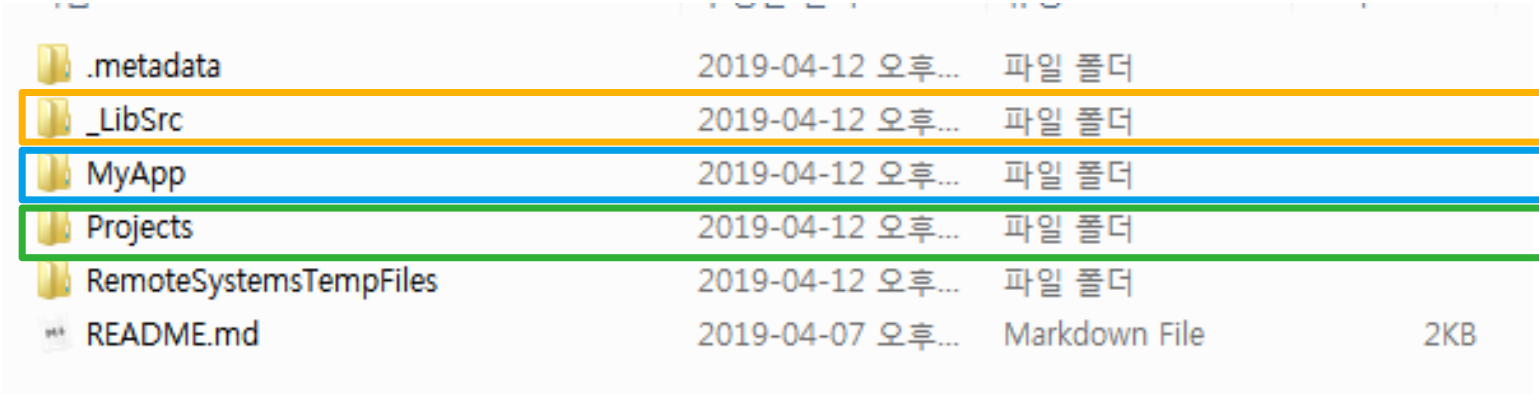
- Provide interface functions and variables



