Advanced Robot Control
Review of MCU peripherals

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Presentation compiled for taking notes during lecture

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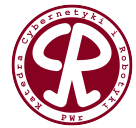

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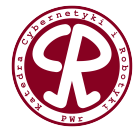

Review of peripherals

Some of the most common peripherals are listed below:

- GPIO,
- ADC,
- DAC,
- timers,
- SPI,
- I2C,
- CAN,
- SDIO,
- USB,
- USART/UART,
- FSMC.

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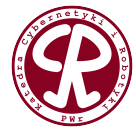

GPIO

GPIO is one of the most popular peripherals available across many different microcontrollers. Usually, a pin can be configured as input or as output. However, in STM32 MCUs several configurations are available:

- Input floating
- Input pull-up
- Input pull-down
- Analog
- Output open-drain with pull-up or pull-down capability
- Output push-pull with pull-up or pull-down capability
- Alternate function push-pull with pull-up or pull-down capability
- Alternate function open-drain with pull-up or pull-down capability

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GPIO

Figure: STM32 basic structure of input/output (STM32F303XB/C) [5]

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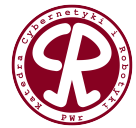

Open-drain and push-pull digital output

Open-drain (Open-collector) is a common type of a circuit which mitigates a switch. It can either be disconnected or connected to the ground. Generally, a NPN transistor or a MOSFET is used.
Push-Pull can either supply current (push) or absorb current (pull). For this type of circuit a pair of transistors is used.

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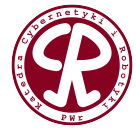

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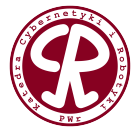

ADC

Figure: STM32 ADC block diagram (STM32F303XB/C) [5]

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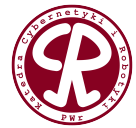

ADC (1/1)

Conversion modes:

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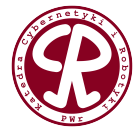

ADC architectures

- Successive approximation ADC
- Pipelined ADC
- Flash ADC
- Sigma-Delta converters

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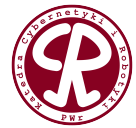

Successive approximation ADC

Figure: Simplified N-bit SAR ADC architecture [3]

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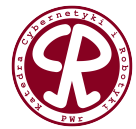

Successive approximation ADC

Figure: SAR operation (4-bit ADC example) [3]

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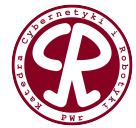

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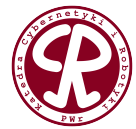

DAC

Figure: STM32 DAC block diagram (STM32F303XB/C) [5]

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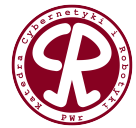

Resistor string DAC

Figure: Resistor string DAC [2]

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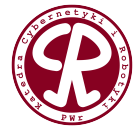

R-2R ladder netowrk DAC

Figure: R-2R ladder network DAC [2]

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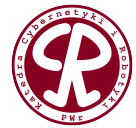

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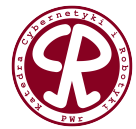

Timers

A timer can be configured in one of the following basic modes:

- Pulse Width Modulation (PWM),
- Output Compare (OC),
- Input Capture (IC),
- Time base.

What is more, different modes of operation which are based on previously listed are also available.

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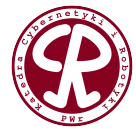

Architecture

Figure: Advanced-control timer block diagram [5]

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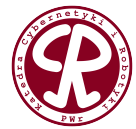

Timer input/output pin description

- TIMx_CHy
- TIMx_CHyN
- TIMx_ETR
- TIMx_BKINy

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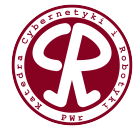

Registers of time base timer

- Counter register (TIMx_CNT) ,
- Prescaler register (TIMx_PSC) ,
- Auto-reload register (TIMx_ARR) ,
- Repetition counter register (TIMx_RCR) .

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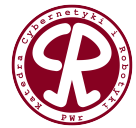

Timer chaining (1/2)

Timers can be chained using master/slave mode.

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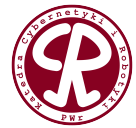

Timer chaining (2/2)

Figure: Timer system link [4]

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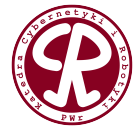

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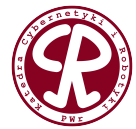

SPI (1/3)

Figure: SPI block diagram [5]

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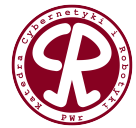

SPI (2/3)

SPI is a serial interface which allows synchronous communication between the MCU and external devices. It characterizes with following dedicated lines:

- MOSI ,
- MISO ,
- SCK .
- NSS .

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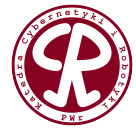

SPI (3/3)

SPI can work in one of the following modes:

- Full-duplex ,
- Half-duplex ,
- Simplex .

