Final   **SM53**

SM53 - Rapid Control Prototyping
Partiel - 13 janvier 2020

Firstname and lastname:

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Duration : 90 minutes.

No documents allowed. - Answer on this page. - Answer in English. - The use of electronic calculators is allowed.

Questions using the sign ♣ may have zero, one or several correct answers. Other questions have a single correct answer.

Negative points may be attributed to bad answers.

Please give the responses in the foreseen boxes and use a well readable pen.

1   Theoretic Background

Question 1   What does RCP stand for?

☐ Rapid Control Prototyping   ☐ Renewable Capacity Prediction
☐ Rare Coordinated Power   ☐ Recent Compilation Protocol

Question 2   What is RCP good for?

☐ Replace not existing ECU   ☐ Replace non existing hardware
☐ Produce missing hardware

Question 3   What does HIL stand for?

☐ High Intengrated Language   ☐ Heavy Intension Learning
☐ Hardware in the Loop

Question 4   What does the Nyquist Shannon theorem say?

☐ It is a diagram that helps to study the stability of a system using frequency and amplitude.
☐ It imposes that the sampling frequency has to be at least two times smaller than the highest signal frequency.
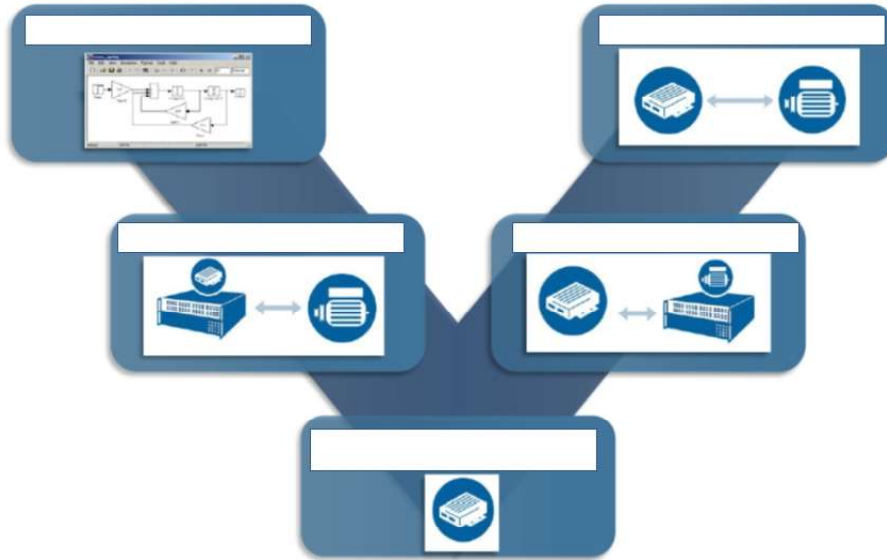☐ It states how to translate an analog signal into digital signals correctly.

Question 5
What is the minimum sampling frequency, when you want to measure a singal with a maximum frequency of 58 kHz?

☐ 5800kHz   ☐ 29kHz   ☐ 116kHz
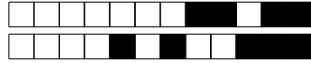
Question 6   Provide the five mising keywords for the Design Process.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5

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Question 7   What does real time mean in the context of RCP?

☐ The loop time is fixed and respected.

☐ The application runs on a dedicated computer.

☐ A very fast running system.

Question 8   Draw an example of what happens during one loop.   ☐0 ☐1 ☐2

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Question 9   Why is real time calculation required for HIL and RCP?

☐ Apply a well working model on the Host computer.

☐ Have a deterministic system, where information are providet at a defined moment.

☐ To use FPGA a real time model is required.

Question 10 ♣   What is FPGA?

☐ Reprogrammable device capable to do parallel computing.

☐ Field Oriented Gate Array

☐ Another name for CPU

☐ *None of these answers are correct.*

2   LabView

In the following you are asked to analyse the working principle of a NI MyRIO system.

You are asked to use a MyRIO System in order to control a power converter based on PWM. The PWM signal will depend on an input voltage that you measure. Therefore you use the Pin AI0+ with a reference AGND.