iLLD Demos

Infineon Low Level Driver

AurixTutorial and iLLD



iLLD

Application

Project

src: Work space

MyIlldModule_SB~ **MyIlldModule_AK~** **_iLLD_Framework_SB~** ○ ○ ○

MyIlldModule

iLLD

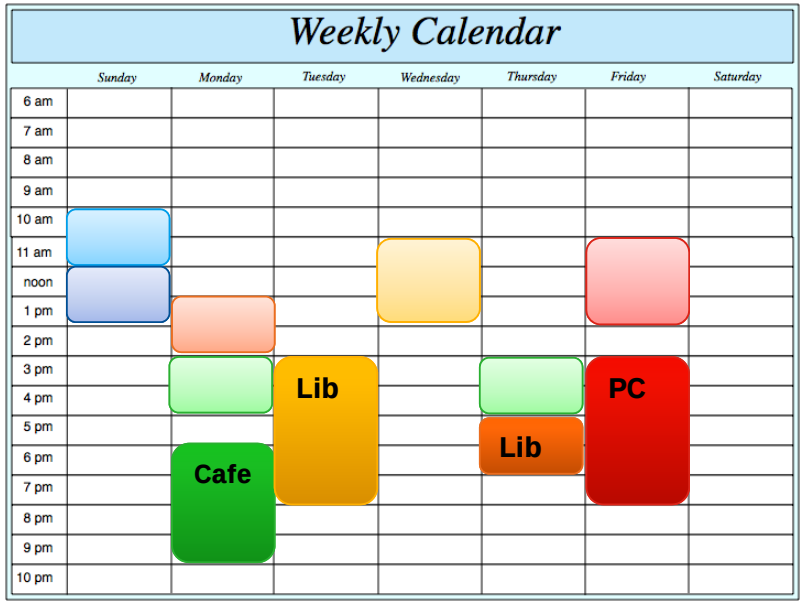
MyStm_SB~

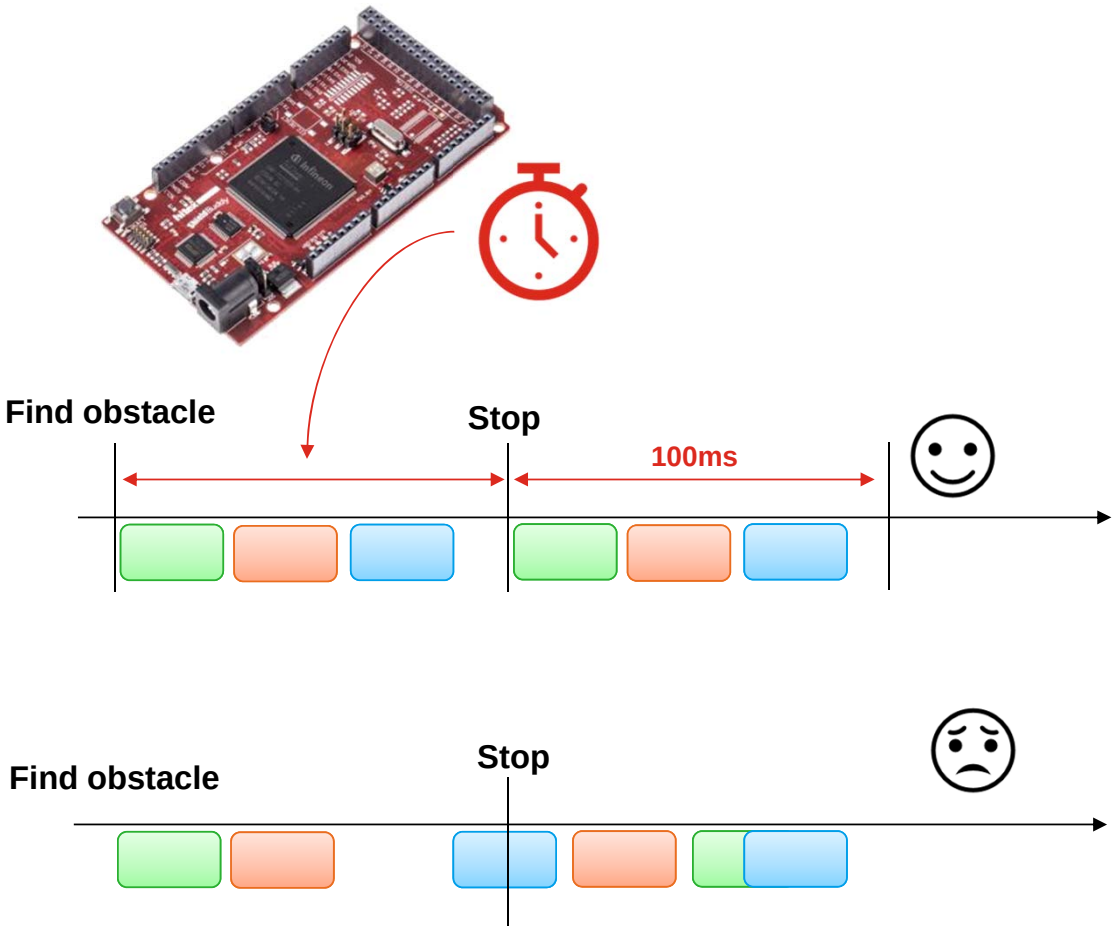
MyStmDemo

iLLD

STM

Scheduler





Concept of interrupt

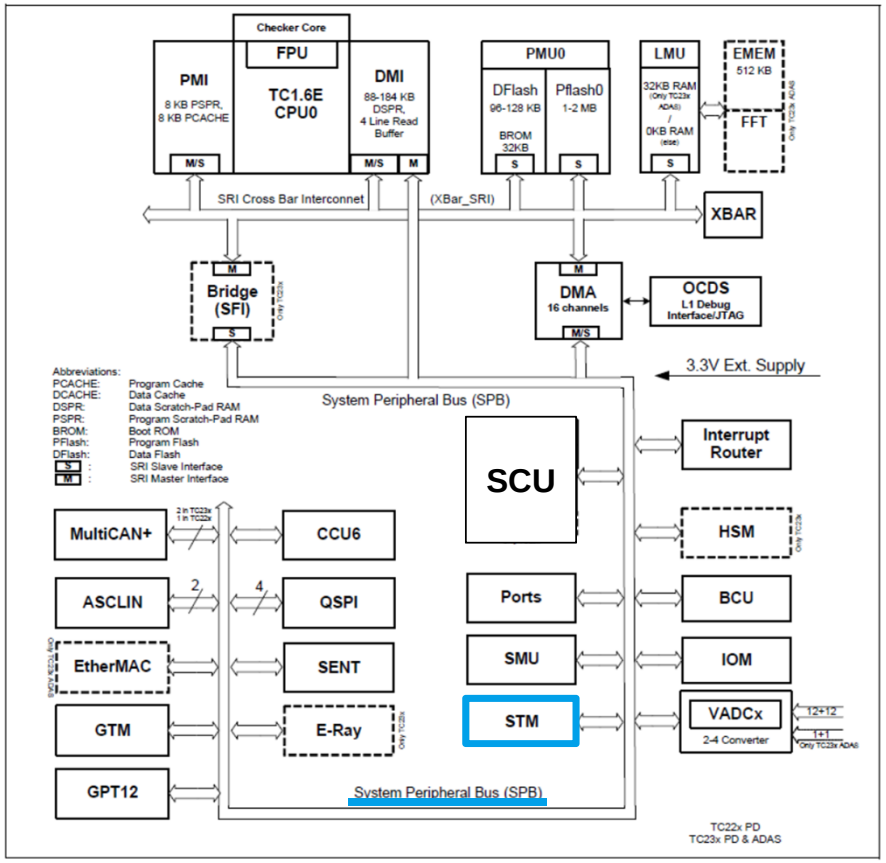
Algorithm (Main)
– computer work

Interrupt (Timer)
– phone call

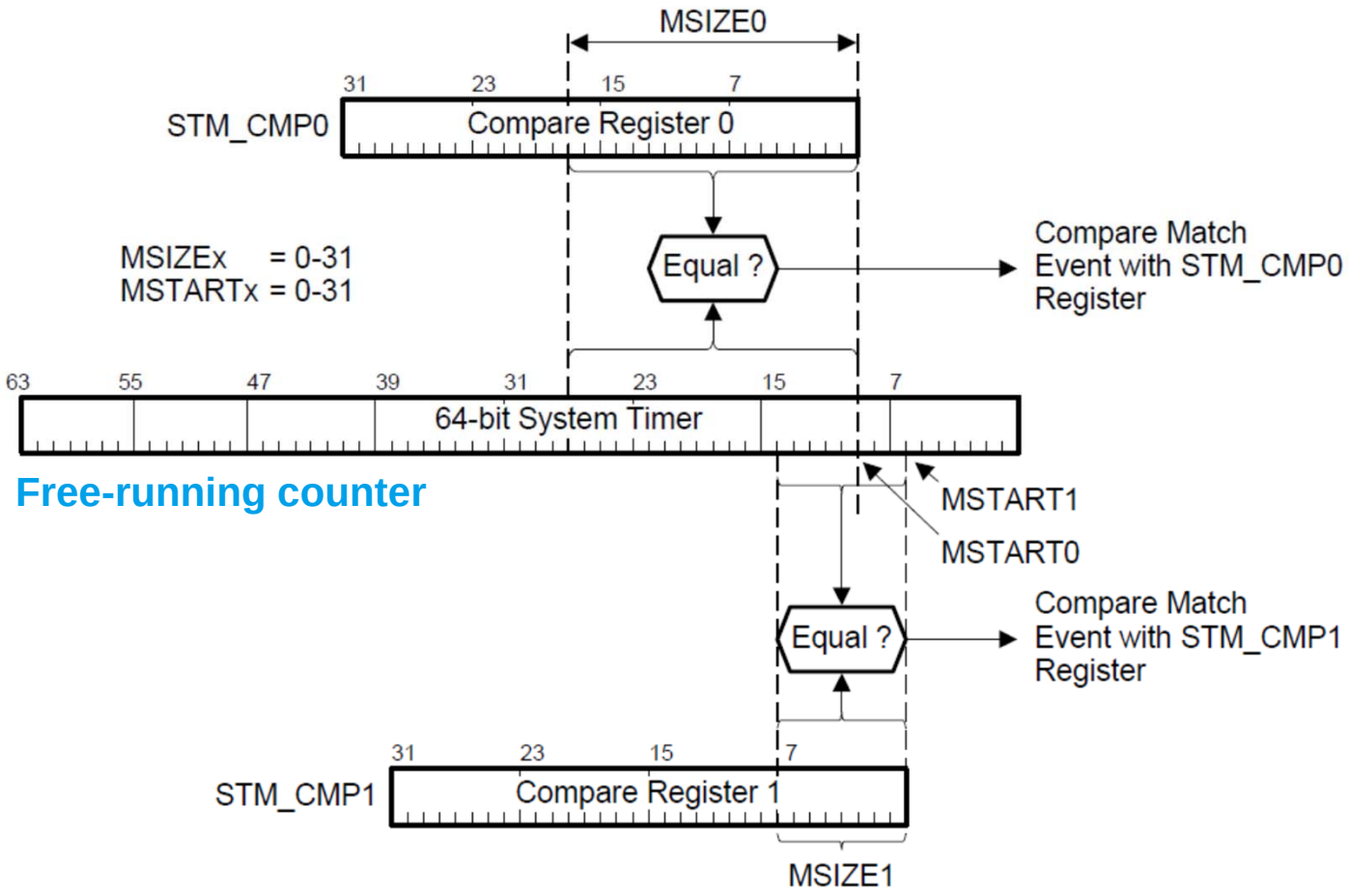
Algorithm (Main)
– computer work

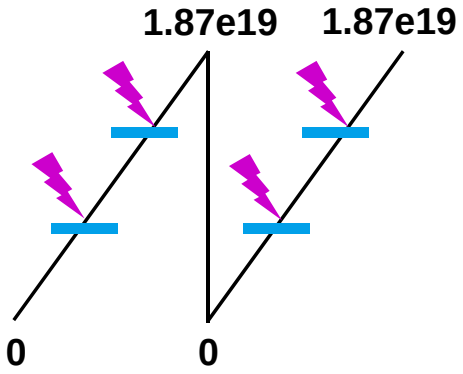
Features of system timer (STM)

- 64-bit free-running counter of the STM
- Use of SPB clock as source clock of the STM
- Generation of a service request (interrupt) based on compare match with STM content

