Software Requirement Specification

Document

Dash Data Display STM32

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| 30/11/2024 | 0.8 | Added Class for the Buzzer and Thermocouple, updated HW interfaces to support the Thermocouples and buzzer | Miroslav Mitrovic |

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# Introduction

## Purpose

This document shall cover the functional and non-functional software requirements. This SRS will focus only on SW and interfaces of the Dash Data Display Application.

## Document Conventions

For higher level abstraction System Architecture shall be followed.

## Intended Audience and Reading Suggestions

This document shall be readable by team members that are working in SW development, architecture and testing. This document is organized in a multiple chapters. Each of chapters provide corresponding information. Reading sequence shall be followed as it is in the document.

## Project Scope

Dash Data Display Application has a goal to provide valuable information to the Driver from Engine Management ECU and other available sensors(Vehicle speed, Oil Pressure and Temperature). This will be further explained in Functional Requirements.

## References

SW Architecture and SW/System Architecture diagrams are available at :  
<https://github.com/MiroslavMitrovic/IgnitionController_STM32/tree/main/Design>

## Acronyms and Abbreviations

<The following acronyms and abbreviation will apply to this document.

|  |  |
| --- | --- |
| SRS  FEE | Software Requirement Specification>  Flash Eeprom Emulation |

# Overall Description

## Product Features

Dash Data Display shall have following features:

* Display Relevant Engine and Sensor data via LCD Display
* Inform Driver about Engine/Sensor Malfunctions via Warnings
* Enter a start mileage(default shall be 0, but at production this value can be entered to any value between 0-999999)
* Calculate and display correct mileage
* Driver can reset the mileage for a trip computer
* Maximum Value of kilometers for trip computer

## User Classes and Characteristics

Following Classes shall be used:

* HW\_Wrapper(to provide the separation between Application and HW Abstraction Layer) :
  + Adc\_Wrapper
  + Can\_Wrapper
  + Gpio\_Wrapper
  + Spi\_Wrapper
  + Uart\_Wrapper
  + Flash\_Wrapper
* CAN\_Main(Main Class)
* CAN\_Processor(To process the CAN data)
* CAN\_Interface(To create interfaces for CAN data to be passed to other classes)
* ~~CAN\_Adapter(To create interface between Hardware Abstraction Layer)~~
* SPI\_Main(Main Class)
* SPI\_Processor(To process the I2C data)
* SPI\_Interface(To create interfaces for I2C data to be passed to other classes)
* ~~SPI\_Adapter(To create interface between Hardware Abstraction Layer)~~
* UART\_Main(Main Class)
* UART\_Processor(To process the I2C data)
* UART\_Interface(To create interfaces for I2C data to be passed to other classes)
* ~~UART\_Adapter(To create interface between Hardware Abstraction Layer)~~
* ADC\_Main(Main Class)
* ADC\_Processor(To process the ADC data)
* ADC\_Interface(To create interfaces for ADC data to be passed to other classes)
* ~~ADC\_Adapter(To create interface between Hardware Abstraction Layer)~~
* Odometer\_Main(Main Class)
* Odometer\_Processor(To process the Sensor interrupt data)
* Odometer\_Interface(To create interfaces for VSS data to be passed to other classes)
* ~~Odometer\_Adapter(To create interface between Hardware Abstraction Layer)~~
* LCD\_Main(Main Class)
* LCD\_Processor(Functions for LCD display handling)
* LCD\_Interface(To create interfaces to LCD data to be passed to other classes)
* ~~LCD\_Adapter(To create interface between Hardware Abstraction Layer)~~
* FEE\_Interface(To create interfaces for odometer data to be passed to other classes)
* FEE\_Wrapper(To have a possibility to wrap different FEE stacks)
* IgnitionSig\_Main(Main Class)
* IgnitionSig\_Processor(Process the ignition Signal Availability)
* IgnitionSignal\_Interface(To create interfaces for Ignition Signal availability to be passed to other classes)
* ~~IgnitionSignal\_Adapter(To create interface between Hardware Abstraction Layer)~~
* DashDataDisp\_Main(Main class of the Application, here is defined the main function of the app)
* TurnSigHdlIndicator\_Main(Main Class)
* TurnSigHdlIndicator\_Adapter(To create interfaces between HAL)
* TurnSigHdlIndicator\_Interface((To create interfaces for Turn Signal and Headlight Indication to be passed to other classes)
* Thermocouple\_Main (Main Class)
* Thermocouple\_Adapter (To create interfaces between HAL)
* Thermocouple\_Interface ((To create interfaces for EGT Temperature Sensor SWC to be passed to other classes)
* Thermocouple\_Processor(Process the EGT Thermocouple Temperature signal)
* Buzzer\_Adapter (To create interfaces between HAL)
* Buzzer\_Interface ((To create interfaces for EGT Temperature Sensor SWC to be passed to other classes)

