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Project task 1

Pololu Zumo 32U4

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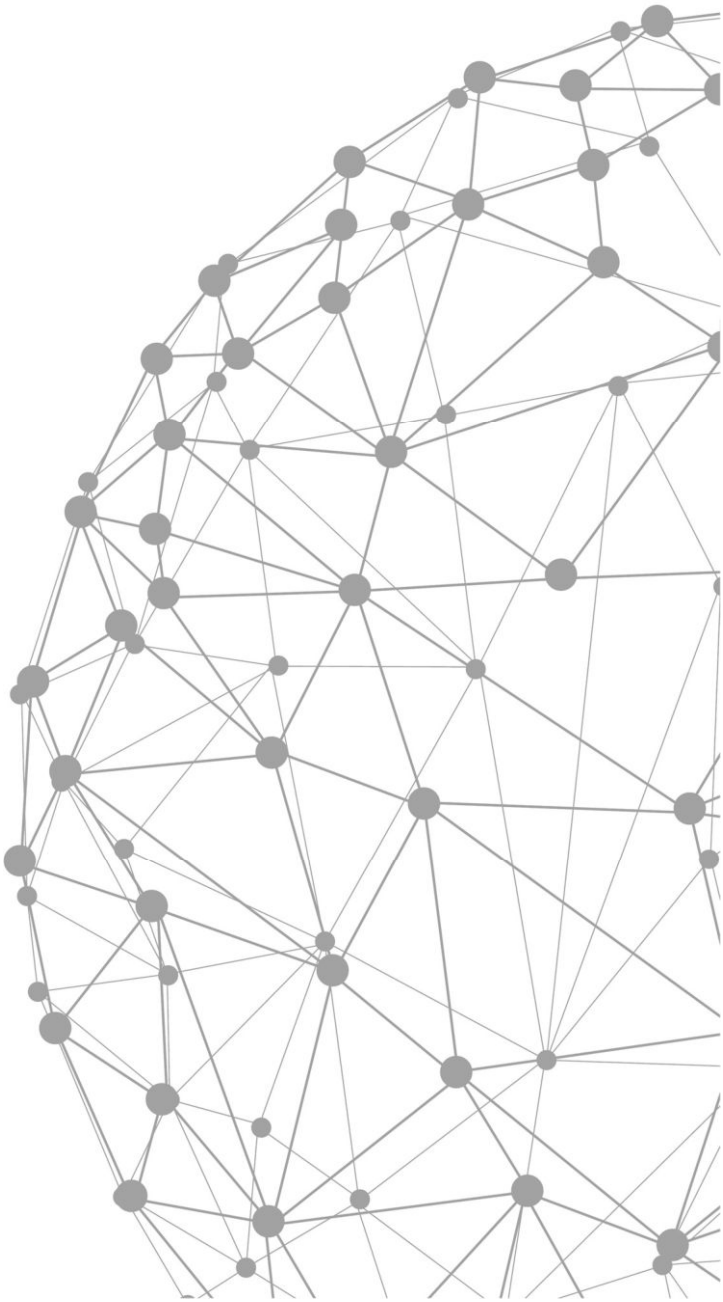

Customer:
NewTec
Development
Buchenweg 3
89284 Pfaffenhofen a. d. Roth
Germany

Author:
Team: ~~ o=o\
Hs Offenburg

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Release

	Name	Responsibility	Date	Signature
Creation				i.A.
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Release				i.A.

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1 General

1.1 Abbreviations

Abbreviation	Description
OLED	Organic light emitting diode
MCU	Microcontroller unit

Table 1: Abbreviations

1.2 Terminology

1.2.1 System scenarios

Term	Description
CalibrateLineSensors	The *LineSensors* are calibrated to the current light conditions
DisplayTeamName	The *TeamName* is shown on the *OledDisplay*
DriveLap	The *Robot* shows the *CountDown* on the *OledDisplay*, drives to the *StartFinishLine* and then drives one *FullLap*
SetParameters	Allows the *User* to choose between different *ParameterSets*
HandleError	Displays an error message on the *OledDisplay* until the *User* resets it

Table 2: Terminology of the system scenarios

1.2.2 Interface scenarios

Term	Description
InitializeMcu	Required system resources and variables are initialized. The *TeamName* is shown on the *OledDisplay*
CalibrateLineSensors	The *LineSensors* are calibrated to the current light conditions
GetReadyForLap	The MCU starts with a *CountDown* from 3 to 0 and the Robot starts moving.
DriveLap	The *Robot* follows the *GuideLine*
DriveOverGap	Allows the robot to drive over an interruption in the *GuideLine*
MeasureTime	Measures the time of a lap. This use case runs parallel to other use cases.
DisplayLapTime	Displays the completed lap time
HandleError	Displays an error message on the *OledDisplay*
SetParameters	Allows parameters to be adjusted during runtime

