

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ  
Федеральное государственное автономное образовательное учреждение  
высшего образования «Южно-Уральский государственный университет»  
(национальный исследовательский университет)  
Высшая школа электроники и компьютерных наук  
Кафедра «Электронные вычислительные машины»

# Разработка пользовательского интерфейса программы диагностики и настройки электронных блоков управления самоходных машин

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# АКТУАЛЬНОСТЬ

Актуальность проекта обусловлена заказом предприятия ДСТ Урал.

На данный момент предприятие использует программу BODAS-service для диагностики и настройки электронных блоков управления Bosch Rexroth BODAS, устанавливаемых на выпускаемую предприятием самоходную технику. В связи с невозможностью будущего использования предприятием лицензионной версии данной программы, требуется графический пользовательский интерфейс для собственной программы диагностики ЭБУ для возможности его настройки и изменения под нужды предприятия.

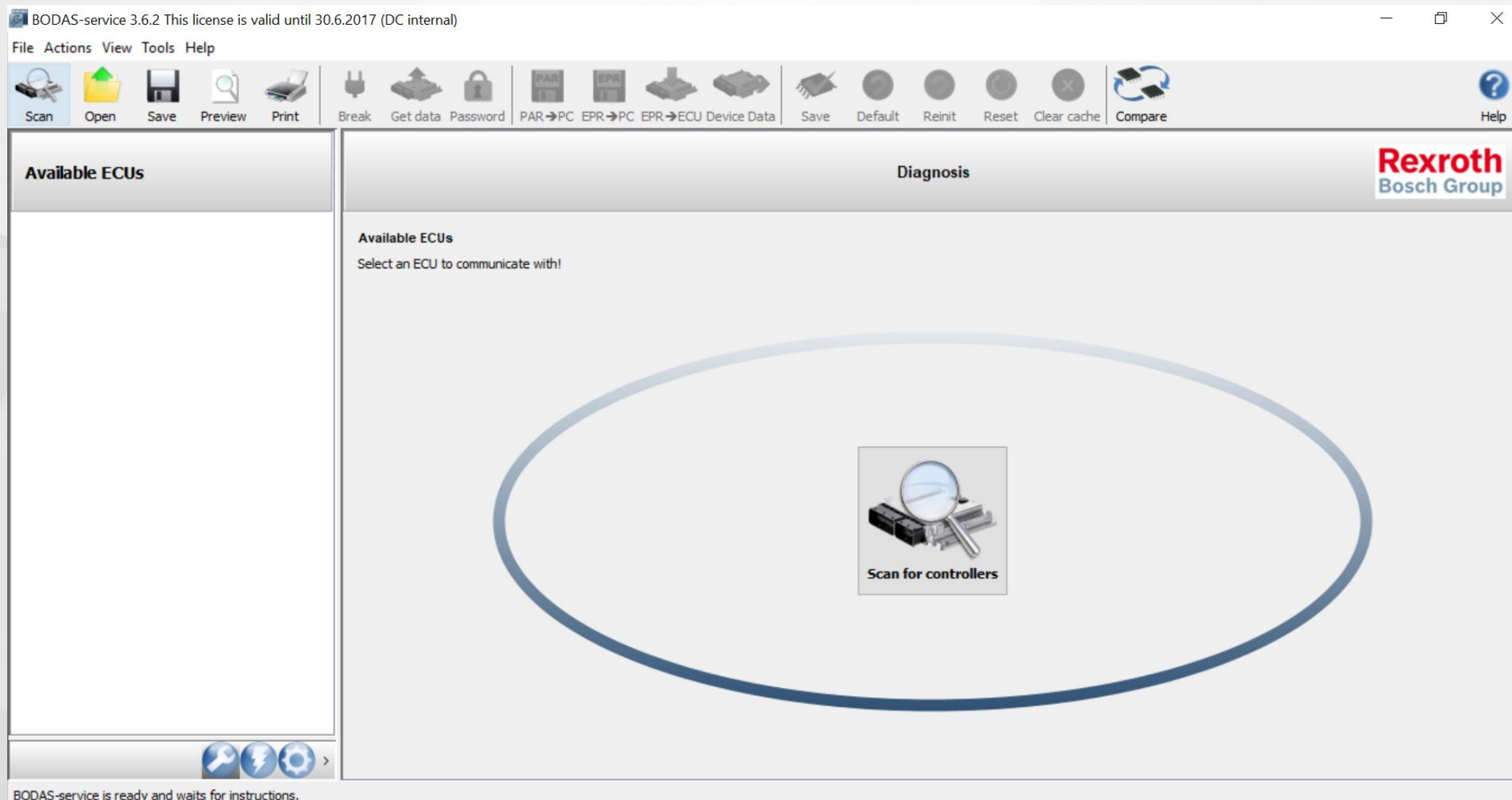
# Цель и задачи

**Цель работы:** разработка графического пользовательского интерфейса программы диагностики и настройки электронных блоков управления семейства BOSCH Rexroth BODAS для операционных систем Windows 7 и Windows 10, визуально и функционально схожего с интерфейсом используемой на предприятии программы BODAS-service.

## **Задачи:**

- 1) анализ предметной области;
- 2) формирование основных требований;
- 3) проектирование интерфейса;
- 4) реализация интерфейса;
- 5) тестирование интерфейса.

# BODAS-service



Главное окно интерфейса программы BODAS-service

# BODAS-service

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The screenshot displays the BODAS-service 3.6.2 software interface. The title bar indicates the license is valid until 30.6.2017. The menu bar includes File, Actions, View, Tools, and Help. The toolbar contains various icons for file operations (Scan, Open, Save, Preview, Print) and diagnostic actions (Break, Get data, Password, PAR→PC, EPR→PC, EPR→ECU, Device Data, Save, Default, Reinit, Reset, Clear cache, Compare). A sidebar on the left shows 