## Operating Environment

Application shall be constructed to be hardware independent, so that can be easily ported to the other hardware platform. Change of display it should be also possible by including corresponding Display Drivers. As a starting point STM32F407VGT6 MCU, and 20x4 characters LCD 1602 Display with I2C shield is used. Dash Data Display app shall run under FREE\_RTOS OS, version 202212.00.

## Design and Implementation Constraints

MCU shall be clocked at 168MHz(Maximum speed). LCD shall output the data at 100ms rate. Data processing shall be performed at 25ms rate. CAN Bus data from Engine Management ECU is sent at 20ms rate with datarate of 500kb. CAN bus base id is 0x5e8.CAN DBC is available in design folder of project. Flash EEPROM Emulation shall be used for storing the mileage data into flash. Memory is limited with 1MB of Flash and 128k of RAM.

## User Documentation

Additional documents are available in Design/Requirements folder.

Following Documents are available:

* Megasquirt\_CAN\_Broadcast.pdf (Description about the broadcasted Data from ECU on CAN bus)
* AN3969\_EEPROM.pdf (Application Note about EEPROM implementation from STM)
* dm00031020-stm32f405415-stm32f407417-stm32f427437-and-stm32f429439-advanced-armbased-32bit-mcus-stmicroelectronics.pdf(Reference Manual for MCU)
* stm32f407vg.pdf(Datasheet for MCU)

## Assumptions and Dependencies

Dependencies are following:

* FREE\_RTOS OS shall be integrated
* STM32 HAL generated code from STM 32 Cube IDE(v.1.10.1) will be used
* 3rd party SW for Flash EEPROM Emulation will be used from STM and integrated
* STM32 Cube IDE v.1.10.1 will be used for development purposes

# System Features

This chapter shall represent the system features that Display Dash Data shall provide.

## Display Relevant Engine and Sensor Data

This feature shall provide the relevant engine and sensor data to the driver via LCD display.

### Description and Priority

Displayed data shall contain information from engine management ECU via CAN bus and external sensors via ADC interfacing. Display of this data has a Medium Priority. There are two pages available with relevant data. User between the pages by a press of a button.

### Stimulus/Response Sequences

User actions are :

* Press Page 1 button -> show Page 1 data
* Press Page 2 button -> show Page 2 data

### Functional Requirements

Below are functional requirements:

REQ-1: Default LCD display will show the Page 1 layout

REQ-2: By pressing the Page1 button switch LCD shall revert to the Page 1

REQ-3: By pressing the Page2 button switch LCD shall switch to Page 2 layout

REQ-4: Page 1 will contain following data:

|  |  |
| --- | --- |
| Source | Data |
| CAN Bus | Engine RPM |
| GPIO Interrupt | Vehicle Speed Signal |
| Derived | Mileage |
| Derived | Trip Mileage |
| GPIO Polling | Turn Signal and Headlight indication |

REQ-5: Page 2 will contain following data:

|  |  |
| --- | --- |
| Source | Data |
| CAN Bus | Manifold Air Temperature |
| CAN Bus | Manifold Air Pressure |
| CAN Bus | Battery voltage |
| ADC | Oil Temperature |
| ADC | Oil Pressure |
| SPI | EGT Temperature Left and Right Cylinder |

REQ-5: Turn signals indicator shall blink at constant rate derived from input GPIO interrupt.

REQ-6: Buzzer will sound with the same frequency as turn signal indicators.

REQ-7: TBD

REQ-8: TBD

## Display System Malfunction Warnings

This feature shall provide Warnings to the Driver via LCD display.

### Description and Priority

Warnings will show as a message that corresponding value is below/above threshold. Values that are considered are:

* Oil Pressure
* Oil Temperature
* Battery Voltage
* Engine RPM

Display of these warnings are considered with High Priority.

### Stimulus/Response Sequences

Warnings will be shown at order mentioned above. If there is more than one warning present, display will switch between the warnings in time sequence of 3 seconds for each warning.

### Functional Requirements

Below are Functional requirements:

REQ-9: Oil Pressure threshold warning value is less than 1 bar

REQ-10: Oil Temperature threshold warning value is greater than 140 degC

REQ-11: Battery Voltage threshold warning value is less than 12 Volts.

