

Belt StarterGenerator (BSG)

Functional Requirements

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Document Change History			
Date	Release	Changed by	Description
10/08/2023	v0.1	Daniel	Initial draft
25/08/2023	v0.2	Rafael	Remove index and fixed
10/09/2023	v0.3	Lucas	Updated traceability model
25/09/2023	v0.4	Paulo	Requirement Revised; Use Case Adjustments
06/10/2023	v0.5	Pedro	Document fully reviewed considering the model and code structure.

i/o	Name	Description	Type	Range	Unit	Baud Rate (ms)
input	voltage	Indicates the current battery voltage.	uint8_t	0-100	V	50
input	rpm	Indicates the current rotation frequency of the engine.	uint16_t	0-30000	Hz	50
input	angleAccPedal	Indicates the angle in which the throttle pedal is pressed.	uint16_t	0-100	%	50
input	angleBrakePedal	Indicates the angle in which the brake pedal is pressed.	uint16_t	0-100	%	50
input	requestCarStart	Indicates whether or not there is a request to start the engine.	uint8_t	0-1	-	50
output	stateBattery	Indicates the current state of the battery.	int	0-3	-	50
output	stateEngine	Indicates the current state of the engine.	int	0-2	-	50
output	driverIntention	Indicates the current driver's intention.	int	0-2	-	50
output	stateBSG	Indicates the BSG operation mode according to the environmental conditions.	int	0-3	-	50

Table 1 - Description of data

Observation: all values on the table are just examples, the values for every system must be defined by the calibration team.

1.Requirements

1.1 Functional Requirements

[FR-01] BSG CONTROL SYSTEM: All broadcast signals for the BSG (Belt Starter Generator) will have a 50ms baud rate.

[FR-02] BSG OPERATION MODES: the BSG will operate in the following modes only:

- Idle;
- Starter;
- Motor;
- Generator.

[SyR-01] VOLTAGE SIGNAL: the BSG control system must be able to receive the signal `voltage` indicating the current battery state in regards to its charge.

[SyR-02] RPM SIGNAL: the BSG control system must be able to receive the signal `rpm` indicating the current rotation frequency of the internal combustion engine.

[SyR-03] THROTTLE PEDAL ANGLE SIGNAL: the BSG must be able to receive the signal `angleAccPedal` indicating the angle in which the throttle pedal has been pressed by the driver.

[Syr-04] BRAKE PEDAL ANGLE SIGNAL: the BSG must be able to receive the signal `angleBrakePedal` indicating the angle in which the brake pedal has been pressed by the driver.

[Syr-05] ENGINE START REQUEST SIGNAL: the BSG must be able to receive the signal `requestCarStart` indicating that the driver has requested the start of the engine.

[FR-03] IDLE MODE: in the IDLE mode, the BSG must not actuate in any of the other modes. It represents the condition in which the BSG is not contributing to the vehicle's condition.

[FR-04] MOTOR MODE: In MOTOR mode, the BSG must provide torque to the vehicle, actively acting on the movement when requested through the energy stored in the batteries;

[FR-05] GENERATOR MODE: In the GENERATOR mode, the BSG must use the REGENERATIVE BRAKING FUNCTION to recharge the vehicle's battery:

[FR-06] STARTER MODE: In the STARTER mode, the BSG must, upon request, start the vehicle's engine through the energy stored in the battery:

Parallel to the control of the electric machine, supervisory processes must take place, ensuring that all functions and systems integrated with the BSG operate harmoniously.

[FR-07] BATTERY MONITORING: The BSG must monitor and control the charge level of the battery, assuring the processes will function correctly;

[SyR-06] MAXIMUM VOLTAGE: a constant `BatteryMaxVoltage` must be specified indicating what is the maximum voltage the battery will operate in;

[SyR-07] SPECIFIED VOLTAGE: a constant `BatterySpecVoltage` must be specified indicating the default functional voltage for the battery.

[SyR-08] MINIMUM VOLTAGE: a constant `BatteryMinVoltage` must be specified indicating the minimum voltage in which the battery may function.