'Available ECUs' with a 'Test Device' (VIRTUAL DEVICE) and a list of views including Parameter, Processdata, I/O Status view, Custom view, Guided Commissioning, and Error messages. The main window is titled 'Parameter' and features the Rexroth Bosch Group logo. Below the title, it states 'Parameter values are displayed and can be edited.' The 'Learning curves' tab is active, showing a list of parameters under '1.1 parameter group 1.1'. A tooltip for '1.1.2 switch' is open, displaying details: Type (switch), Current value (1), minimum value (0), maximum value (1.7 V), switch mode (0), default value (1), and Value at connection establishment (1). The interface includes a search bar, filter options (Show only menus, Show groups, Show all parameters), and an update interval setting.

Connected with: Test Device + VIRTUAL DEVICE + PEAK PCAN-USB

Вкладка Parameter

# PCMSCAN

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Главное окно интерфейса программы PCMSCAN

# OBD Scan Tech

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OB2 II GENERIC

File Vehicle Edit View Option Help

1- DATA PARAMETER 2- MONITOR STATUS 3- CODES/FREEZE FRAME 4- VEHICLE INFORMATION 5- SUPPORTED PIDS

THROTTLE POSITION	●	N/A	%	COOLANT TEMPERATURE	●	N/A	Deg (F)
VEHICLE SPEED	●	N/A	MPH	INTAKE AIR TEMPERATURE	●	N/A	Deg (F)
SPARK ADVANCE	●	N/A	Deg	O2 BANK 1 SENSOR 1	●	N/A	Volts
AIR FLOW (MAF)	●	N/A	gm/s	O2 BANK 1 SENSOR 2	●	N/A	Volts
CALCULATED LOAD	●	N/A	%	O2 BANK 1 SENSOR 3	●	N/A	Volts
MAP	●	N/A	In/Hg	O2 BANK 1 SENSOR 4	●	N/A	Volts
R.P.M.	●	N/A	R.P.M.	O2 BANK 2 SENSOR 1	●	N/A	Volts
FUEL SYSTEM 1	●	N/A	Open/Close	O2 BANK 2 SENSOR 2	●	N/A	Volts
FUEL SYSTEM 2	●	N/A	Open/Close	O2 BANK 2 SENSOR 3	●	N/A	Volts
FUEL PRESSURE	●	N/A	P.S.I.	O2 BANK 2 SENSOR 4	●	N/A	Volts
MIL LIGHT	●	N/A	On/Off	LONG TERM FUEL TRIM B1	●	N/A	%
# OF TROUBLE CODES	●	N/A		SHORT TERM FUEL TRIM B1	●	N/A	%
STFT O2B1S1	●	N/A	%	LONG TERM FUEL TRIM B2	●	N/A	%
STFT O2B1S2	●	N/A	%	SHORT TERM FUEL TRIM B2	●	N/A	%
STFT O2B1S3	●	N/A	%	POWER TAKE OFF	●	N/A	Yes/No
STFT O2B1S4	●	N/A	%	TIME SINCE ENGINE START	●	N/A	Sec
STFT O2B2S1	●	N/A	%	AIR STATUS	●	N/A	
STFT O2B2S2	●	N/A	%				
STFT O2B2S3	●	N/A	%				
STFT O2B2S4	●	N/A	%				