REQ-12: Charging Voltage less than 13.5 Volts

## Display Mileage Data

This feature shall provide Mileage data to the Driver via LCD display.

### Description and Priority

Mileage data shall be displayed at Page 1 of LCD display. Mileage data is derived from calculation based on inputs from Vehicle Speed Sensor and Vehicle Parameters. Mileage calculation will be based on how many pulses are per one kilometer. Storing of Mileage data will be performed at Ignition OFF signal by writing the data into FEE. Display of Mileage data are considered with Low Priority.

### Stimulus/Response Sequences

Mileage value shall be updated by increment of 1, and only when value is updated, updated value will be shown on LCD display.

### Functional Requirements

Below are Functional requirements:

REQ-13: Mileage Calculation shall be performed by measuring the pulses from VSS signal.

REQ-14: Mileage value shall be updated at increments by 1.

REQ-15: ~~Persistency of Mileage value shall be performed by storing latest value in FEE when ignition ON-->OFF sequence is performed.(~~obsolete for now since there is no HW support for supporting this requirement)

REQ-16:Persistency shall be maintened by storing the Mileage in meters and Mileage in FEE at each change.

## Display Vehicle Speed

### Description and Priority

Vehicle Speed shall be displayed at Page 1 of LCD display. Vehicle Speed data is derived from calculation based on inputs from Vehicle Speed Sensor and Vehicle Parameters. Vehicle Speed calculation will be based on how many pulses are unit of time.

### Stimulus/Response Sequences

Vehicle Speed value shall be updated be updated at each 1 second. Updated value will be shown on LCD display.

### Functional Requirements

Below are Functional requirements:

REQ-17: Vehicle Speed Calculation shall be performed by measuring the pulses from VSS signal and calculating the speed by dividing it at 1 s with corresponding time factor.

Formula for vehicle speed calculation is following:

Where n is RPM and rd is Dynamic Rolling Radius of the vehicle(vehicle parameters)

in FEE when ignition ON-->OFF sequence is performed.

REQ-18: Based on REQ-17, Dynamic rolling radius is 0.267m and number of pulses per one revolution shall be 10. This means that for one meter of covered distance 6 pulses shall be present. Circumference is 1.167m, this means that we have 0.167m covered by each pulse. Six pulses cover 1m of distance.

REQ-19: Addendum to REQ-17. Additional Vehicle speed calculation explanation. Theta is angle covered by one revolution and units are in radians. This must be converted to meters by multiplying by .

Δt will be determined based on function execution timing between the two function calls for calculation of vehicle speed. Derivated vehicle speed calculation formula shall be :

REQ-20: TBD

## Display Turn Signal and Headlights Indicators

This feature shall provide Turn signal and Headlight Indication to the Driver via LCD display.

### Description and Priority

Indication data shall be displayed at Page 1 of LCD display. Indication of signals is provided via corresponding GPIO pins that are connected to the Turn Signals and Headlights indicators.

### Stimulus/Response Sequences

Indication of Turn signals or Headlights will be considered active when on corresponding GPIO pin Active High Signal is present.

### Functional Requirements

Below are Functional requirements:

REQ-21 : Turn Signals and Headlight Indicators shall be updated at 10ms rate.

REQ-22 : There shall be no priorities between Turn Signal and Headlight Indicators.

REQ-23: TBD

## Thermocouple EGT

This feature shall process the Exhaust Gas Temperature of left and right cylinder that will be shown on the Second Page of LDC display.

### Description and Priority

EGT data shall be displayed at Page 2 of LCD display. Data is provided via corresponding MAX31855 IC on SPI bus. This Value is updated @100ms rate.

### Stimulus/Response Sequences

Expected temperatures are around 20~30degC(Ambient Temperature) with cold engine, and up to 900degC if engine is under heavy load.

### Functional Requirements

Below are Functional requirements:

REQ-24 : Thermocouple EGT shall be updated at 100ms rate due to HW limitation.

REQ-25 : Fault detection mechanism shall be available to show if the difference of temperatures between cylinders is greater than 50degC.

REQ-26: Thermocouple EGT data shall be displayed on Second Page of LCD display

REQ-27:TBD

REQ-28:TBD

REQ-29:TBD

## Buzzer

This feature shall create a buzzing sound by utilizing Buzzer available on PCB.

### Description and Priority

Buzzer will sound itself when there are turn signals active, with the same frequency as turn signals. Also if some warning condition is present it shall create a noise with 0.5Hz frequency.