[SoR-01] CHARGING CONDITION: if the value indicated in `voltage` is higher than `BatteryMaxVoltage`, the battery is considered to be charging.

[SoR-02] LOW CHARGE CONDITION: if the value indicated in `voltage` is lower than `BatterySpecVoltage`, the battery is considered to be low in charge.

[SoR-03] OPERATIONAL CONDITION: if the value indicated in `voltage` is higher than `BatterySpecVoltage`, the battery is considered to be operational.

[SoR-04] DEAD CONDITION: if the value indicated in `voltage` is lower than `BatteryMinVoltage`, the battery is considered to be dead.

[SyR-09] BATTERY STATE SIGNAL: once the battery state is determined, the BSG must generate an intermediate signal called `stateBattery` that indicates which of the four mentioned states the battery is in. The value contained in this signal is different for each of the states as follows:

Table 2 - Battery State Signal

STATE	NAME	VALUE
Dead	BATTERY_DEAD	0
Low	BATTERY_LOW	1
Operational	BATTERY_OPERATIONAL	2
Charging	BATTERY_CHARGING	3

[FR-08] ENGINE MONITORING: The BSG must monitor and control the rotation frequency of the engine, assuring the processes will function correctly.

[SyR-09] MAXIMUM RPM: a constant `EngineRPMMaximum` must be specified indicating the maximum rpm in which the motor may still operate.

[SoR-05] MAXIMUM RPM CONDITION: if the value indicated in `rpm` is equal to `EngineRPMMaximum`, the engine is considered to be in its maximum operating rotation.

[SoR-06] ENGINE WORKING CONDITION: if the value indicated in `rpm` is lower than `EngineRPMMaximum`, the engine is considered to be operational.

[SoR-07] ENGINE DEAD CONDITION: if the value indicated in `rpm` is equal to zero, the engine is considered to be dead.

[SyR-10] ENGINE STATE SIGNAL: Once the engine state is determined, the BSG must generate an intermediate signal called `stateEngine` that indicates which of the three mentioned states the engine is in. The value contained in this signal is different for each of the states as follows:

STATE	NAME	VALUE
Dead	ENGINE_OFF	0
Working	ENGINE_WORKING	1
Maximum RPM	ENGINE_RPM_MAXIMUM	2

[FR-09] VEHICLE MONITORING: The BSG must monitor and control the driver's inputs on the pedals, assuring the processes will function correctly.

[SyR-11] BRAKE PEDAL MINIMUM ANGLE: a constant `VehicleMinBrakePedal` must be specified for reference to determine the state of the vehicle.

[SyR-12] THROTTLE PEDAL MINIMUM ANGLE: a constant `VehicleMinAccPedal` must be specified for reference to determine the state of the vehicle.

[SoR-08] REDUCE SPEED CONDITION: if the value in `angleBrakePedal` is higher than the value in `VehicleMinBrakePedal`, then the vehicle is considered to be in a condition of decreasing speed.

[SoR-09] INCREASE SPEED CONDITION: if the conditions in SoR-08 are not met and the value in `angleAccPedal` is higher than the value in `VehicleMinAccPedal`, then the vehicle is considered to be in a condition of increasing speed.

[SoR-10] MAINTAIN SPEED CONDITION: if the conditions in SoR-08 are not met and the value in `angleAccPedal` is lower than the value in `VehicleMinAccPedal`, then the vehicle is considered to be in a condition of maintaining speed.

[SyR-13] VEHICLE STATE SIGNAL: Once the vehicle state is determined, the BSG must generate an intermediate signal called `driverIntention` that indicates which of the three mentioned states the vehicle is in. The value contained in this signal is different for each of the states as follows:

STATE	NAME	VALUE
Maintain speed	DRIVER_INTENTION_NOTHING	0
Reduce speed	DRIVER_INTENTION_REDUCE_SPEED	1
Increase speed	DRIVER_INTENTION_INCREASE_SPEED	2

[FR-10] BSG CONTROL: the BSG must receive the signals `driverIntention`, `stateEngine`, `stateBattery` and `requestCarStart` to determine its functioning mode.