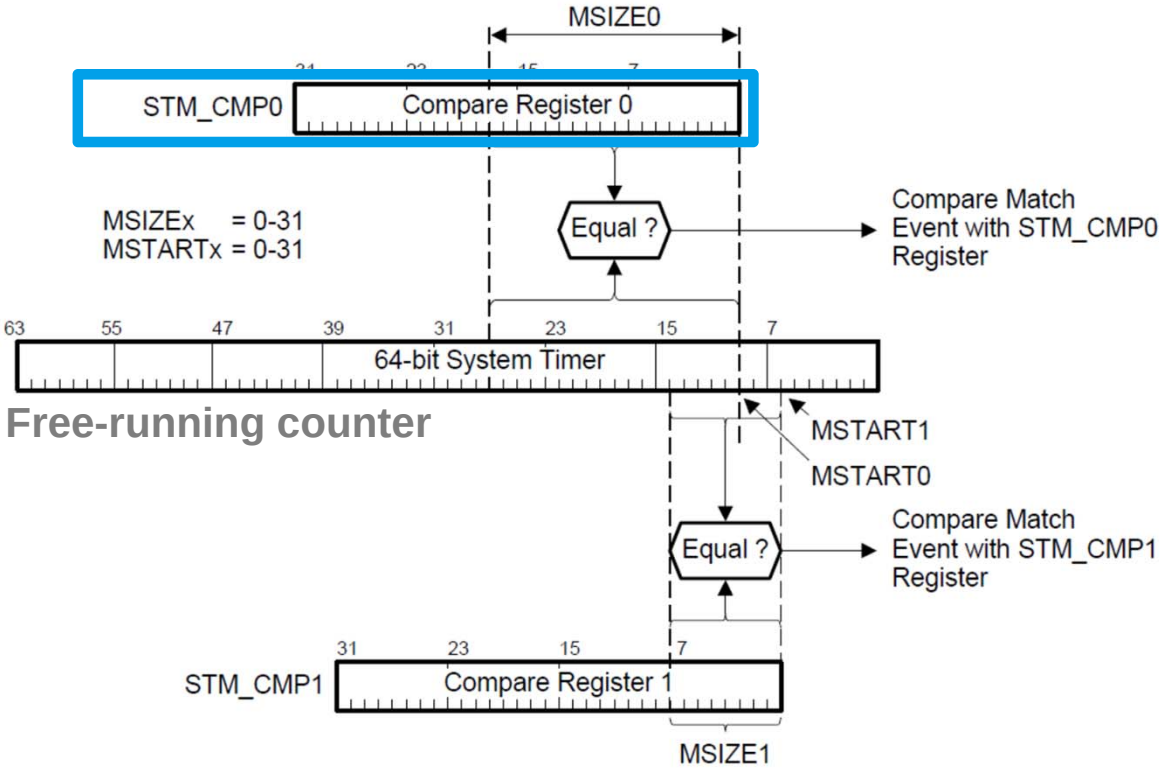


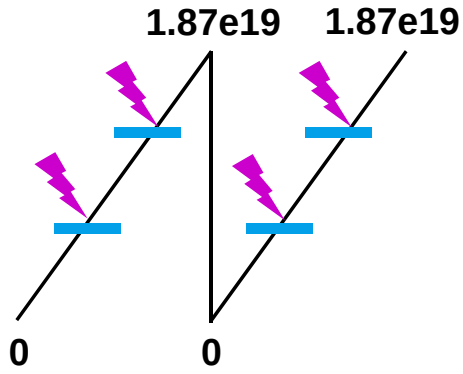
Generation of STM interrupt





Update of the compare value





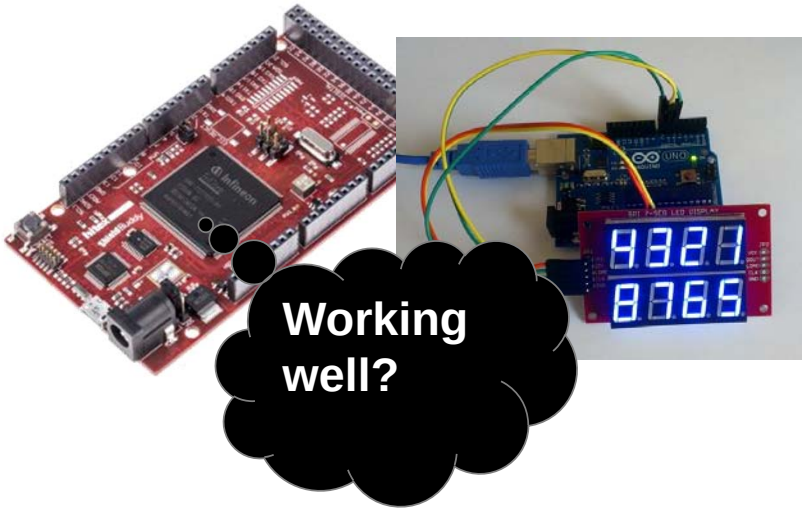
ASC

Debugging of cross platform development

Host System

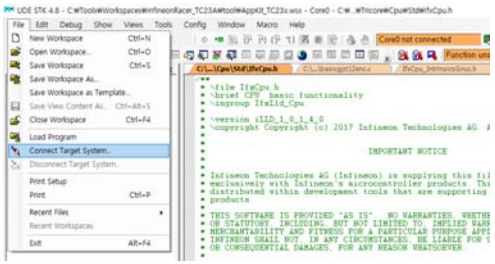
Algorithm designed by Human

Target System

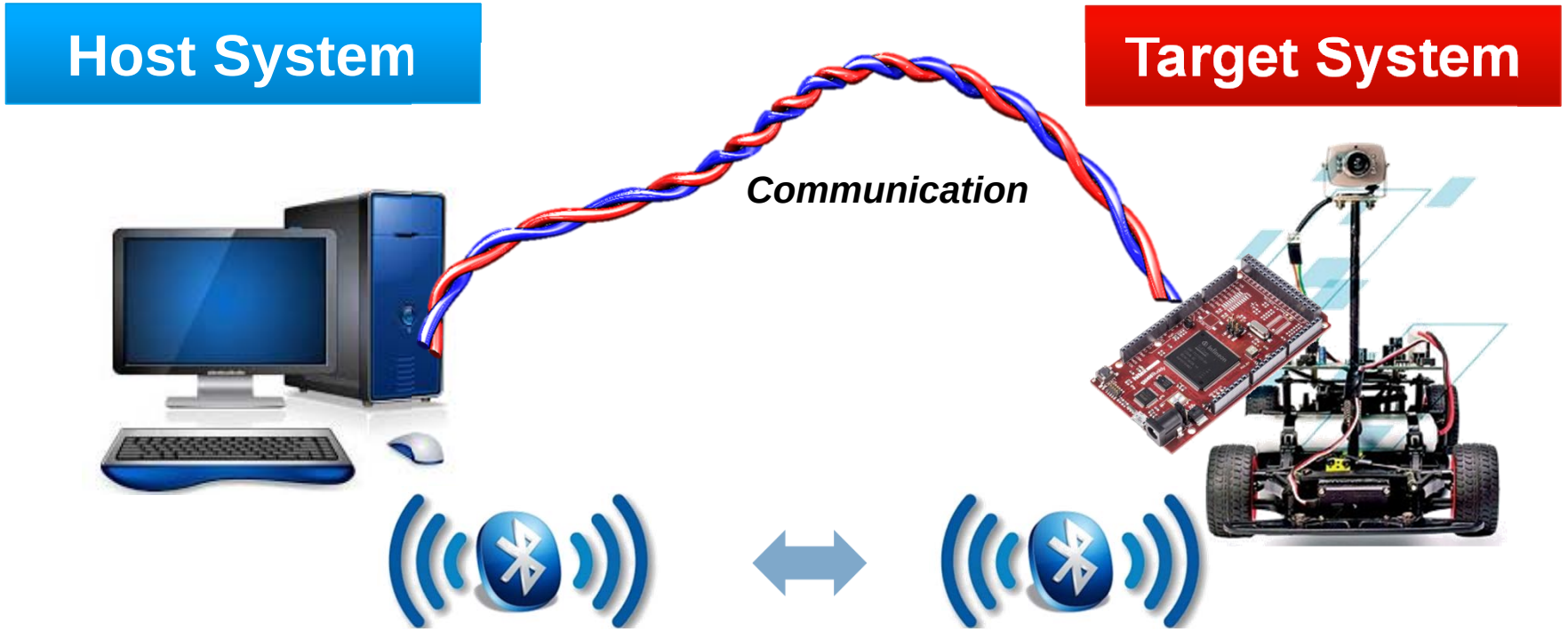


Download

Debugging program

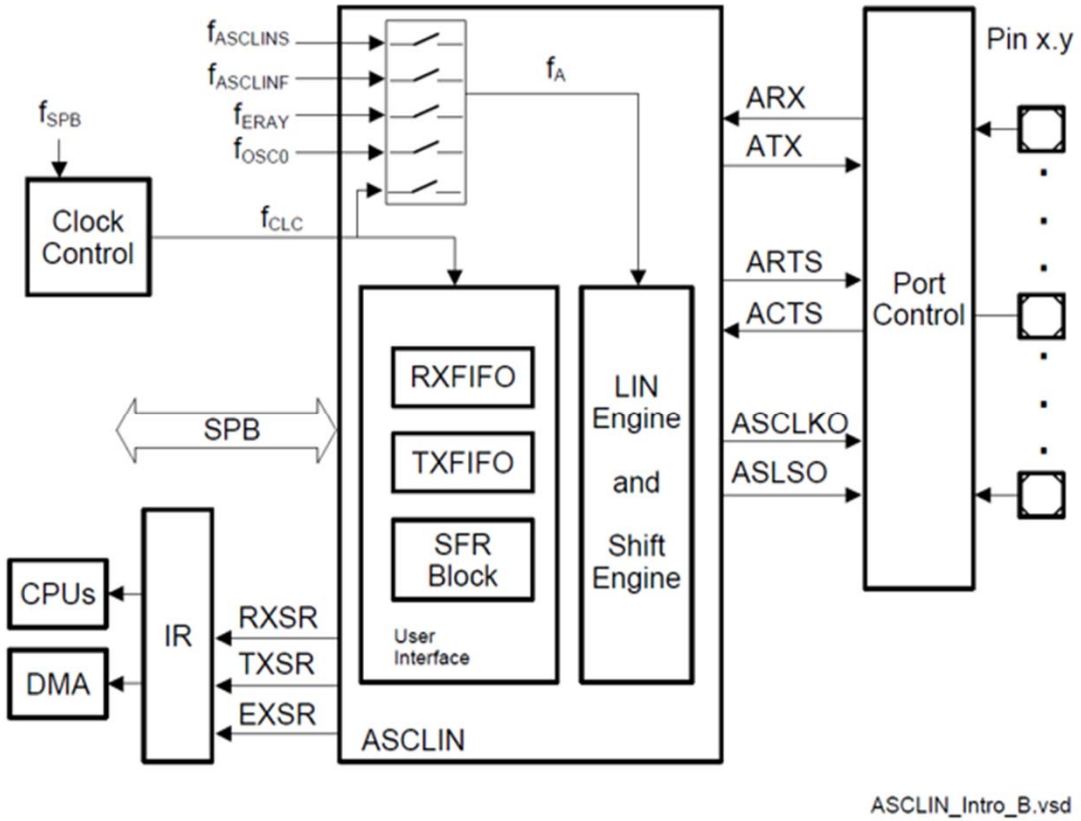


Debugging of cross platform development



SCI communication

- 16 bytes TxFIFO, 16 bytes RxFIFO
- Pack / unpack capabilities of the Tx and Rx FIFO
- Interrupt generation

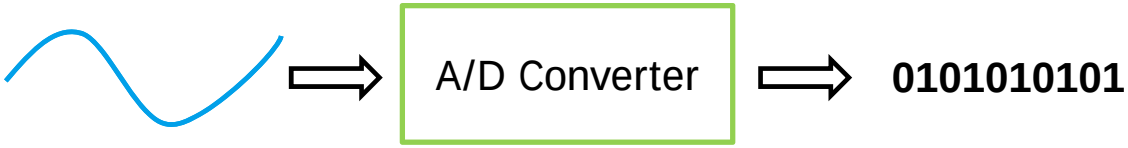


ADC

Introduction to A/D Converter (I)

A/D Converter

- Physical parameters (temperature, pressure, light intensity, and etc.)