### Stimulus/Response Sequences

Buzzer will be activated by a corresponding GPIO pin on MCU.

### Functional Requirements

Below are Functional requirements:

REQ-30 : Buzzer shall be activated in the same frequency as Turn Signal indicators.

REQ-31 :Buzzer shall be activated in case of warnings with frequency of 0.5Hz.

REQ-32: Warnings have priority over the Turn Signal indicators.

REQ-33:TBD

REQ-34:TBD

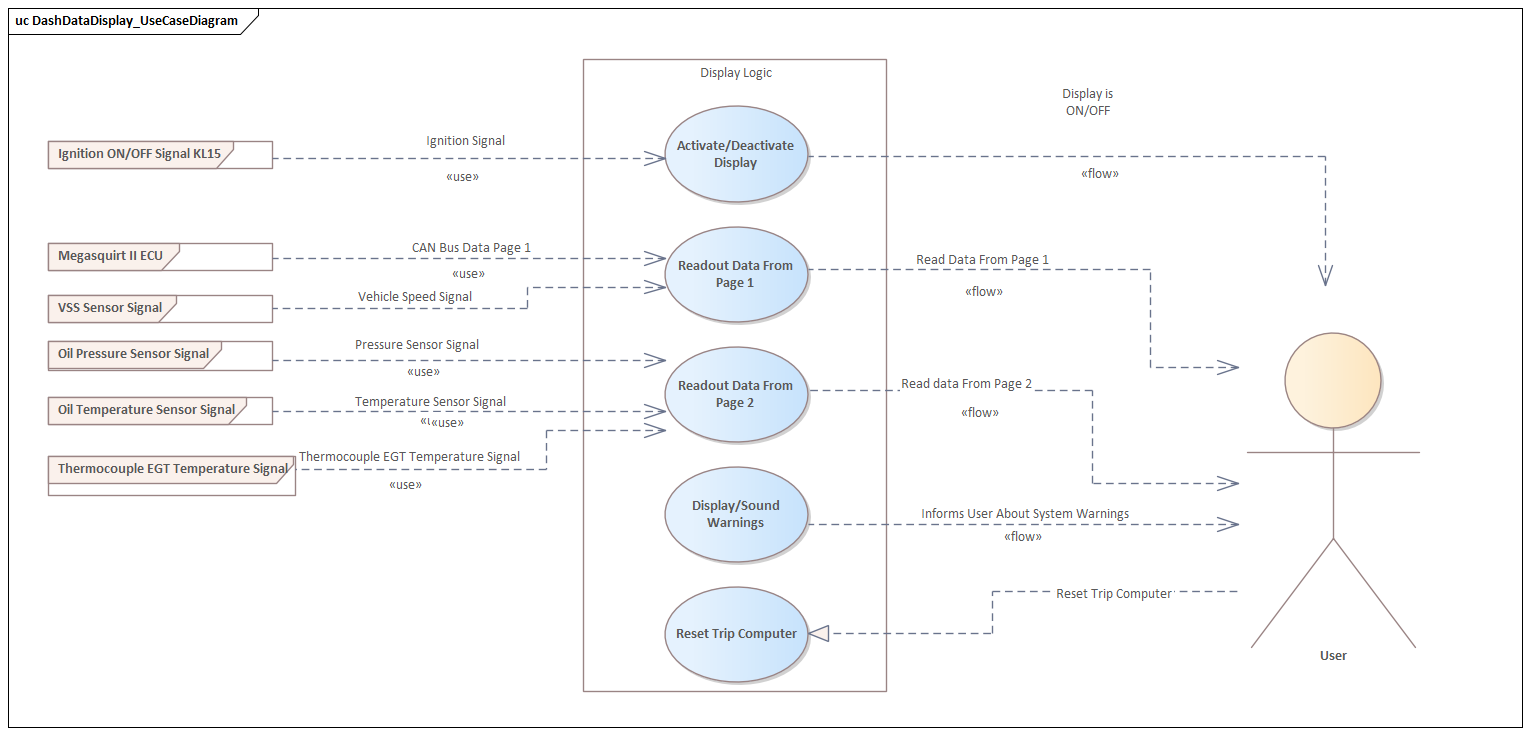
REQ-35:TBD

# External Interface Requirements

## User Interfaces

As an user interface Three Buttons will be used, one for page one selection, second one for page two selection and the third one for resetting the Trip Mileage.

Use Case diagram is below.