[SoR-11] STARTER MODE CONDITION: if `stateBattery` differs from `BATTERY_DEAD`, `stateEngine` equals `ENGINE_OFF` and `requestCarStart` is true, the BSG operation mode is STARTER.

[SoR-12] GENERATOR MODE CONDITION: if `driverIntenrion` equals `DRIVER_INTENTION_DECREASE_SPEED`, the BSG operation mode is GENERATOR.

[SoR-13] MOTOR MODE CONDITION: if `driverIntention` equals `DRIVER_INTENTION_INCREASE_SPEED`, the BSG operation mode is MOTOR.

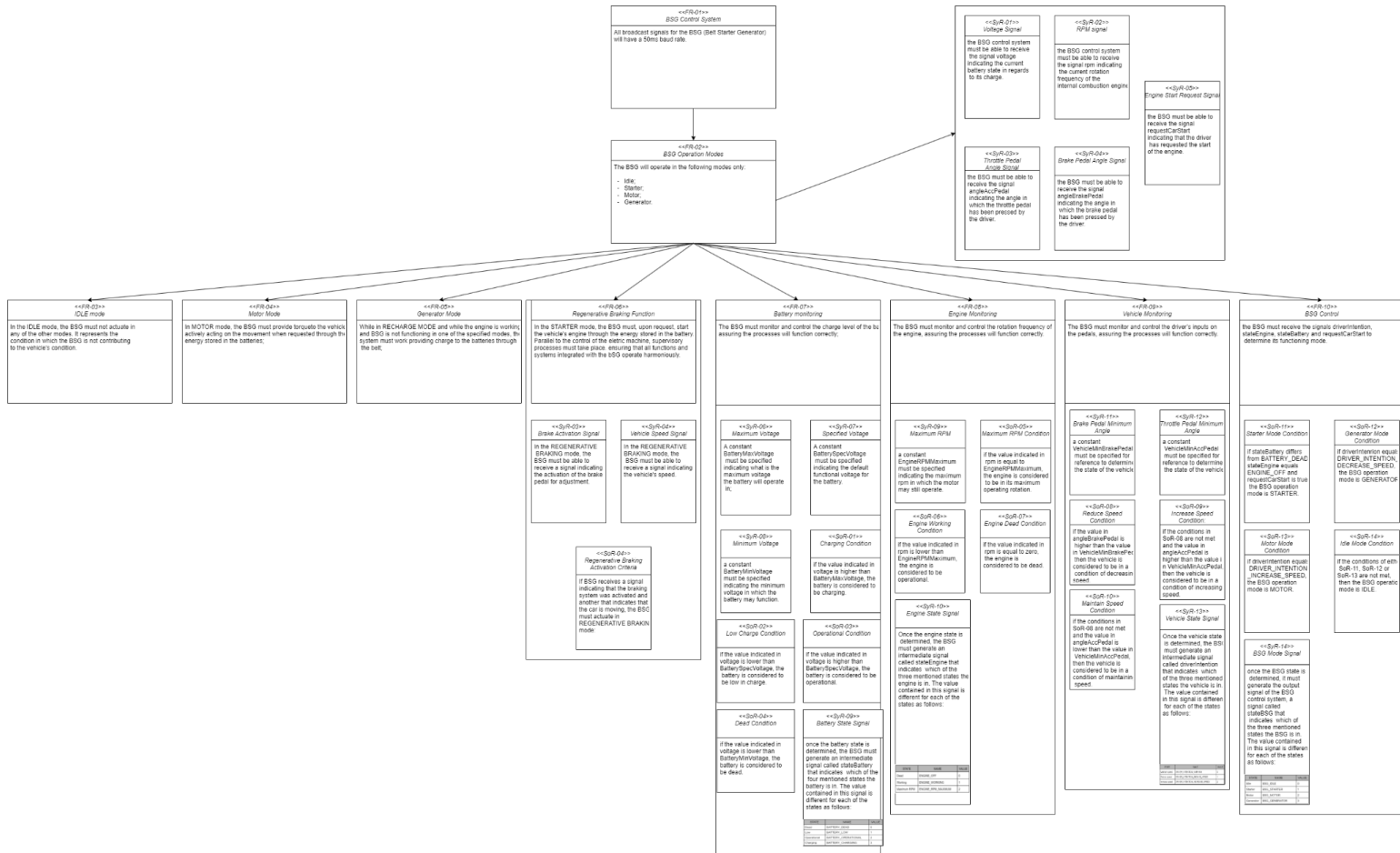
[SoR-14] IDLE MODE CONDITION: if the conditions of either SoR-11, SoR-12 or SoR-13 are not met, then the BSG operation mode is IDLE.