  - Continuous and analog
- Unfortunately, microcontroller only understands '0' and '1'
- A/D converter can convert physical parameters into digital variables

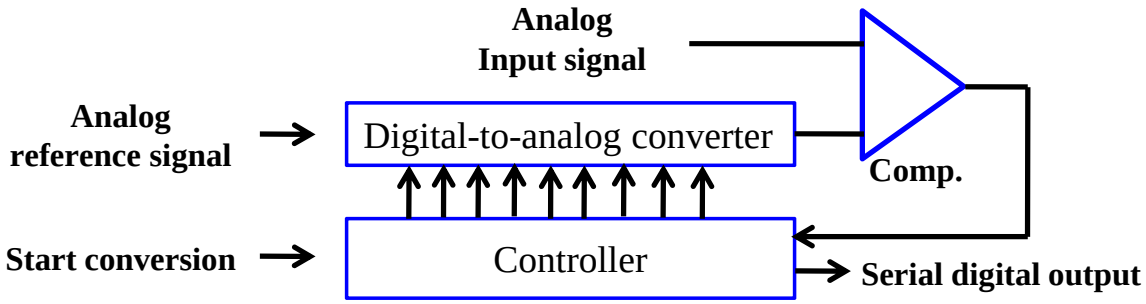


A/D Converter technologies

- Successive-approximation converter
- Integration-based converters
- Counter type converters
- Parallel converters

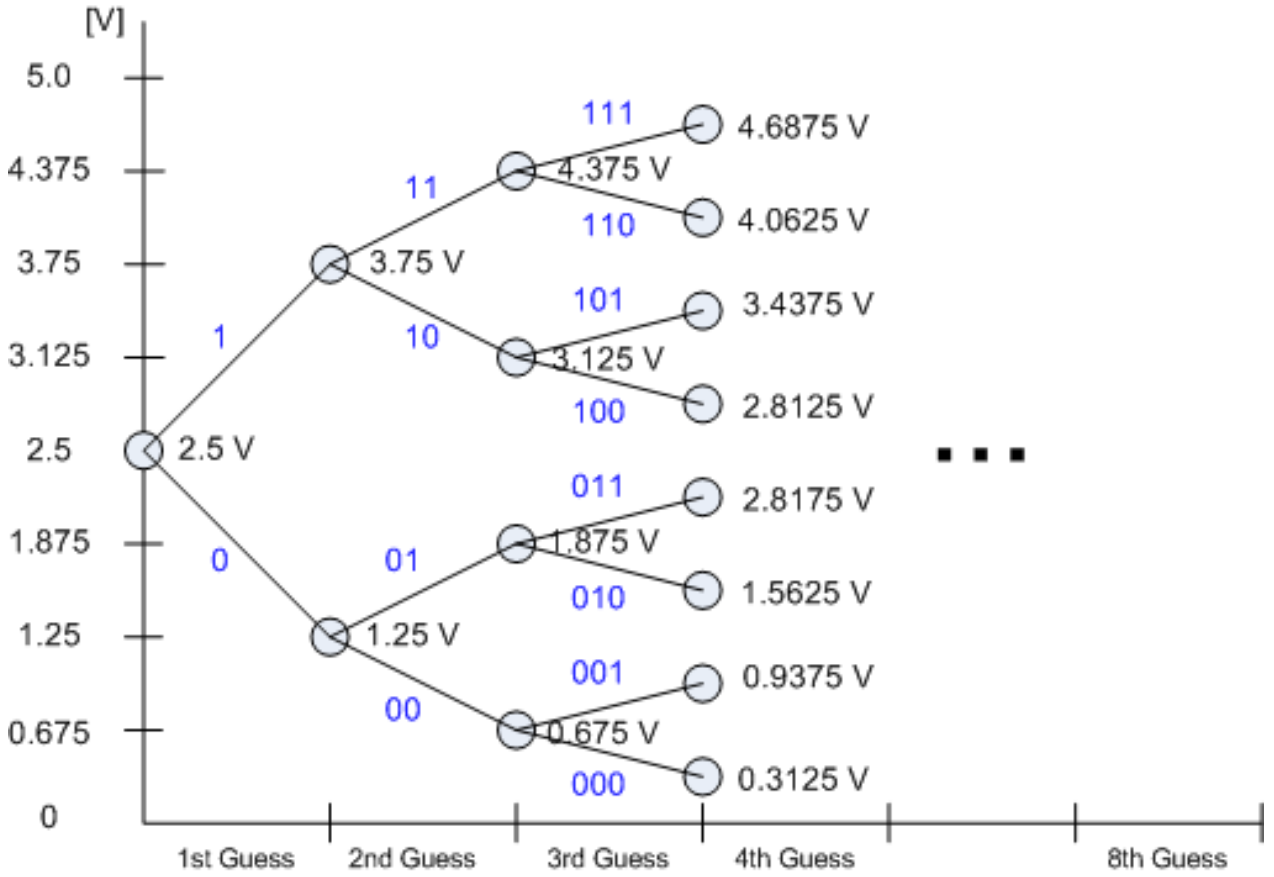
Successive-approximation converter

- Advantages
  - The conversion time is fixed and independent of the magnitude of the analog sample
  - Each conversion process is independent and unique of the results of previous conversions
- Disadvantages
  - The hardware implementation is quite complex
  - Relative to other conversion techniques, successive-approximation is slower