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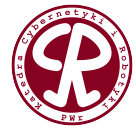

Full-duplex

Figure: SPI Full-duplex [5]

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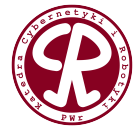

Half-duplex

Figure: SPI Half-duplex [5]

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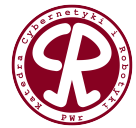

Simplex

Figure: SPI Simplex [5]

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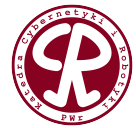

Clock polarity and clock phase (1/3)

Depending on the configuration of clock polarity and clock phase the SPI can work in one of four different modes

		CPHA	
		0	0
CPOL	0	00	01
	1	10	11

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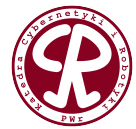

Clock polarity and clock phase (2/3)

Figure: Data clock timing diagram, low clock phase[5]

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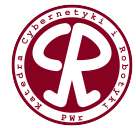

Clock polarity and clock phase (3/3)

Figure: Data clock timing diagram, high clock phase[5]

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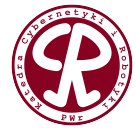

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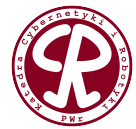

I2C (1/5)

Figure: I2C block diagram [5]

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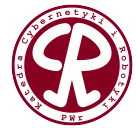

I2C (2/5)

I2C is a serial interface which can interconnect different devices while supporting multimaster capabilities. The I2C device can operate in one of four modes:

- Slave transmitter
- Slave receiver
- Master transmitter
- Master receiver

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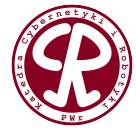

I2C (3/5)

In an I2C interface two signal lines are present:

- SDA (data line) .
- SCL (clock line) .

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I2C (4/5)

Figure: I2C bus protocol [5]

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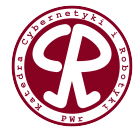

I2C (5/5)

I2C can operate in three speed modes:

- Standard mode (100 kHz)
- Fast mode (400 kHz)
- Fast mode + (1 MHz)

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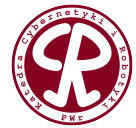

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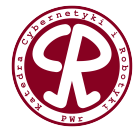

CAN (1/4)

CAN operates on 2^{nd} layer of OSI model which means it does not only provides a physical layer but also a data link layer.

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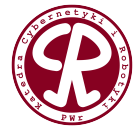

CAN (2/4)

Figure: CAN network topology [5]

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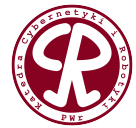

CAN (3/4)

CAN supports [6]:

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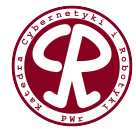

CAN (4/4)

Figure: Standard CAN frame [6]

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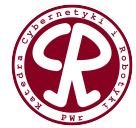

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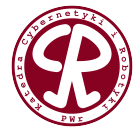

USB (1/2)

Figure: USB peripheral block diagram [5]

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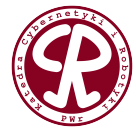

USB (2/2)

The USB peripheral provides an USB-compliant connection between the host PC and the function implemented by the microcontroller. Data transfer between the host PC and the system memory occurs through a dedicated packet buffer memory accessed directly by the USB peripheral [5].

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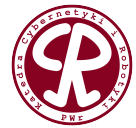

Endpoint

An endpoint is a uniquely identifiable portion of a USB device that is the terminus of a communication flow between the host and device [1]. Each USB logical device is composed of a collection of independent endpoints.

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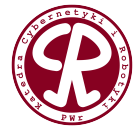

Outline

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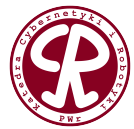

USART (1/2)

Figure: USART block diagram [5]

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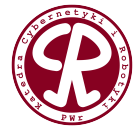

USART (2/2)

The universal synchronous asynchronous receiver transmitter (USART) offers a flexible means of Full-duplex data exchange [5].
The USART offers a very wide range of baud rates using a programmable baud rate generator.
It supports synchronous one-way communication and Half-duplex Single-wire communication, as well as multiprocessor communications.

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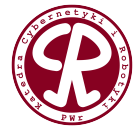

USART pin description (1/1)

- **RX**
- **TX**
- **CK**
- **CTS**
- **RTS**
- **DE**

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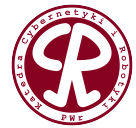

Quiz for videoconference (1/1)

Prepare yourself for a short test. Select the host of the meeting as the chat receiver. Do not send answers to everyone.
You will have 60 seconds for each question. When writing answer to the question. write down also the question number.
Question 0. What is your favourite colour? Answer 0. My favourite colour is blue.

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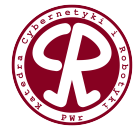

Quiz (1/1)

Calculate group number as the rest from dividing the Student ID number by 4.

Example

Student ID number is 123456, thus the group is 0.
Take last 2 digits from Student ID number (56) and calculate the rest from dividing by 4 (56 % 4 = 0).

Write down your name, Student ID number and group.

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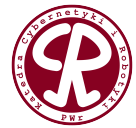

Literature (1/2)

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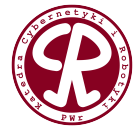

Literature (2/2)

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