[SyR-14] BSG MODE SIGNAL: once the BSG state is determined, it must generate the output signal of the BSG control system, a signal called `stateBSG` that indicates which of the three mentioned states the BSG is in. The value contained in this signal is different for each of the states as follows:

STATE	NAME	VALUE
Idle	BSG_IDLE	0
Starter	BSG_STARTER	1
Motor	BSG_MOTOR	2
Generator	BSG_GENERATOR	3

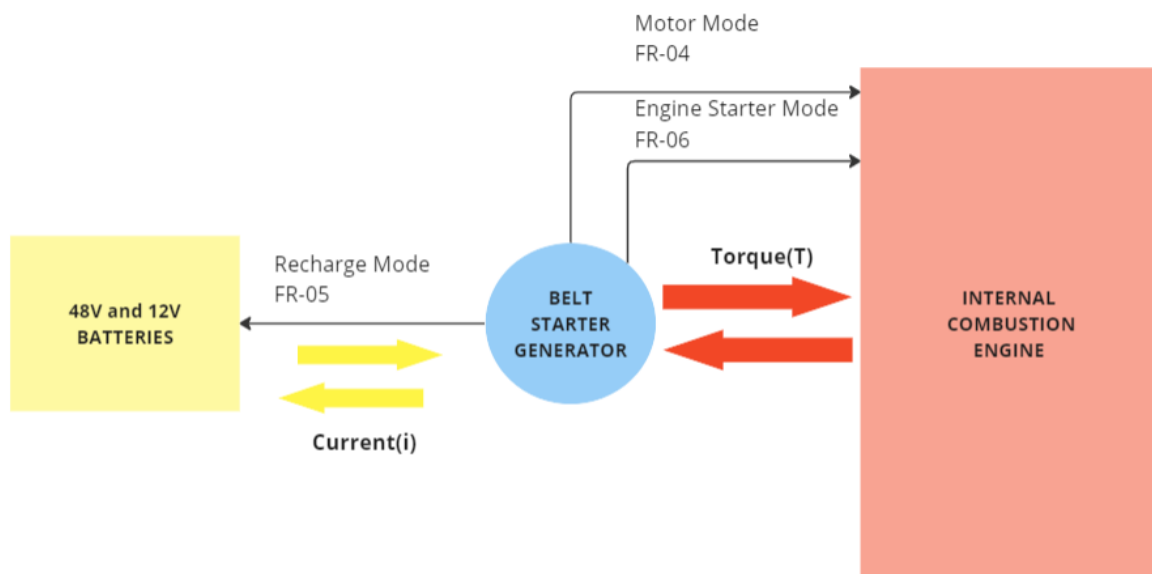
Table 5

2. Requirements Diagram



In high resolution in the project repository.