Introduction to A/D Converter (III)

Successive-approximation converter



Introduction to A/D Converter (IV)

Quantization and resolution of A/D Converter

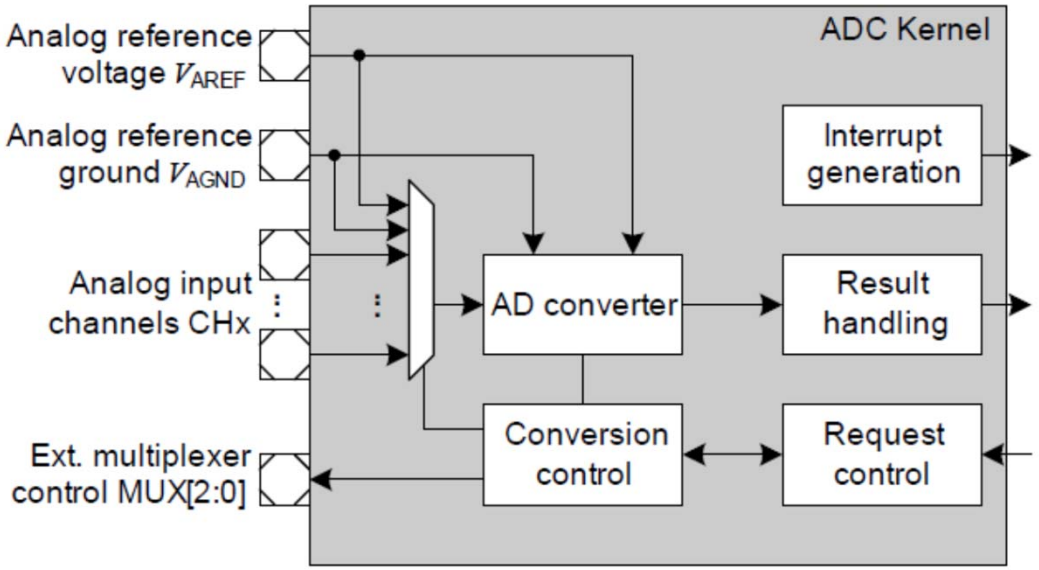
- Terms
  - V_{AREF}: Analog reference
  - V_{AGND}: Analog ground
- Resolution

  = $(V_{AREF}-V_{AGND})$ / (Number of steps)

  = $(V_{AREF}-V_{AGND}) / 2^b$
- Example
  - V_{AREF} = 5V, V_{AGND} = 0V, 12-bit A/D Converter
  - Resolution = $(5 – 0)/2^{12}$ = 1.22 mV/steps

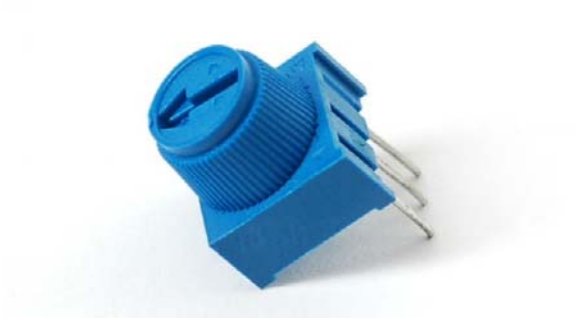
ADC of Tricore 237

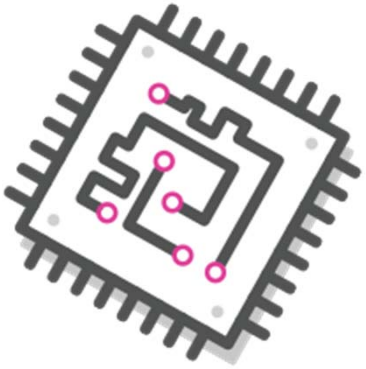
- Programmable conversion sequence (single or repeated)
- Selectable conversion resolution (8/10/12 bits)
- Conversions triggered by software, timer events, or external events
- Conversion speed and sample time adjustable to adapt to sensors and reference

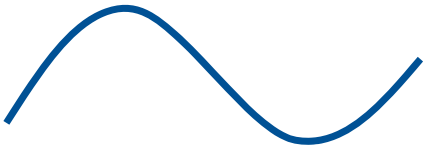


PWM

ADC (Analog to Digital Convertor)







Analog signal

Digital signal

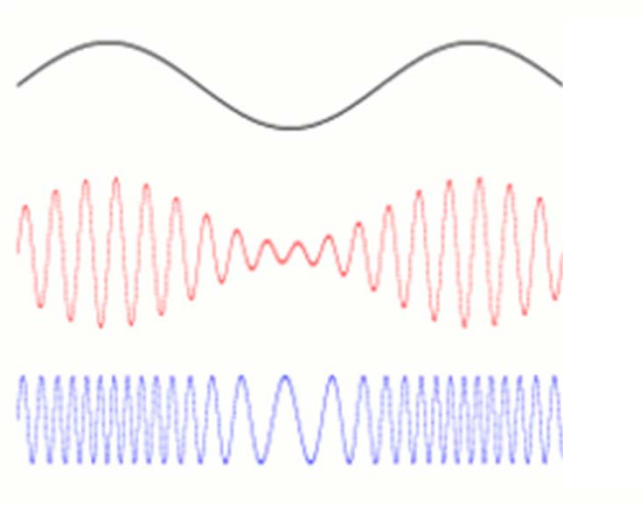
Modulation

The way to generate the analog signal at the digital system

Signal:

AM:
(Amplitude Modulation)

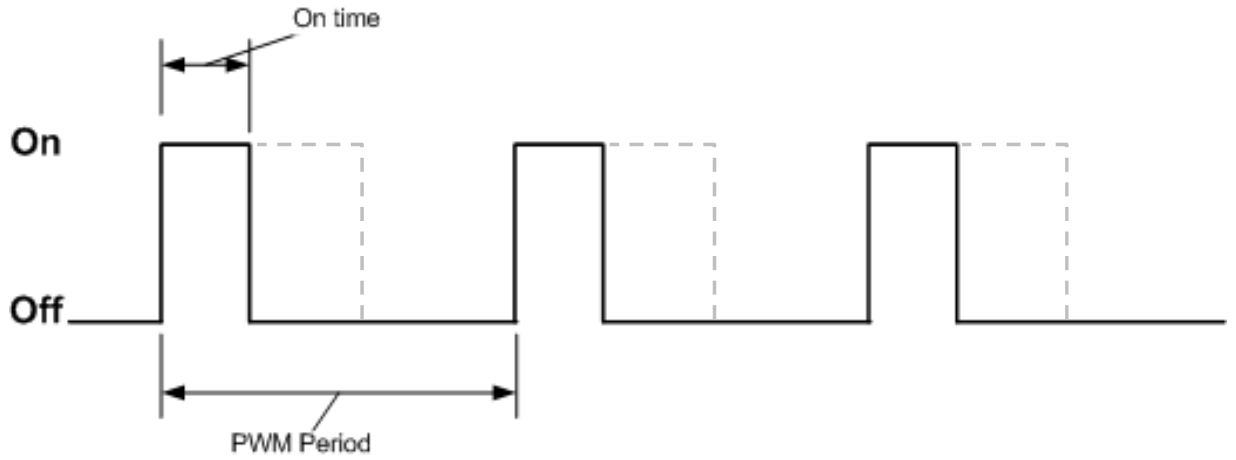
FM:
(Frequency Modulation)



Introduction to PWM (I)

Pulse Width Modulation (PWM)

- A powerful technique for controlling analog circuits with a processor's digital outputs