1 = UPSTREAM FIRST CATALYST  
2 = DOWNSTREAM FIRST CATALYST INLET  
3 = ATMOSPHERE OFF

CONNECTION STATUS: DISCONNECTED ● COM PORT: N/A DISPLAY SETTING: 1920 X 1080 TRUE COLOR 21:07 | 24.02.2023 | CAPS | NUM |

Главное окно интерфейса программы OBD Scan Tech

# Функциональные требования

- Вывод всей полученной информации о контроллере (Device Info);
- Работа с параметрами контроллера (Parameter);
- Вывод данных процесса (Processdata);
- Отображение информации о входах и выходах (портах) контроллера (Input/Output Status);
- Вывод ошибок контроллера (Error messages);
- Сохранение введенной пользователем информации в память контроллера.

# Нефункциональные требования

- Совместимость с операционными системами Windows 7 и Windows 10;
- Внешняя схожесть с интерфейсом программы BODAS-service;
- Адаптация интерфейса под любой доступный размер окна;
- Невысокие системные требования, исключение "засорения" ОЗУ в процессе работы программы.



# Выбор средств разработки

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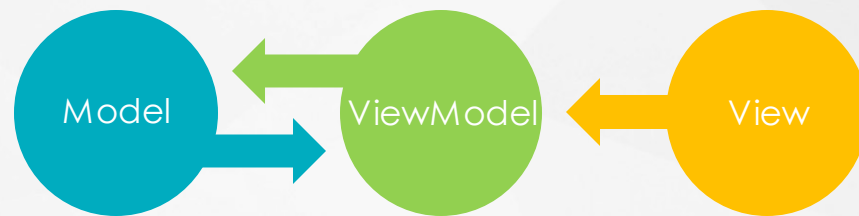
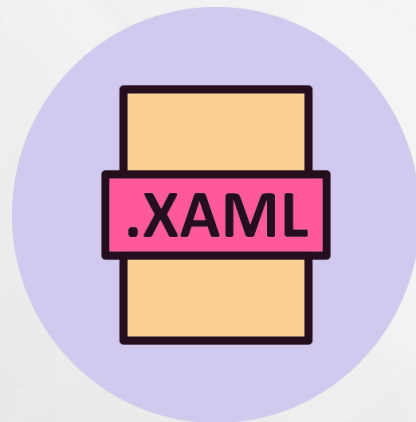
Фреймворк WPF

Язык программирования C#, язык разметки XAML

Шаблон проектирования MVVM

Среда разработки Visual Studio 2019

Вспомогательные библиотеки Microsoft.Extensions.DependencyInjection, Microsoft.Xaml.Behaviors.Wpf и др.