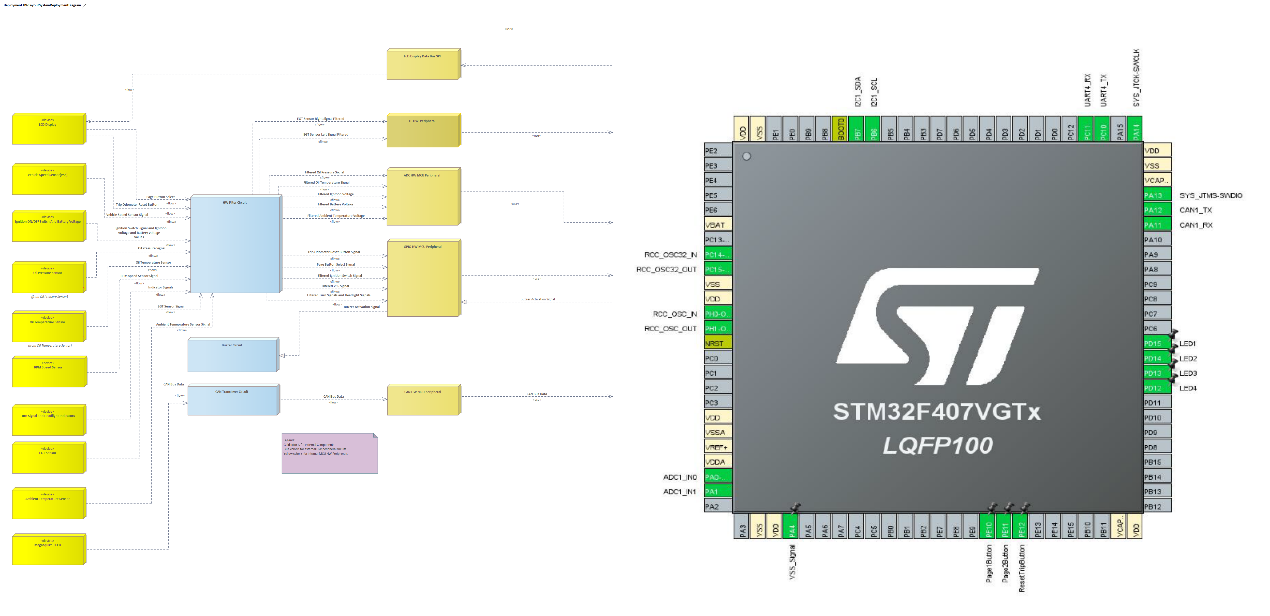
**Figure 1 Use Case Diagram**

## Hardware Interfaces

Hardware interfaces are following:

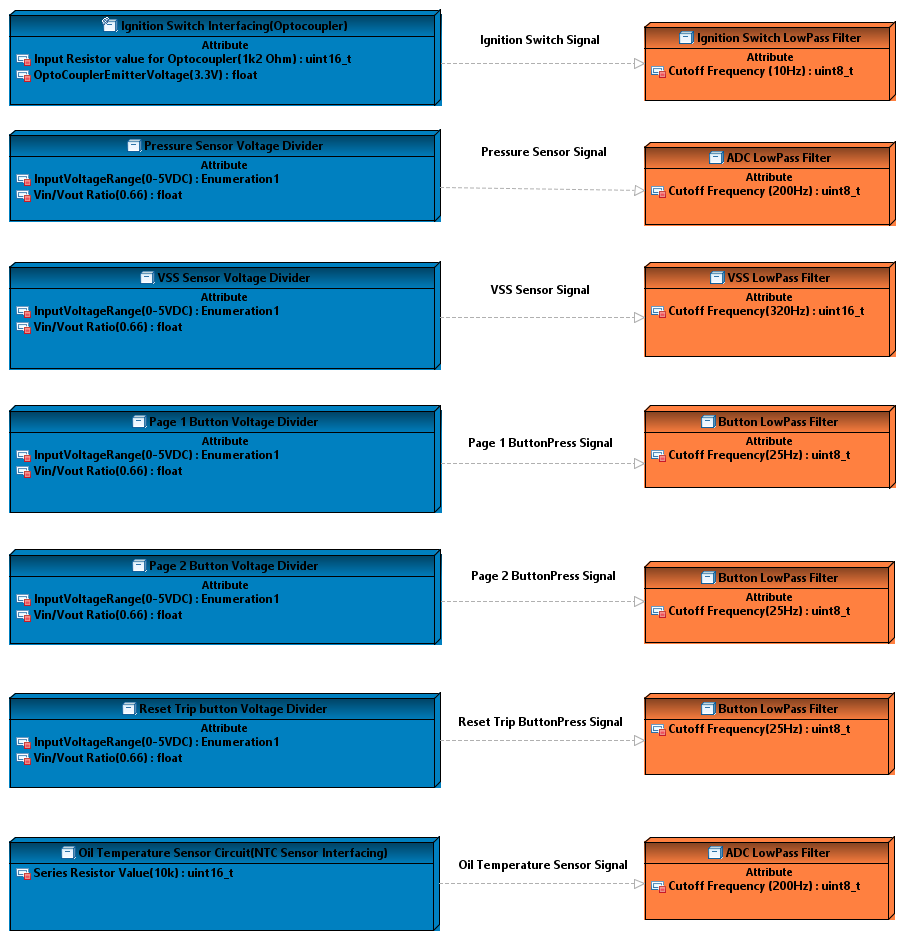
* LCD Display shall ~~have I2C or UART~~ SPI interfacing
* Vehicle Speed Sensor is Hall Sensor that shall be filtered and after filtering interfaced via GPIO interrupt routine
* Ignition signal- 12+VDC signal shall be filtered and reduced to supported Voltage level for ADC HW peripheral in MCU.
* Oil Pressure sensor shall be filtered and reduced to supported Voltage level for ADC HW peripheral in MCU. Voltage signal range shall be between 0.5VDC – 4.5VDC. Please see the datasheet of chosen sensor.
* Oil Temperature sensor shall be filtered and reduced to supported Voltage level for ADC HW peripheral in MCU. Sensor is usually of NTC type, so the proper coefficients and calculation must be performed.Please see the datasheet of chosen sensor.
* Data from Megasquirt ECU shall be received via CAN bus. CAN bus signal will go to Transciever Circuit and Transciever will forward the processed data to CAN HW peripheral of MCU.
* Ignition Switch detection signal shall be interfaced via the optocoupler and filtered via low pass filter. Further it will be sent to GPIO HW peripheral of MCU.
* Turn Signal and Headlight Indications detection shall be interfaced via optocoupler and filtered via low pass filter. Further it will be sent to GPIO HW peripheral of MCU.
* EGT Temperature sensors will be interfaced via corresponding Thermocouple ICs via SPI bus.

Hardware interfaces Layout picture is below.