Question 11   What is the maximum power you can measure using this configuration?

☐ 10 V   ☐ 20 V   ☐ 5 V

You use both input lines for measurements with the following specifications:

- Aggregate sample rate 500 kS/s

- Resolution 12 bits

Question 12   What is the minimum loop time for dada acquisition in this case?

☐ 4 ms   ☐ 0.5 ms   ☐ 8 ms

Question 13   What is the minimum measurement precision?

☐ 0.08 mV   ☐ 0.15 mV   ☐ 0.31 V

Question 14   Why is real time calculation required for HIL and RCP?

☐ Have a deterministic system, where information are providet at a defined moment.

☐ Apply a well working model on the Host computer.

☐ To use FPGA a real time model is required.

The program (figure 106) was developped for a simple PWM using My RIO. Please identify the following elements.

Question 15   Which number identifies the **loop time constant**?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

Question 16   Which number identifies the **input value**?

☐ 1   ☐ 2   ☐ 3   ☐ 4   ☐ 5

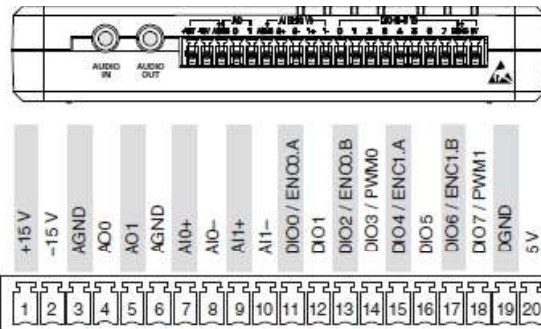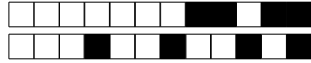**Question 17**   Which small letter indicates a boolean?

☐ a   ☐ b

Table 2. Descriptions of Signals on MSP Connector C

| Signal Name	Reference	Direction	Description
+15V/-15V	AGND	Output	+15 V/-15 V power output.
AI0+/AI0-; AI1+/AI1-	AGND	Input	±10 V, differential analog input channels. Refer to the *Analog Input Channels* section for more information.
AO <0..1>	AGND	Output	±10 V referenced, single-ended analog output channels. Refer to the *Analog Output Channels* section for more information.
AGND	N/A	N/A	Reference for analog input and output and +15 V/-15 V power output.
+5V	DGND	Output	+5 V power output.
DIO <0..7>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the *DIO Lines* section for more information.
DGND	N/A	N/A	Reference for digital lines and +5 V power output.

Figure 105: Primary/Secondary Signals on MSP Connector of MyRIO
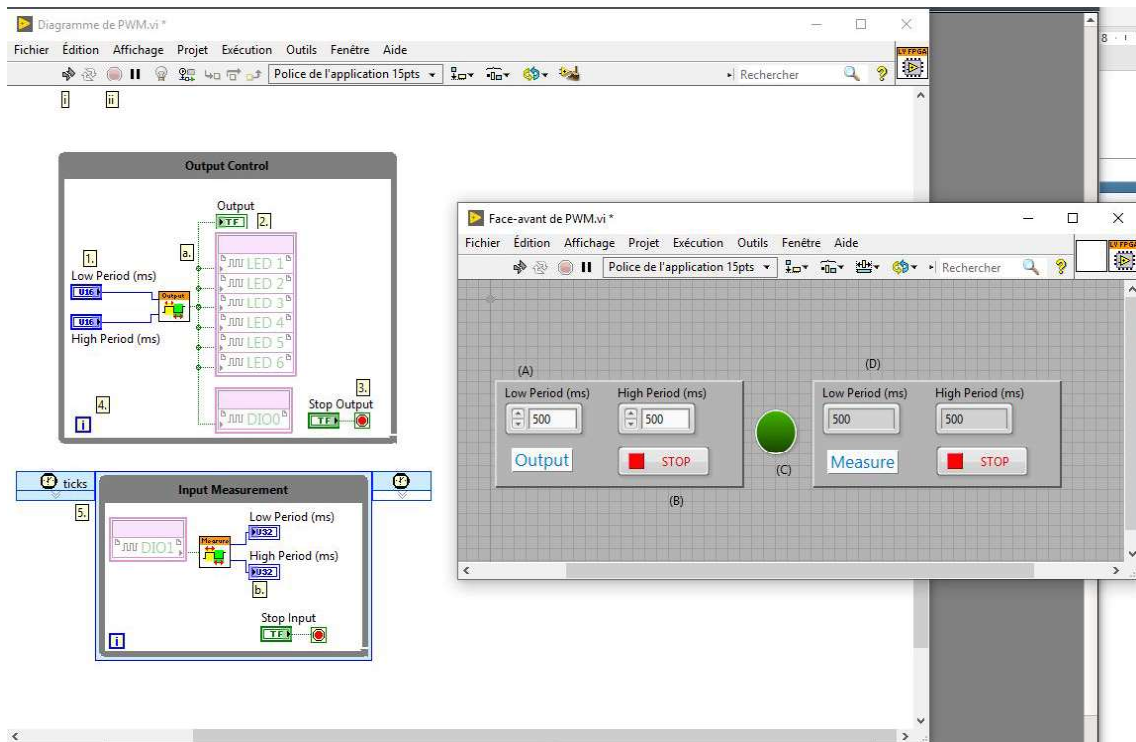
Figure 106: Lab View Programm for simple PWM in MyRIO