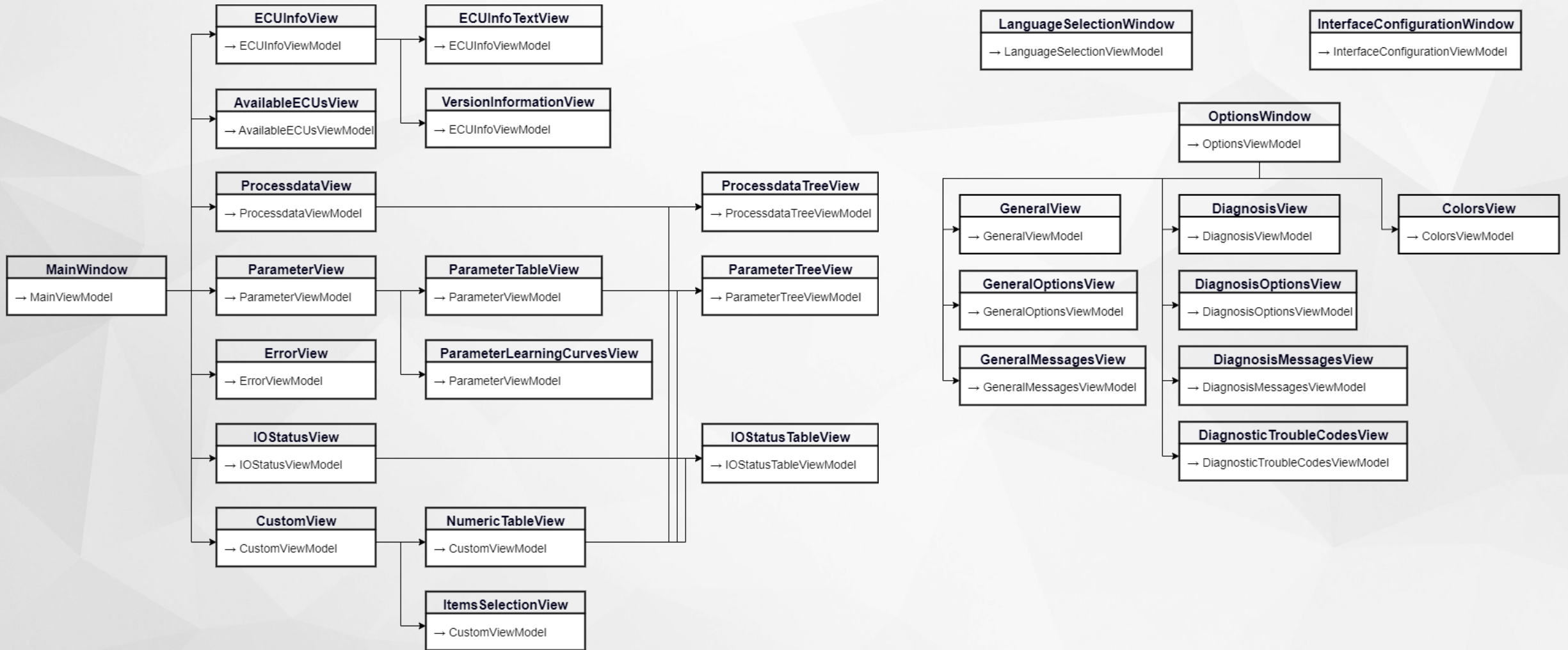
MVVM  
MODEL VIEW VIEWMODEL



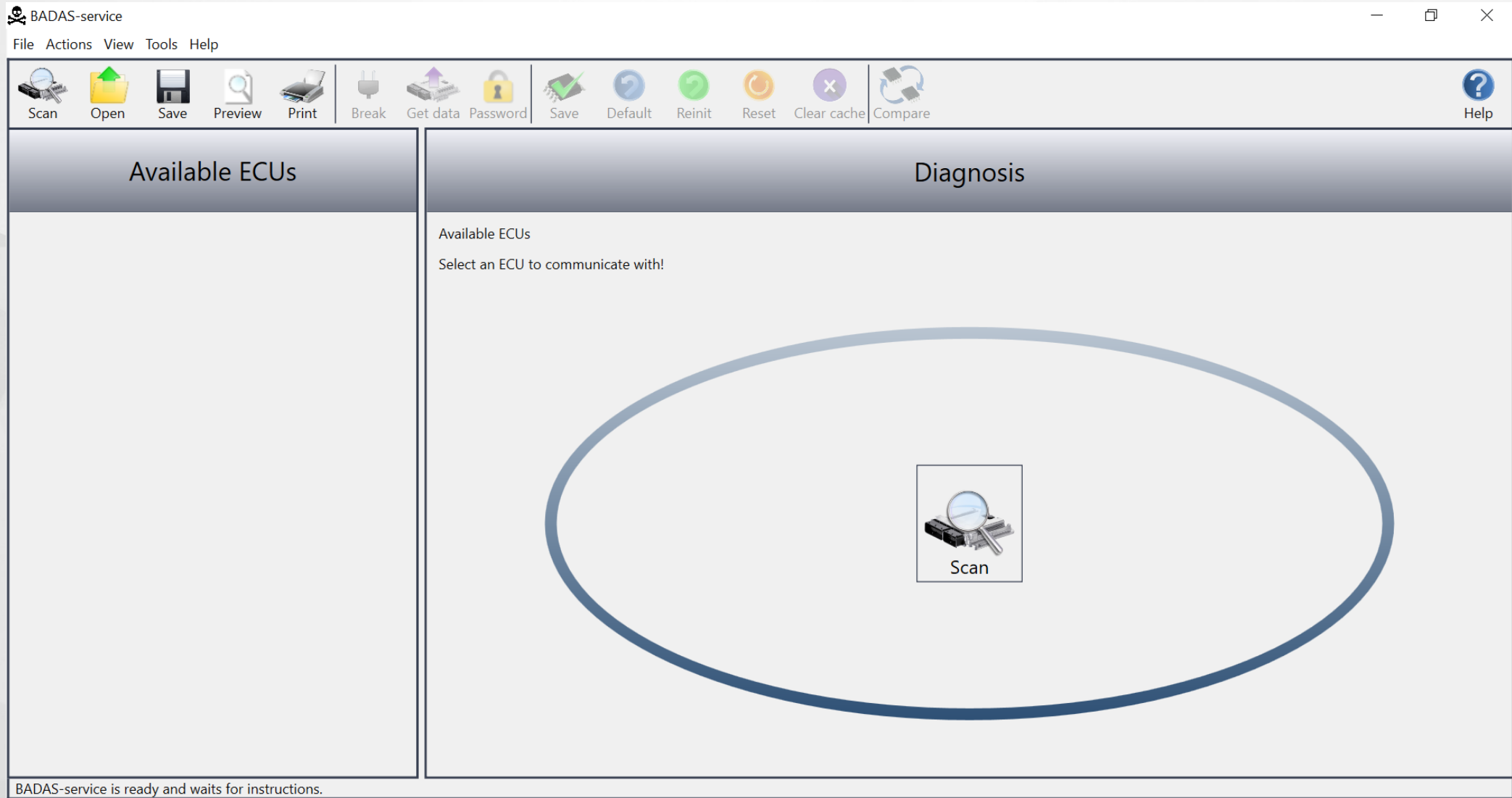
# Схема использования



# Архитектура представлений



# Реализация



Главное окно интерфейса

# Реализация

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The screenshot displays the BADAS-service application window. The title bar reads 'BADAS-service'. The menu bar includes 'File', 'Actions', 'View', 'Tools', and 'Help'. The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two main sections:

- Available ECUs:** A table listing the connected devices.

Test Device	SN: 00000000
VIRTUAL DEVICE	HwCode: 001234
Errors detected	
▷ Parameter	
▷ Processdata	
▷ I/O Status view	
▷ Custom view	
▷ Guided Commissioning	
▷ Error messages	
- Diagnosis:** A section for the selected device, titled 'Test Device (SN: 00000000) + VIRTUAL DEVICE'. It contains:
  - Device info:** A sub-section with a 'Rexroth Bosch Group' logo and an image of a diagnostic tool. To the right, a list of parameters is shown in a table:

Controller type:	Test Device
Operation time:	208:44
Reset counter:	370
Voltage:	12 / 24 Volt
Connection mode:	CAN @250 kBaud
Application name:	VIRTUAL DEVICE
Last reprogrammed on:	9999-99-99 by:
  - Information:** A scrollable text area containing:
    - Hardware version: R902038795
    - Serial number: 01234567
    - BIOS / API / Firmware:
      - software information: RC12-8 API V81.0000
      - date of installation: 9999-99-99
      - installer identification: BR
      - API/Library/Module information:
        - RC/22-LIB B1.0
        - DIAG-LIB B1.0
        - POTI-LIB B1.0
        - STM-LIB B1.0
        - J1939-LIB B1.0
    - Customer bootloader:
      - software information: Your BootL V01.00.C0
      - date of installation: 2007-01-01
      - installer identification: BR
    - Version information: Ecu info text