3.1 Operating Modes Diagram

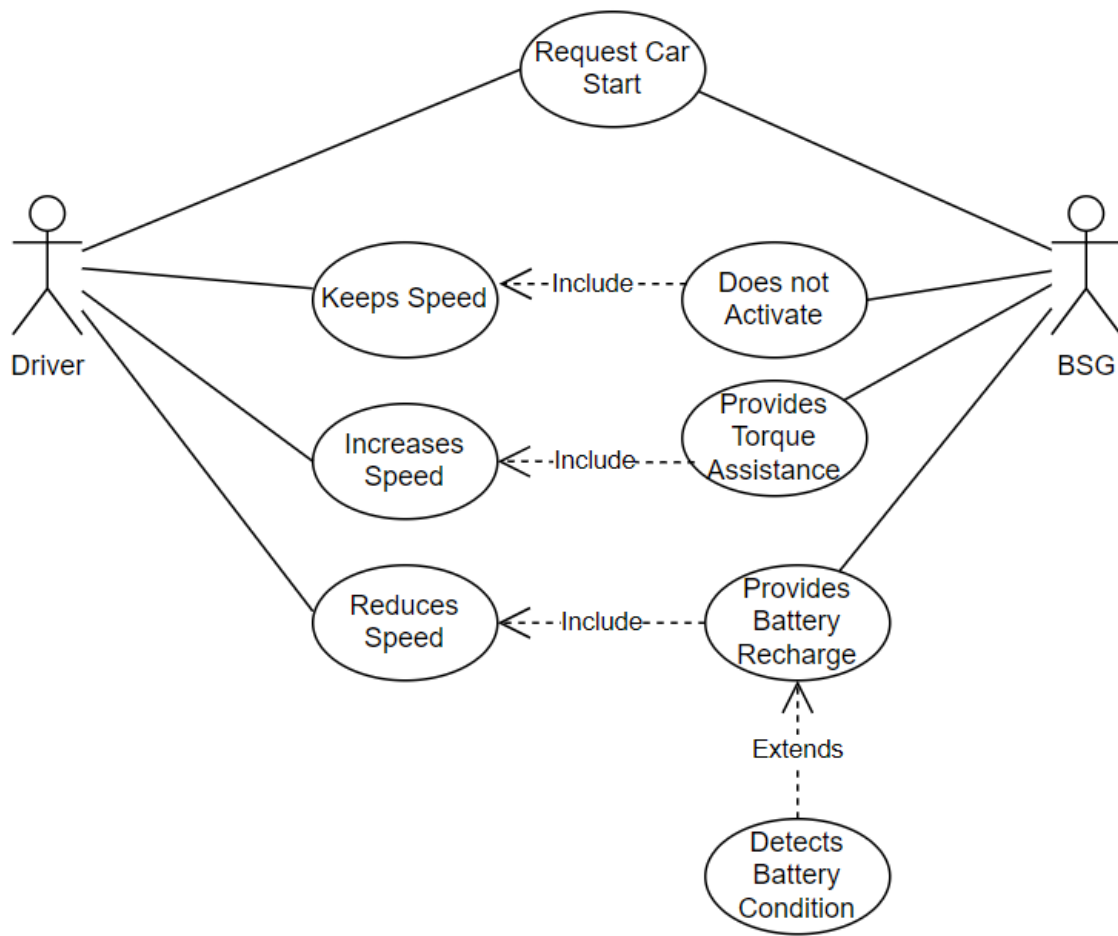


Subtitles:

—→ Operating Modes

█→ Processes

3.2 Use case Diagram





3.3 Requirements traceability table



Req.	Depends on								
FR-01									
FR-02	FR-01								
FR-03	FR-01	FR-02	FR-04	FR-05	FR-06				
FR-04	FR-01	FR-02	FR-07	FR-08	FR-09				
FR-05	FR-01	FR-02	FR-07	FR-09					
FR-06	FR-01	FR-02	FR-07	FR-08					
FR-07	FR-01								
FR-08	FR-01								
FR-09	FR-01								
FR-10	FR-01	FR-02	FR-03	FR-04	FR-05	FR-06	FR-07	FR-08	FR-09

4. Version Control

last week

 akafael

 v0.4

 73c6f1c 

Compare


2023-09-25 Code with Unit Tests

Pre-release


Draft version with the all unit tests for code.


Assets



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 akafael

 v0.3

 24b1166 

Compare


2023-09-10 First Version Code

Pre-release


Draft version with the code manually created using the model and requirements as reference.


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
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Aug 28

 akafael

 v0.2

 91e8c12

Compare


2023-08-25 First Version Models

Pre-release

Draft version with system requirements and models.

Assets

2





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
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
Verified


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
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