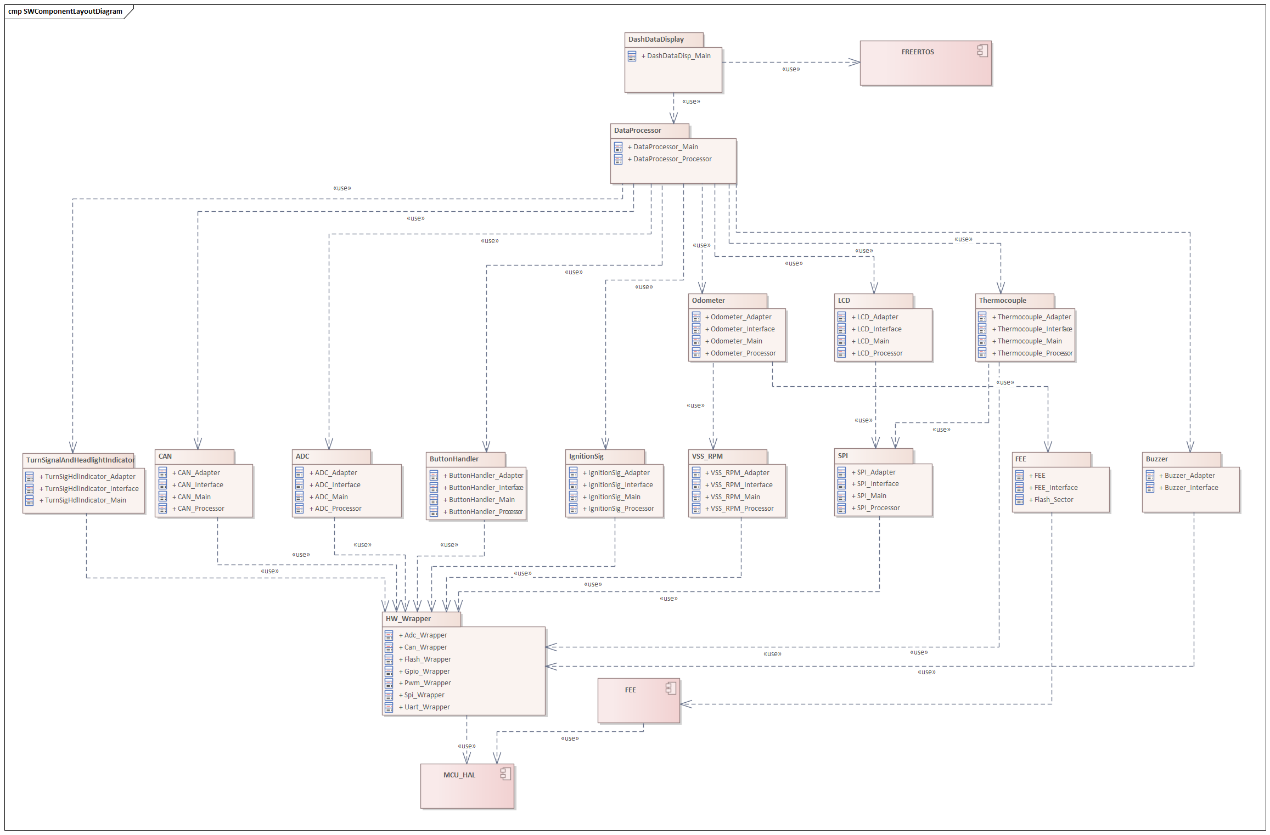
**Figure 2 HW Interfaces**

Hardware Filter Circuit Layout Diagram is below:



**Figure 3 HW filter Circuit Layout Diagram**

## Software Interfaces -TBD



**Figure 4 SW Component Layout Diagram**

<Describe the connections between this product and other specific software components (name and version), including databases, operating systems, tools, libraries, and integrated commercial components. Identify the data items or messages coming into the system and going out and describe the purpose of each. Describe the services needed and the nature of communications. Refer to documents that describe detailed application programming interface protocols. Identify data that will be shared across software components. If the data sharing mechanism must be implemented in a specific way (for example, use of a global data area in a multitasking operating system), specify this as an implementation constraint.>

## Communications Interfaces

Following Communication interfaces are used:

* ~~Two UART interfaces~~ One UART interface for FREE RTOS realtime debugging and two SPI interfaces for LCD Display(optional- Nextion Display is used) and ADC IC.
* CAN interface for receiving data from MS II ECU shall have following setup : using CAN standard addressing format and 500k baud rate.
* SPI interface is used for Different type of LCD controller(~~1602 20x4~~ 128x64 LCD display).

# Other Nonfunctional Requirements

## Performance Requirements

REQ-36: All available data shall be processed and displayed to the driver via LCD in 100ms cyclic periods.

## Safety Requirements

REQ-37: As a safety measure simple Watchdog Triggering will be implemented. If Watchdog timer window expires, Application shall initiate a reset.

## Security Requirements

Security Requirements are not in the scope of this project.

## Software Quality Attributes

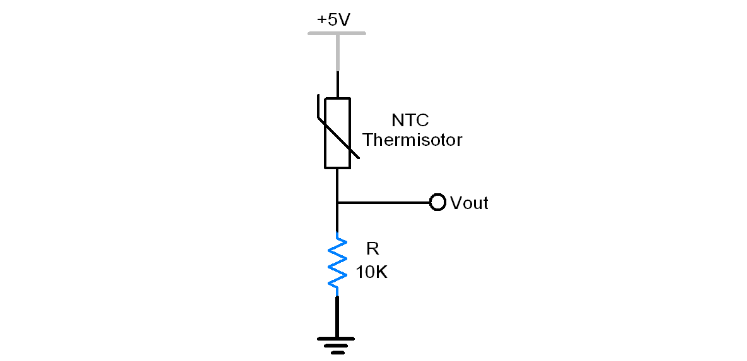
Following Software Quality Attributes shall be adhered to:

* adaptability (interfaces shall be modified easily without jeopardizing other interfaces)
* correctness (SW shall be thoroughly tested)
* portability (SW shall be easily ported to other MCUs or LCDs)

## Hardware Requirements

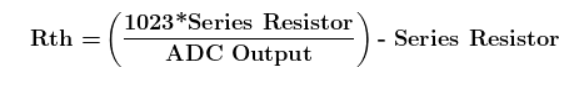
### Oil Temperature Sensor HW requirements

REQ-38: Oil Temperature Sensor shall use 12 BIT ADC conversion via ADC IC. Example Circuit for NTC Thermistor is below :



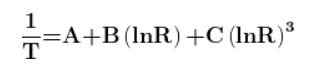
**Figure 5 NTC Thermistor Cicrcuit**

REQ-39: Oil Temperature Sensor temperature value shall be determined based on NTC sensor resistance. From equation below we can get the resistance.