Table 3: Terminology of the interface scenarios

1.2.3 System states

Term	Description
LineSensorCalibrationDone	The calibration of the *LineSensors* is finished
Ready	The *Robot* is ready to retrieve a command from the *User*
Running	The *Robot* is driving on the *PlayField*
Setup	The *Robot* shows the parameters and allows them to be adjusted
Error	An error sets the *Robot* into an error *State*. This *State* must be reset by the *User*

Table 4: Terminology of the system states

1.2.4 Interface states

Term	Description
InitializationDone	The initialization of the system is done
ReadyToDrive	The *Robot* is ready to drive
Drive1	The *Robot* move to the *StartFinishLine*
Drive2	The *Robot* drives a lap on the *PlayField*
DisplayTime	The *Robot* displays the lap time on the *OledDisplay*
Setup	The *Robot* shows the parameters and allows them to be adjusted
Error	An error sets the *Robot* into an error *State*. This *State* must be reset by the *User*

Table 5: Terminology of the interface states

1.2.5 Hardware

Term	Description
Robot	Zumo32U4
OledDisplay	The OLED display on the top of the Robot that allows visible feedback to the *User*
Buzzer	The buzzer on the *Robot* that allows audio feedback to the *User*
LineSensors	The sensor array at the front on the underside of the *Robot* that is able to recognize the lines of the *PlayField*
PowerSwitch	The switch at the back of the *Robot*. The *Robot* is only supplied with power when the switch is in the “ON” position
ResetButton	The rightmost button on the back of the *Robot*
StateButton	The leftmost button on the back of the *Robot*
ParamButton	The middle button on the back of the *Robot*

Table 6: Terminology of the hardware

1.2.6 Other

Term	Description
AlarmSignal	Signal of frequency 440Hz, duration 200ms, repeated thrice in 200ms intervals, volume min. 60dB at 10cm distance
CountDown	A countdown that starts with 3 and counts down to 0. The number is always decremented after 1s and is shown on the *OledDisplay* in addition to the *TeamName*
DriveMotors	The two metal gearmotors that are connected to the wheels on the backside of the *Robot*
FullLap	One lap on the *PlayField* that starts with the *StartFinishLine* and ends with the same *StartFinishLine*
FullStop	The *Robot* is not moving because the *DriveMotors* do not receive any power
GuideLine	The line on the PlayField that marks the lap and shows the Robot where it must drive
ParameterSets	The *Robot* allows to choose between different sets of parameters which affect the *Robot*'s behavior, e.g. a more cautious driving style
PlayField	The flat surface the *Robot* drives on
PoweredOn	The *Robot* is supplied with power for at least 500ms so that all the software of the Mcu had enough time to finish all initialization steps
Redetect	Recognizing *GuideLine* after losing *GuideLine* while driving
ShortBeep	Signal of frequency 440Hz, duration 100ms, volume min. 60dB at 10cm distance
StartFinishLine	The line perpendicular to the *GuideLine* that marks the beginning and end of the lap
State	The state of the Robot. Only one state can be active at the same time
TeamName	The name that identifies the team that owns the Robot. The name is defined by the software of the Mcu and cannot be changed
User	The person that interacts with the *Robot*