Вкладка Device Info

# Реализация

The screenshot displays the BADAS-service application window. The title bar reads "BADAS-service" and the menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two panes. The left pane, titled "Available ECUs", shows a "Test Device" (VIRTUAL DEVICE) with SN: 00000000, HwCode: 001234, and "Errors detected". A tree view on the left lists: Parameter, Processdata, I/O Status view, Custom view, Guided Commissioning, and Error messages.

The right pane, titled "Parameter", contains the text "Parameter values are displayed and can be edited". The "Parameter" dropdown is set to "Learning curves". The interface shows a hierarchical menu structure: menu 0, menu 1, submenu 1.0, and submenu 1.1.

Under submenu 1.0, the following parameters are visible:

- 1.0.0 num\_param: A slider with values 15, 74, 133, 192, 250 and a numeric input field set to 95. Includes STD and Help buttons.
- 1.0.1 hex\_num\_param: A slider with values 0x041a, 0x060e, 0x0800 and a hex input field set to 5A. Includes STD and Help buttons.
- 1.0.2 switch\_param: Includes STD and Help buttons.
- 1.0.3 list\_param: A dropdown menu set to "1VALUE" and a "Value:" input field set to 1. Includes STD and Help buttons.

A tooltip for "hex\_num\_param" is displayed, showing: current value 0x005a, minimum value 0x0032, maximum value 0x0800, step width 0x0001, and default value 0x03fe.

At the bottom of the parameter pane, there are filters: "Show only menus", "Show groups", "Show all parameters", and a "Write text for filtering..." input field. The "Update interval" is set to 3000 ms.

The status bar at the bottom left says "Connected with:" and the bottom right says "Test Device".

Вкладка Parameter

# Реализация

The screenshot displays the BADAS-service application window. The title bar reads "BADAS-service" and the menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two main sections:

- Available ECUs:** A sidebar on the left showing the "Test Device" (VIRTUAL DEVICE) with details: SN: 00000000, HwCode: 001234, and Errors detected. A list of navigation options includes Parameter, Processdata (selected), I/O Status view, Custom view, Guided Commissioning, and Error messages.
- Processdata:** The main area titled "Processdata" with the subtitle "Current variables for available processdata". It displays "group 0" with five parameters:
  - 0.0 num\_param: Input field with value 92.
  - 0.1 switch\_param: Toggle button set to OFF.
  - 0.2 hex\_num\_param: Input field with value 0x05b7.
  - 0.3 binary\_param: Input field with value 0000000000000000000000001110001111010.
  - 0.4 bargraph\_param: A bargraph with a value of 133. A tooltip for this parameter shows: binary\_param, current value 0000000000000000000000001110001111010, minimum value 00000000000000000000000000000000110010, maximum value 000000000000000000000000111101101010101, and number of digits 32.

At the bottom of the Processdata section, there are buttons for "Show groups", "Show all process variables", and a "Write text for filtering..." input field. The "Update interval" is set to 251 ms.

The status bar at the bottom left says "Connected with:" and the bottom right says "Test Device".

Вкладка Processdata

# Реализация

The screenshot displays the BADAS-service application window. The title bar reads "BADAS-service" and the menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two panes. The left pane, titled "Available ECUs", shows a "Test Device" section with the following details:

- Test Device: SN: 00000000, HwCode: 001234
- VIRTUAL DEVICE: Errors detected

Below this are several expandable sections: Parameter, Processdata, I/O Status view (which is currently selected and highlighted), Custom view, Guided Commissioning, and Error messages.