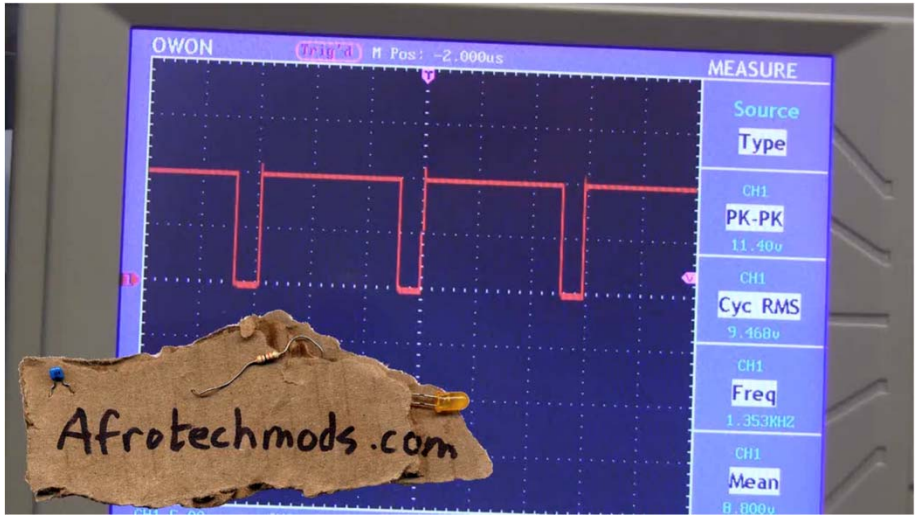
$$Duty\ Cycle(\%) = \frac{On\,time}{period} \times 100$$

$$Effective\ Voltage(\mathrm{V}) = VDC \times Duty\ Cycle$$

Introduction to PWM (II)

Applications

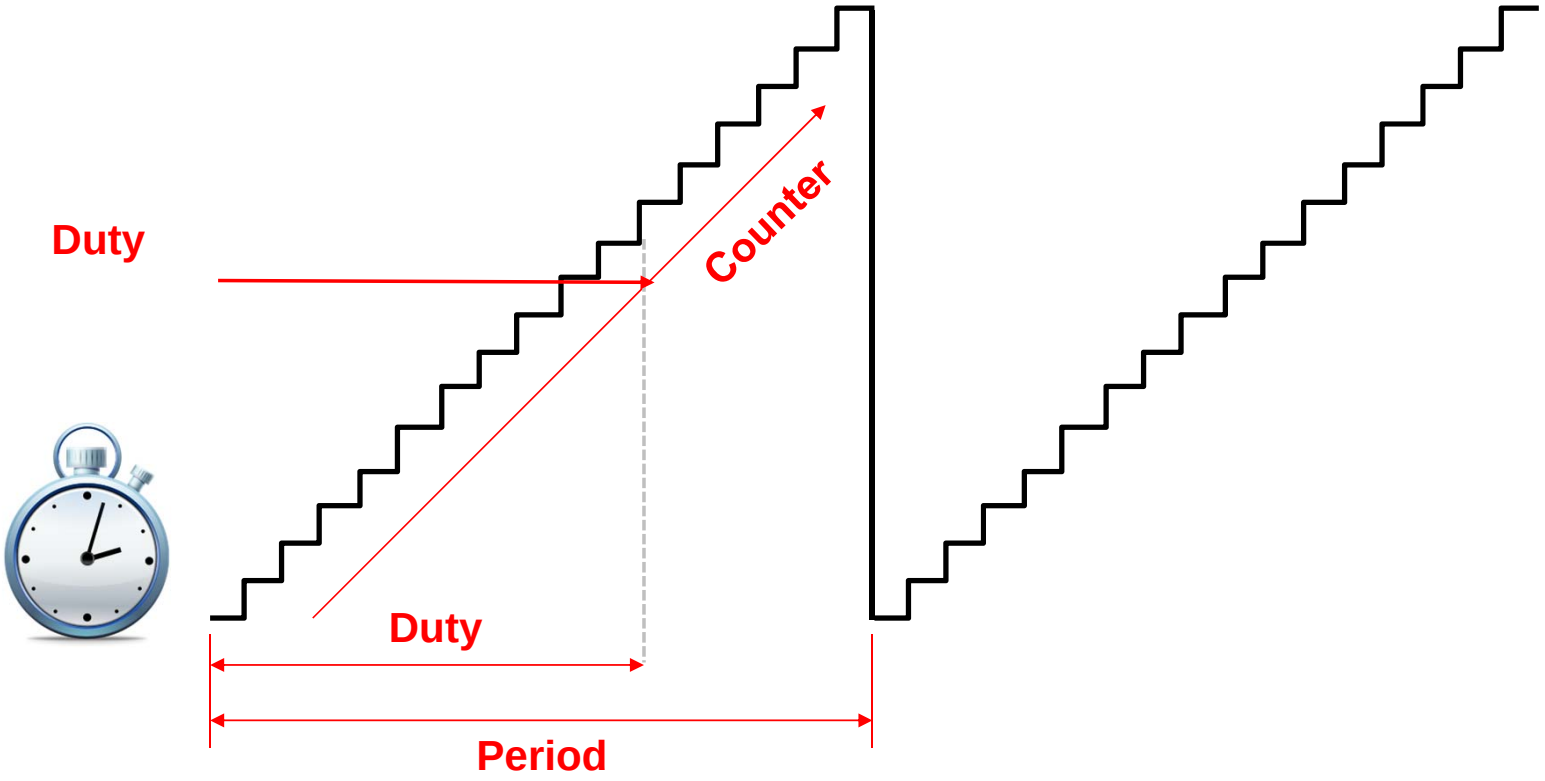
- Telecommunication
- Power delivery
- Motor Control
- Voltage regulation
- …



※ Reference: Afrotechmods(https://www.youtube.com/watch?v=YmPziPfaByw)

Basic principles of PWM output generation

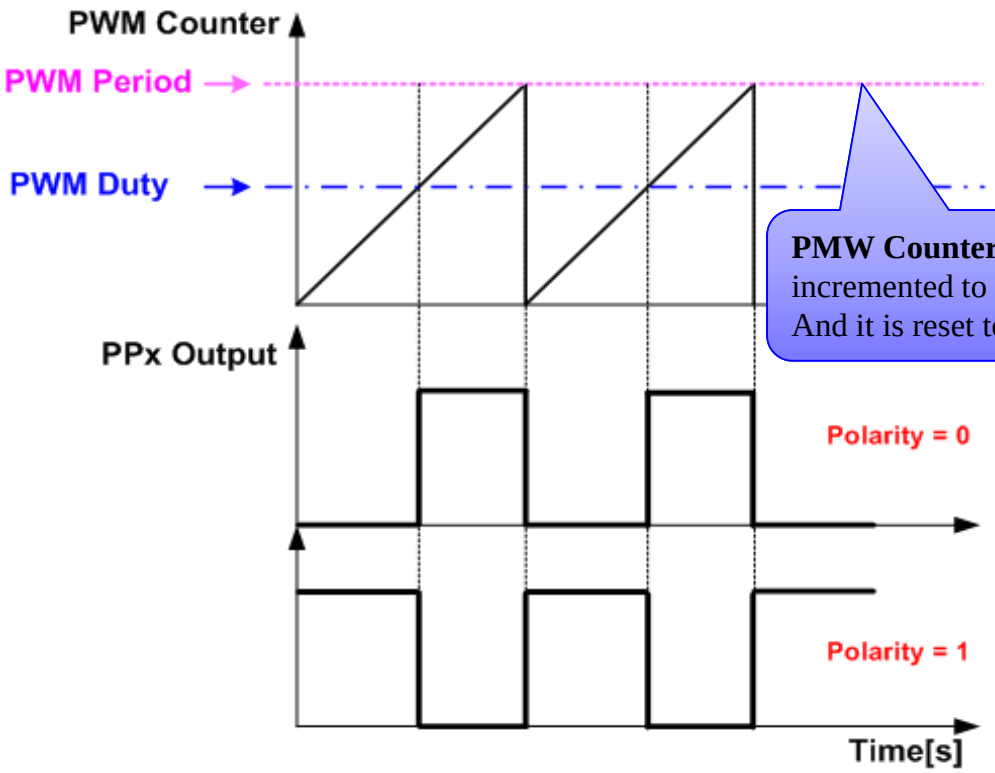
- Counter, Period, Duty, Polarity, Operation Mode