Question 18   Which capital letter indicates a numeric input?

☐ A   ☐ B   ☐ C   ☐ D

Question 19   Which capital letter indicates a loop boolean?

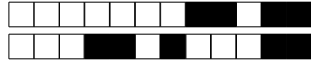☐ A   ☐ B   ☐ C   ☐ D

Question 20   Which symbol (i) or (ii) indecates system start button?

☐ i   ☐ ii

3   Sensors

Question 21 ♣   What is a sensor?

☐ A sensor acquires a physical quantity and converts it inot a signal suitable for processing.

☐ A device, which provides a usable output in response to a specific measure.

☐ A device, wich measures a voltage in function of time.

☐ *None of these answers are correct.*

Question 22   Introduce shortly the working principle of a Hall Effect Sensor.   ☐0 ☐1 ☐2

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4   dSpace

Question 23

You want to measure a voltage of 21 V using a dSpace system. You have a differential probe with a factor 1/100. What is the gain that you have to use in Simulink to show the correct value

     ☐   10   ☐   100   ☐   1000

Question 24   Explain shrortly why: ☐0 ☐1 ☐2

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Question 25   You want to keep an existing ECU and add an RCP system to add special functionalities. In this case you do:

     ☐   By-passing   ☐   Neither   ☐   Full-passing

Question 26

You want to control a sine wave with a maximum frequency of 176 Hz. What is the time step you choose?

     ☐   0.06ms   ☐   5.68ms   ☐   0.57ms

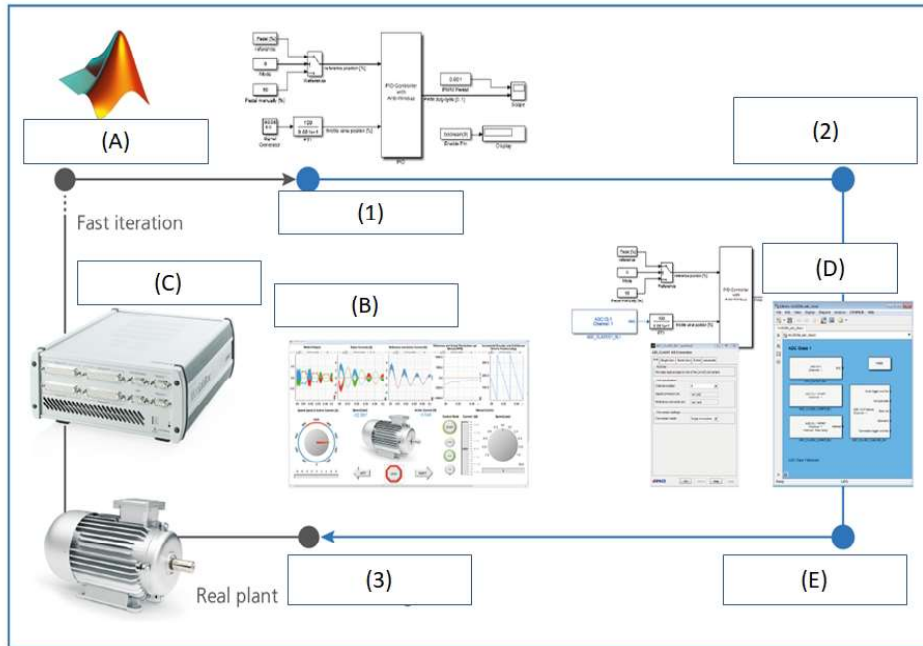The dSPACE design process is presented in 107.