The right pane, titled "I/O Status view" with the subtitle "View of port signals", contains a table of port signals. The table has six columns: Port, Pin number, DI, AIV, DO\_ST, and PO\_CUR. The data is as follows:

Port	Pin number	DI	AIV	DO_ST	PO_CUR
IN_001	1_001	14	0	0	0
IN_002	1_002	134	0	0	0
IN_003	1_003	78	0	0	0
IN_004	1_004	102	0	0	0
IN_005	1_005	0	54914	0	0
IN_006	1_006	221	0	0	0
IN_007	1_007	118	0	0	0
IN_008	1_007	64	0	0	0
IN_009	1_007	16	0	0	0
IN_010	1_007	157	0	0	0
OUT_001	1_001	0	0	57	0
OUT_002	1_002	0	0	180	0
OUT_003	1_003	0	0	237	0
OUT_004	1_004	0	0	120	0
OUT_005	1_005	0	0	0	4051
OUT_006	1_006	0	0	19	0
OUT_007	1_007	0	0	243	0
OUT_008	1_007	0	0	134	0
OUT_009	1_007	0	0	248	0
OUT_010	1_007	0	0	75	0

At the bottom of the right pane, there is a text input field labeled "Write text for filtering..." and an "Update interval" set to "514 ms".

The status bar at the bottom of the window shows "Connected with:" on the left and "Test Device" on the right.

Вкладка I/O Status view



# Реализация

The screenshot shows the BADAS-service application window. The title bar reads "BADAS-service" and the menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two panes. The left pane, titled "Available ECUs", shows a "Test Device" section with the following details:

- Test Device: SN: 00000000, HwCode: 001234
- VIRTUAL DEVICE: Errors detected

Below this are expandable sections: Parameter, Processdata, I/O Status view, Custom view (selected), Guided Commissioning, and Error messages.

The right pane, titled "Custom view", displays "Parameter values are displayed and can be edited". It has two tabs: "Items selection" and "Numeric table view". The "Items selection" tab is active, showing a tree structure:

- Parameter
  - menu 0
  - menu 1
    - submenu 1.0
    - submenu 1.1

- Processdata
- I/O Status view

The "I/O Status view" section contains a table with the following data:

Port	Pin number	DI	AIV	DO_ST	PO_CUR
IN_001	1_001	247	0	0	0
IN_002	1_002	227	0	0	0
IN_003	1_003	22	0	0	0
IN_004	1_004	106	0	0	0
IN_005	1_005	0	5820	0	0
IN_006	1_006	97	0	0	0
IN_007	1_007	174	0	0	0

At the bottom right of the Custom view pane, there is an "Update interval" field set to "517 ms".

At the bottom of the application window, it says "Connected with: Test Device".

Вкладка Custom view

# Реализация

The screenshot displays the BADAS-service application window. The title bar reads "BADAS-service" and the menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The main interface is divided into two main sections:

- Available ECUs:** Shows "Test Device" with SN: 00000000 and HwCode: 001234. Below this is a list of views: Parameter, Processdata, I/O Status view, Custom view, Guided Commissioning, and Error messages (which is currently selected).
- Error messages:** Titled "Error messages" with the subtitle "Overview of current active and saved error messages". It contains two tables:
  - Active errors:**

Index	Error code	Occurences	Timestamp	Error message	Param
1	0x2201	22	19:43	in: param out of range	1
2	0x0515	9	10:55	in: getFreqPhase: out of range	0
  - Saved errors:** A table with the same headers as the active errors table, but it is currently empty.

At the bottom of the Error messages section, there are buttons for "Delete active errors" and "Delete saved errors", followed by "Operation time:" and "Update interval" set to "3013 ms".

The status bar at the bottom left says "Connected with:" and the bottom right says "Test Device".

Вкладка Error messages

# Тестирование

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The screenshot displays the BADAS-service software interface. The window title is "BADAS-service". The menu bar includes "File", "Actions", "View", "Tools", and "Help". The toolbar contains icons for Scan, Open, Save, Preview, Print, Break, Get data, Password, Save, Default, Reinit, Reset, Clear cache, Compare, and Help.

