Advanced Robot Control
Review of MCU peripherals

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Presentation compiled for taking notes during lecture

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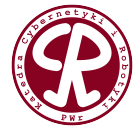

Outline

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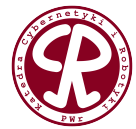

Review of peripherals

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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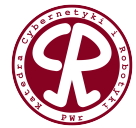

Open-drain and push-pull digital output

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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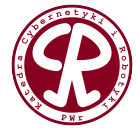

ADC

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

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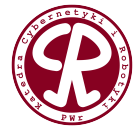

ADC (1/1)

Conversion modes:

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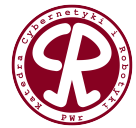

ADC architectures

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

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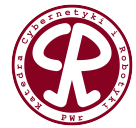

Successive approximation ADC

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

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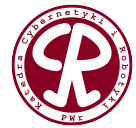

Successive approximation ADC

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

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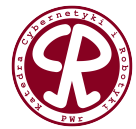

DAC

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

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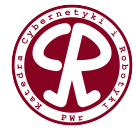

Resistor string DAC

Figure: Resistor string DAC [2]

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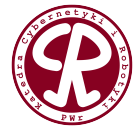

R-2R ladder netowrk DAC

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

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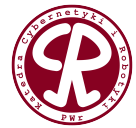

Timers

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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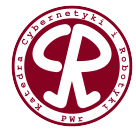

Architecture

Figure: Advanced-control timer block diagram [5]

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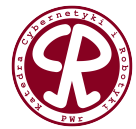

Timer input/output pin description

- TIMx_CHy
- TIMx_CHyN
- TIMx_ETR
- TIMx_BKINy

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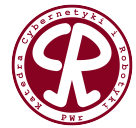

Registers of time base timer

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

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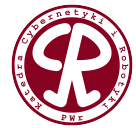

Timer chaining (1/2)

Timers can be chained using master/slave mode.

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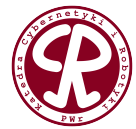

Timer chaining (2/2)

Figure: Timer system link [4]

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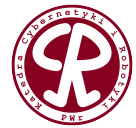

SPI (1/3)

Figure: SPI block diagram [5]

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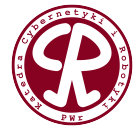

SPI (2/3)

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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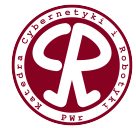

SPI (3/3)

SPI can work in one of the following modes:

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

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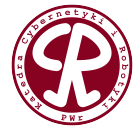

Full-duplex

Figure: SPI Full-duplex [5]

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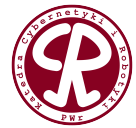

Half-duplex

Figure: SPI Half-duplex [5]

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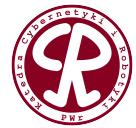

Simplex

Figure: SPI Simplex [5]

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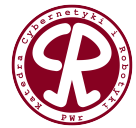

Clock polarity and clock phase (1/3)

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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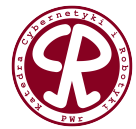

Clock polarity and clock phase (2/3)

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

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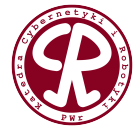

Clock polarity and clock phase (3/3)

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

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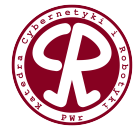

I2C (1/5)

Figure: I2C block diagram [5]

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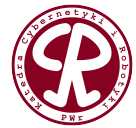

I2C (2/5)

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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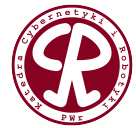

I2C (3/5)

In an I2C interface two signal lines are present:

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

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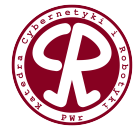

I2C (4/5)

Figure: I2C bus protocol [5]

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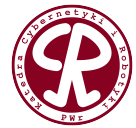

I2C (5/5)

I2C can operate in three speed modes:

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

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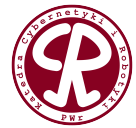

CAN (1/4)

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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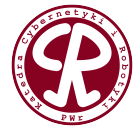

CAN (2/4)

Figure: CAN network topology [5]

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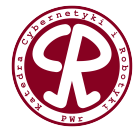

CAN (3/4)

CAN supports [6]:

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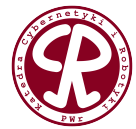

CAN (4/4)

Figure: Standard CAN frame [6]

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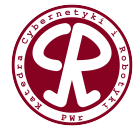

USB (1/2)

Figure: USB peripheral block diagram [5]

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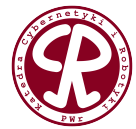

USB (2/2)

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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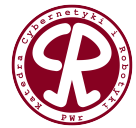

Endpoint

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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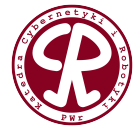

USART (1/2)

Figure: USART block diagram [5]

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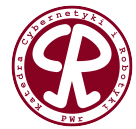

USART (2/2)

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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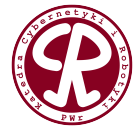

USART pin description (1/1)

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

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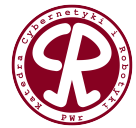

Quiz (1/1)

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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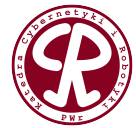

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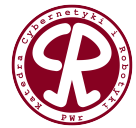

Literature (2/2)

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STM32 cross-series timer overview, Application note.
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