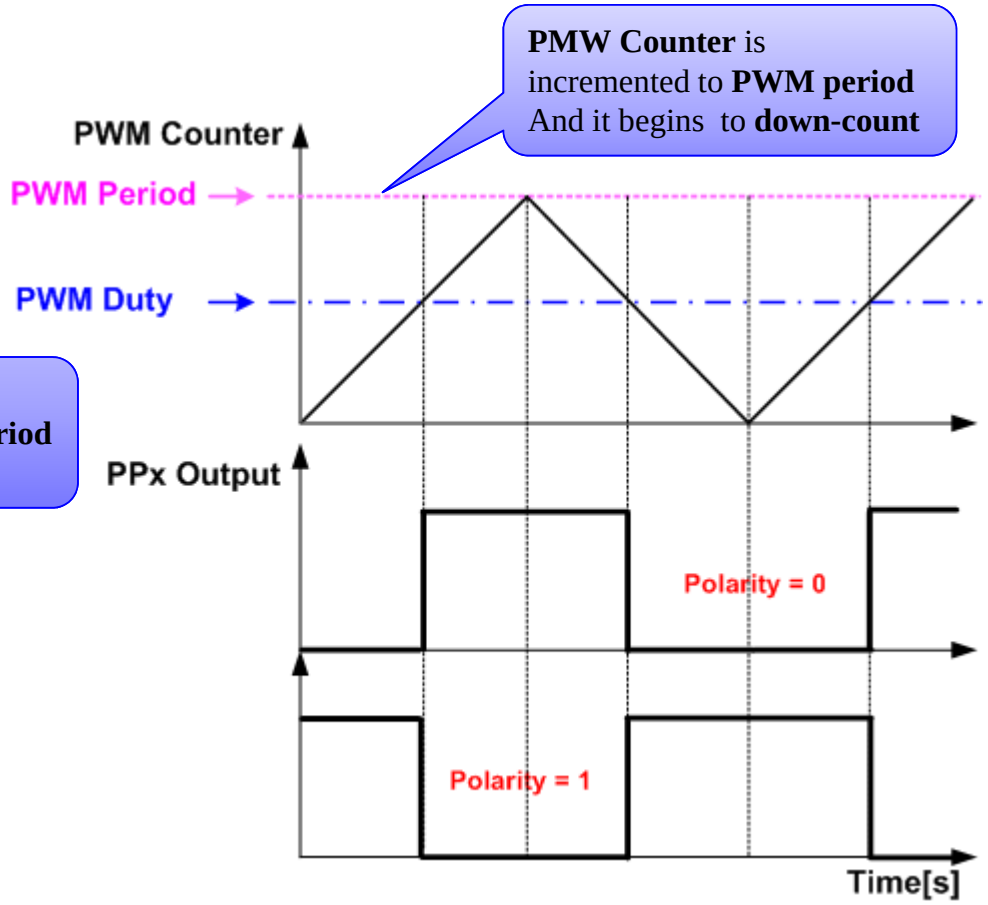
PWM operation example

Basic principles of PWM output generation

- Counter, Period, Duty, Polarity, Operation Mode



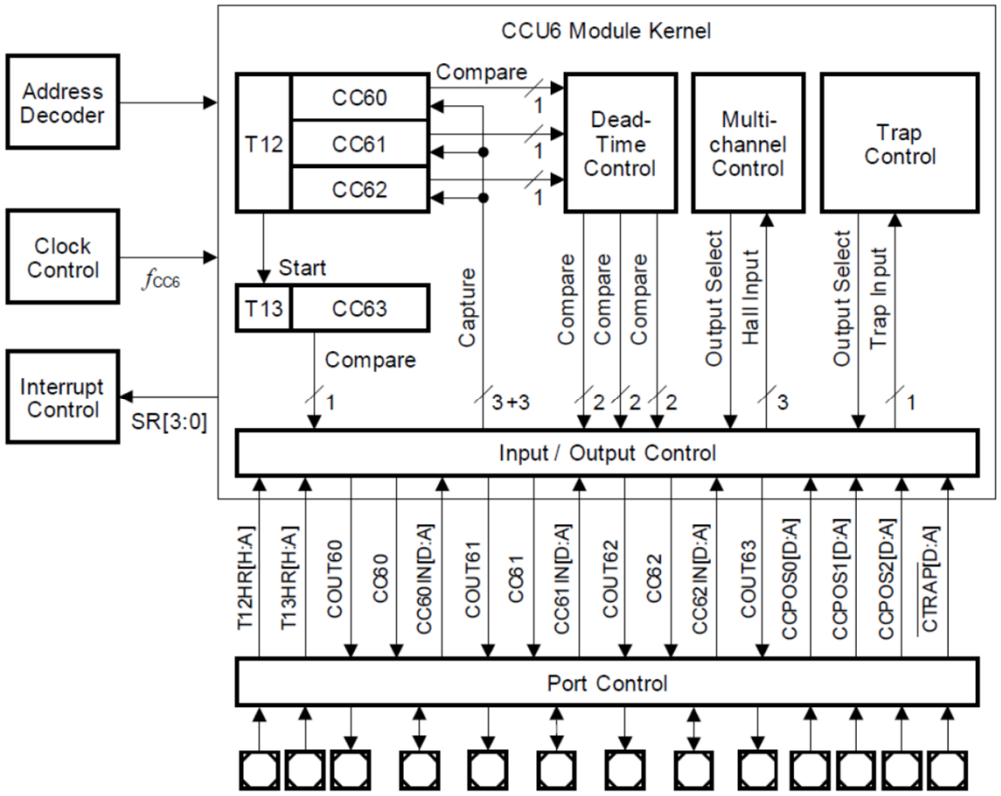
< Left-aligned mode>



< Center-aligned mode>

Features of CCU6 (Capture/Compare Unit)

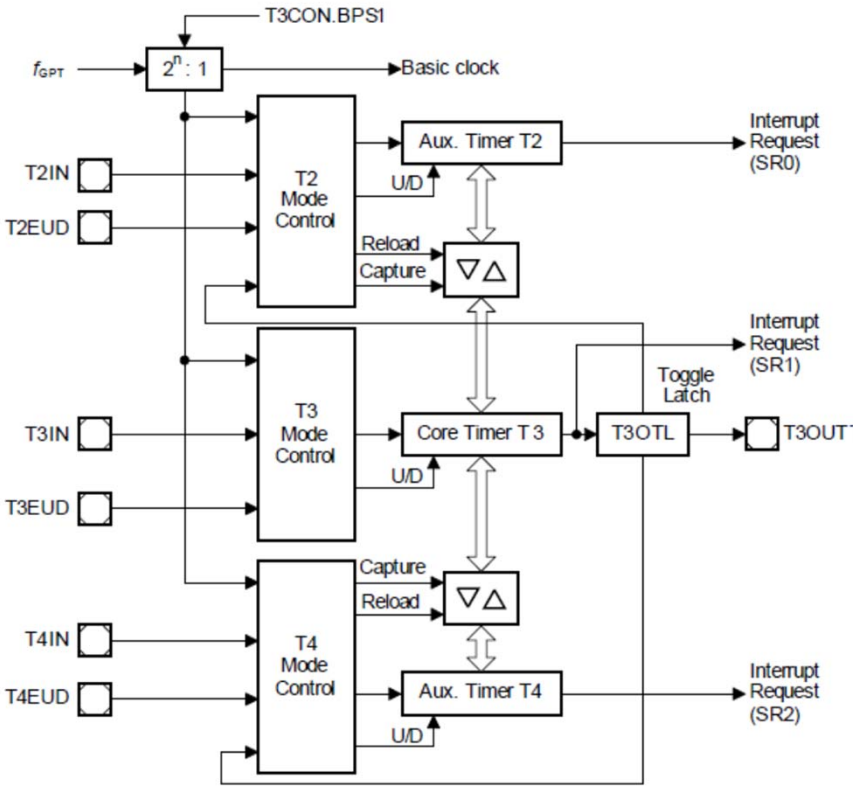
- Three capture/compare channels (Timer 12)
- One independent compare channels (Timer 13)
- Supply of 16-bit resolution
- Concurrent update of T12 and T13 registers
- Generation of center or edge-aligned PWM
- Support of single shot mode