The interface is divided into two main sections:

- Available ECUs:** Shows "TEST DEVICE" with fields for SN, HwCode, and "No errors". A tree view on the left lists: Parameter (selected), Processdata, I/O Status view, Custom view, Guided Commissioning, and Error messages.
- Parameter:** Displays parameter values and allows editing. The "Learning curves" tab is active, showing a list of parameters under "4.6 Limitations":
  - 4.6.1 Temp Limit: ON
  - 4.6.2 P Snsr Err Limit: ON
  - 4.6.3 Oil Temp Lim On: 95 °C (with a tooltip showing: current value 95, minimum value 85, maximum value 105, step width 1, default value 95)
  - 4.6.4 Oil Temp Lim Off: 75 °C

At the bottom, there are filters: "Show only menus", "Show groups", "Show all parameters", and a text input "Write text for filtering...". The "Update interval" is set to 3011 ms. The status bar at the bottom left says "Connected with:" and the bottom right says "TEST DEVICE".

Вывод данных на примере вкладки Parameter

# Тестирование

BADAS-service

File Actions View Tools Help

Scan Open Save Preview Print Break Get data Password Save Default Reinit Reset Clear cache Compare Help

Available ECUs

TEST DEVICE SN:  
HwCode:  
No errors

- ▷ Parameter
- ▷ Processdata
- ▷ I/O Status view
- ▷ Custom view
- ▷ Guided Commissioning
- ▷ Error messages

Parameter  
Parameter values are displayed and can be edited

Parameter Learning curves

1 Common Parameters

1.8 Options III

1.8.1 Gearbox Limitation  ON STD Help

3 Aggregate Parameters

3.1 Engine / TRCA

3.1.8 TRCA Gear Ratio  100 STD Help

4 Control Parameters I

4.1 Gearbox DPC\_v1

4.1.1 Manual Gear Set  OFF STD Help

Show only menus Show groups Show all parameters  Update interval  ms

Connected with: TEST DEVICE

Поиск в дереве параметров

# Тестирование

Проверка правильности ввода.

Ввод значения недопустимого типа:

The image shows two screenshots of a control interface for the parameter '3.1.2 DieselMaxSpeed'. Each screenshot features a horizontal slider with tick marks at 160, 183, 206, 229, and 250. To the right of the slider is a numeric input field with up/down arrows and the unit 'rpm'. In the first screenshot, the input field contains the text 'ggg', which is not a valid number. In the second screenshot, the input field contains the number '215', which is a valid number but is not highlighted in blue, suggesting it might be outside the slider's range or not the current selection. Both screenshots include 'STD' and 'Help' buttons on the far right.

Ввод значения больше максимального / меньше минимального:

The image shows two screenshots of a control interface for the parameter '3.1.2 DieselMaxSpeed'. Each screenshot features a horizontal slider with tick marks at 160, 183, 206, 229, and 250. To the right of the slider is a numeric input field with up/down arrows and the unit 'rpm'. In the first screenshot, the input field contains the number '270', which is greater than the maximum value of 250. In the second screenshot, the input field contains the number '250', which is at the maximum value of the slider. Both screenshots include 'STD' and 'Help' buttons on the far right.

Установка в значение по умолчанию:

The image shows two screenshots of a control interface for the parameter '2.2.7 BrakePedalmax'. Each screenshot features a horizontal slider with tick marks at 0, 1250, 2500, 3750, and 5000. To the right of the slider is a numeric input field with up/down arrows and the unit 'V'. In the first screenshot, the input field contains the number '2140', which is within the range of the slider. In the second screenshot, the input field contains the number '5000', which is at the maximum value of the slider. Both screenshots include 'STD' and 'Help' buttons on the far right.

# Заключение

В рамках выпускной квалификационной работы с соблюдением всех заявленных требований был разработан графический пользовательский интерфейс программы диагностики и настройки электронных блоков управления самоходных машин, реализующий функционал предоставленного предприятием бэкенда и имеющий возможность для расширения.

Перспективы развития проекта:

- построение графиков изменения значений параметров и портов, взаимодействие пользователя с графиками;
- создание, сохранение и загрузка готовых диагностических проектов;
- возможность выбора интерфейса подключения и языка контроллера;
- возможность более детальной настройки отображения вкладки Custom view.

Спасибо за внимание!