**Figure 5 Determining the NTC Resistance Value**

REQ-40: Temperature will be calculated based on NTC sensor resistance using Steinhart Hart equation.



**Figure 6 Steinhart Hart equation**

### Oil Pressure Sensor HW requirements

REQ-41: Oil pressure sensor shall use 12 BIT ADC via ADC IC.

~~Chosen Oil pressure sensor if of Resistor type, with measuring range from 1.0 to 10 bars. Resistance is almost linear(difference due to measuring error of measurement setup). Due to the sensor type following requirement is derived.~~

~~REQ-27: Oil pressure sensor characteristic shall be linear, or close to linear.~~

~~After the fitting of measured data from sensor testing, following polynomial coefficients are derived for sensor characteristic :~~

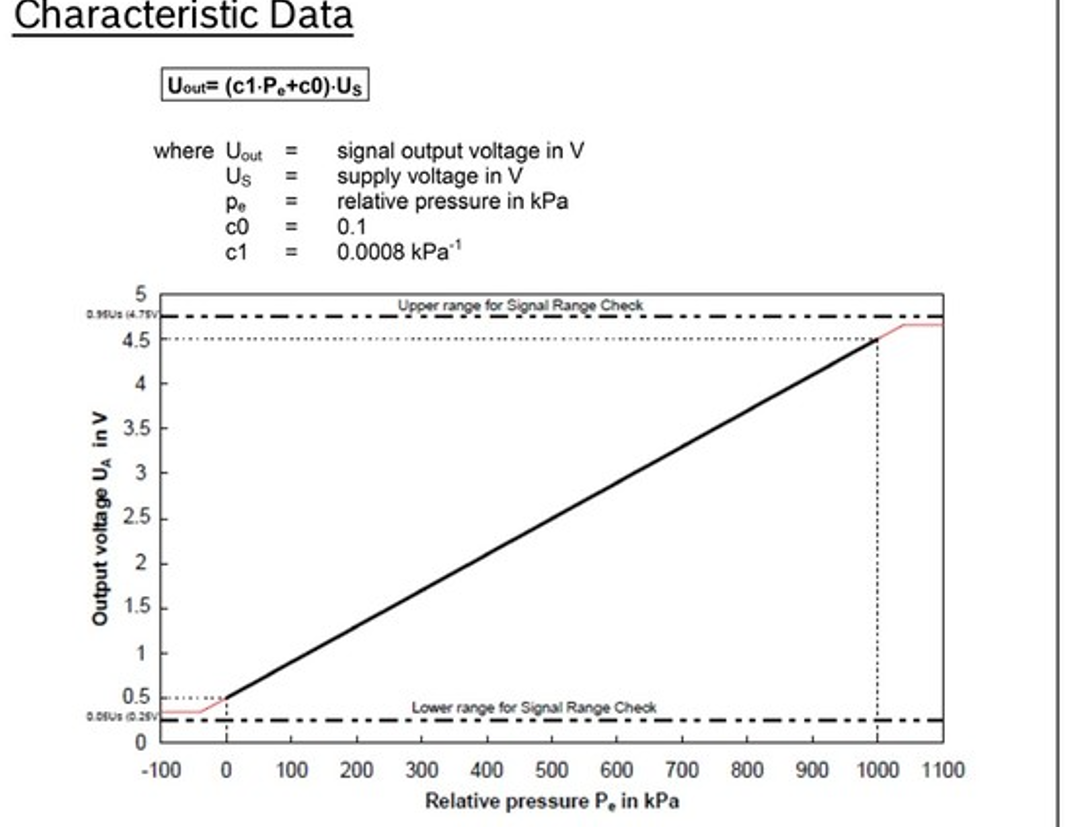
* ~~P1 = 12.5737~~
* ~~P2 =~~ ~~19.3474~~

~~From there Pressure sensor characteristic is :~~

~~y = P1 \* x + P2 = 12.5737 \* x + 19.3474~~

~~For interfacing to the MCU ADC peripheral voltage divider circuit will be used, picture is below.~~ – Obsolete

Oil pressure sensor used is Bosch 0 261 230 365, it is a relative pressure sensor that have measuring range from 0 up to 10bar. Voltage output is 0.5-4.5VDC.



**Figure 7 Pressure Sensor Characteristic**

# Other Requirements

TBD

# Appendix A: Glossary

TBD

# Appendix B: Analysis Models

TBD

# Appendix C: Issues List

TBD