Figure 107: dSPACE design process

Question 27 Provide the five mising keywords for the Capital letters desinging specific Software (Packages) or Hardware in the Design Process.

☐0 ☐1 ☐2 ☐3 ☐4 ☐5

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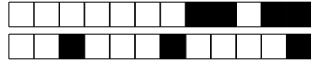...

Question 28 Provide the three mising keywords for the numbers designing key development steps in the Design Process.

☐0 ☐1 ☐2 ☐3

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5   PI Control

Question 29 ♣ Name some advantages of a empiric control tuning.

☐ No risk   ☐ Optimal results   ☐ Easy to apply
☐ No need to do caluclation   ☐ *None of these answers are correct.*

6   Representation using EMR/IBC

Question 30 ♣ On which main aspects Energetic Macroscopic Reprsentation is based?

☐ Acausal   ☐ Structural   ☐ Cartesia   ☐ Backward   ☐ Causal
☐ Systemic   ☐ Static   ☐ Forward   ☐ Dynamic   ☐ Functional
☐ *None of these answers are correct.*

Question 31 How do describe a **source element** using EMR?

☐ Orange square or circle   ☐ Orange square with obelic bar
☐ Overlapping orange squares or circles   ☐ Green oval

Question 32 How do describe a **conversion element** using EMR?

☐ Orange square or circle   ☐ Orange square with obelic bar
☐ Overlapping orange squares or circles   ☐ Green oval

Question 33 How do describe an **inversion element with controller** using EMR?

☐ blue parallelogram with obelic bar   ☐ Green oval   ☐ Orange square or circle
☐ blue parallelogram

PhotoVoltaic Conversion System
Goal of this work is to representa PV System (figure 108) using EMR and IBC. The System consists of the following elements:

- Solar panel
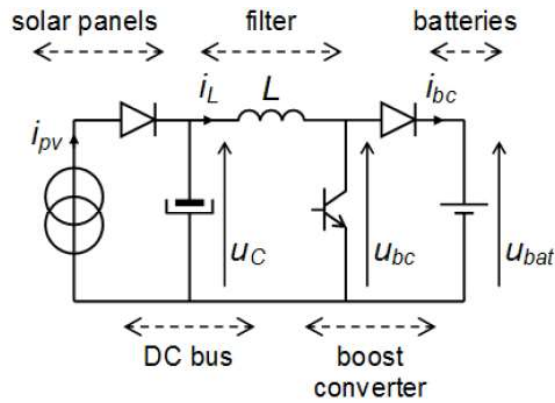
- LC filter

- Boost converter

Figure 108: PV System to be descrived

- Battery

The solar panel and the battery can be described as source elements. The filter contains two elements, namely:

$$C\frac{d}{dt}u_C + \frac{u_c}{R_c} = i_{pv} - i_L \qquad (105)$$

and

$$L\frac{d}{dt}i_L + R_L i_L = u_C - u_{bc} \qquad (106)$$

The boost converter is controlled via m_{bc} and can be described using:

$$i_{bc} = m_{bc}i_L \qquad (107)$$

$$u_{bc} = m_{bc}u_{bat} \qquad (108)$$

Question 34 Desing the EMR and IBC including the blocks, action/reaction parameters and inversion based control. Make sure to label every element. You can indicate the correct colors by words (red, yellow etc.)
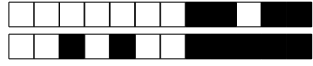
☐0 ☐1 ☐2 ☐3 ☐4 ☐5

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