PA

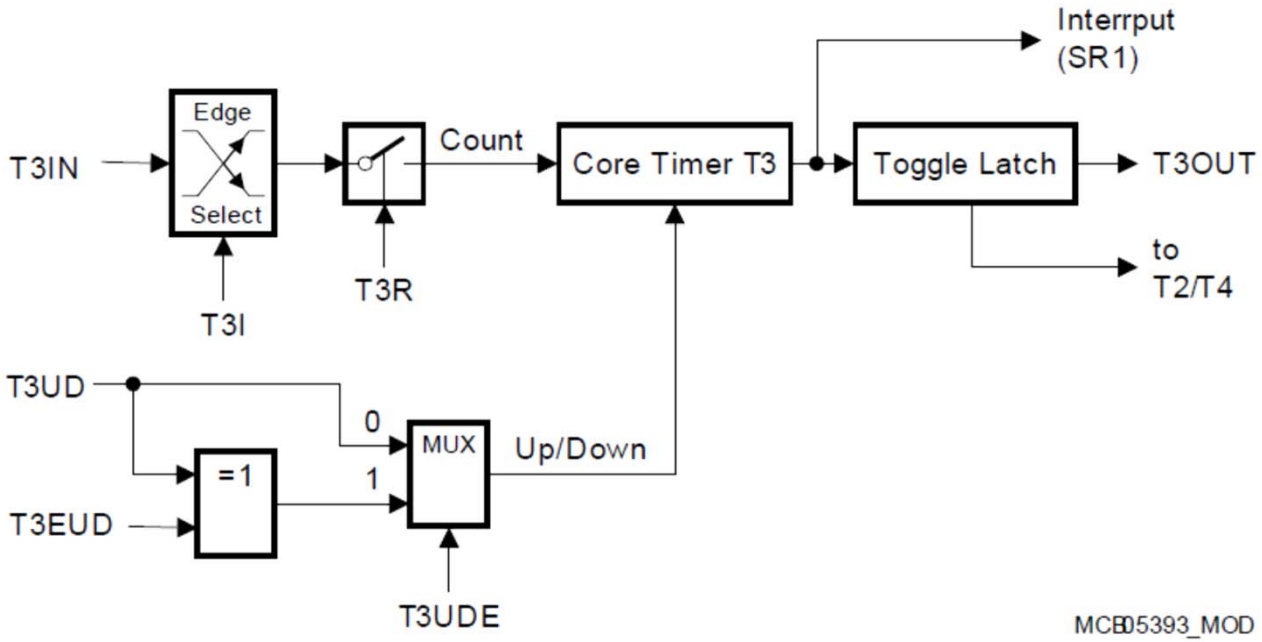
Introduction to General Purpose Timer Unit (GPT12)

- **Useful for event counting, pulse width measurement, pulse generation, and frequency multiplication**
- **Features of the GPT12**
  - Maximum resolution: $f_{GPT}/4$ (GPT1) and $f_{GPT}/2$ (GPT2)
  - 3 independent timers/counters
  - Timers/counters can be concatenated
  - 4 operating modes:
    - Timer Mode
    - Gated Timer Mode
    - Counter Mode
    - Incremental Interface Mode
  - Reload and capture functionality
  - Separate interrupts



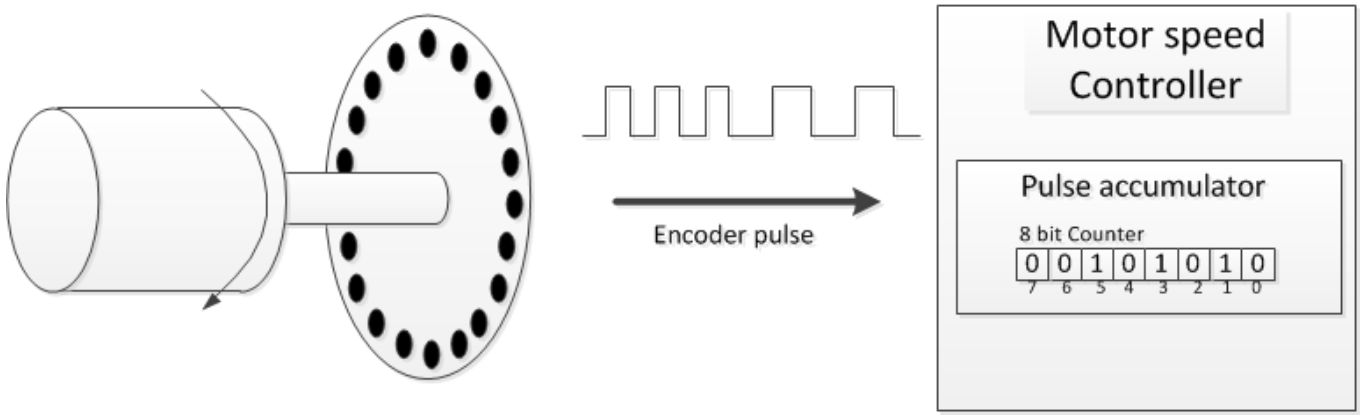
Introduction to Pulse Accumulator (PA)

- **Input edges on PA input pin increment the 16-bit counter**
- **In addition, the following may occur:**
  - The pulse accumulator overflow bit may set
  - An interrupt is generated to CPU, if enabled.



Application of PA (I)

Calculation of the motor speed (I)

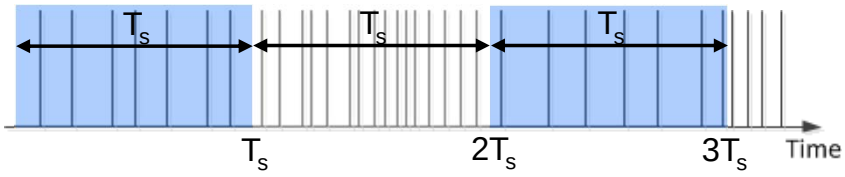


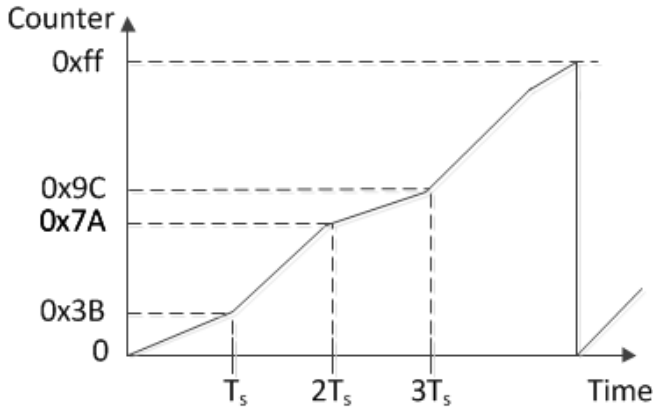
- Rising or falling edges of the encoder pulses are counted by the pulse accumulator in the MCU
- Pulse accumulator
  - A function of the micro processor
  - Counting the number of encoder pulses
  - The counting number is stored in the 16 bit register

Application of PA (II)

Calculation of the motor speed (II)

- Signal processing





- Basic equation

$$\omega = \frac{d\theta}{dt} = \frac{\Delta\text{Pulse}}{\text{GearRatio} \times \text{PulsePerRev} \times T_s} \times 2\pi \quad [\text{rad/s}]$$

$$= \frac{(\text{Current counter value - Previous counter value})}{\text{GearRatio} \times \text{PulsePerRev} \times T_s} \times 60 \ [\text{RPM}]$$

Application of PA (III)

Counter overflow handling

- The counter register reaches its maximum value
- Maximum counter value of the 16 bit counter: 2^{16} -1 = 65,534 (0xFFFF)
- Handling method 1 (Addition of 2^{16})
  - DeltaCounter = $CNT_1+2^{16}-CNT_2$
- Handling method 2 (Counter reset)
  - DeltaCounter = CNT_1