Table 7: Other terminology

1.3 Referenced Documents

Reference	Document-Identification	Description
[1]	N/A	N/A
	N/A	N/A

Table 8: Referenced Documents

1.4 Applicable Standards

Reference	Document-Identification	Description
[1]	N/A	N/A
	N/A	N/A

Table 9: Applicable Standards

2 Introduction

2.1 System Overview

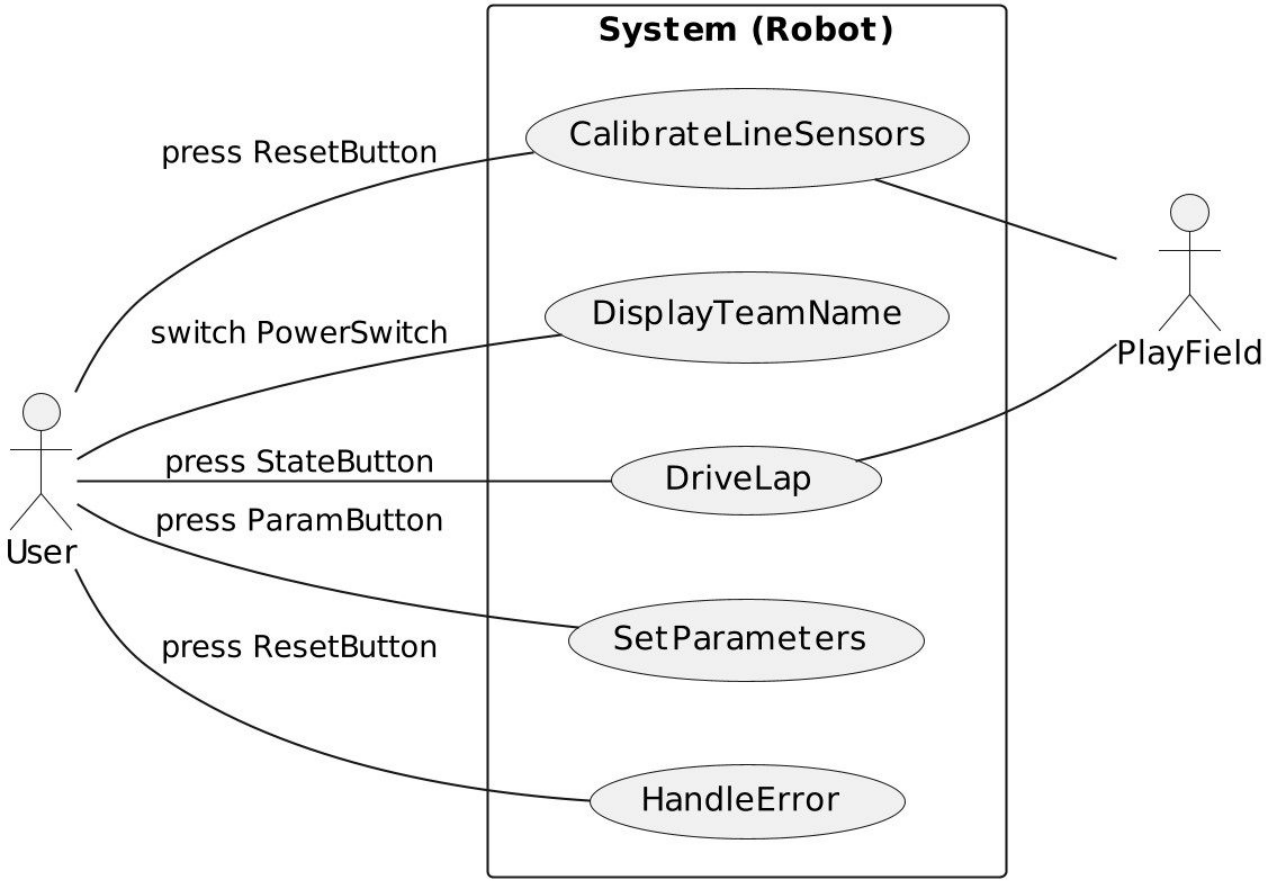

Figure 1 System Overview

2.2 Interface Overview

Figure 2 Interface Overview

2.3 Scenarios

2.3.1 System

Reference number	2.3.1.1
Name	*CalibrateLineSensors*
Short description	The *LineSensors* are calibrated to the current light conditions
Precondition	There are two different sets of preconditions in this use case. All the conditions of one set must be met. The condition sets are mutually exclusive and therefore cannot be both met at the same time. Precondition set 1 (Robot is powered on) • The *Robot* is placed on the *GuideLine* of the *PlayField* • The *PowerSwitch* is in the position “OFF” Precondition set 2 (Calibration is triggered by the user) • The *Robot* is placed on the *GuideLine* of the *PlayField* • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Postcondition	The *State LineSensorCalibrationDone* is active
Error case	none
Actors	*User, PlayField*
Trigger	There are two different triggers. The first trigger is only effective if precondition set 1 met: • The *PowerSwitch* is switched from “OFF” to “ON” The second trigger is only effective if precondition set 2 met: • The *User* presses the *ResetButton*
Standard sequence	1. The *Robot* is placed on the *GuideLine* of the *PlayField* 2. The *PowerSwitch* is switched from “OFF” to “ON” 3. The *LineSensors* are calibrated to the current light conditions 4. The *State LineSensorCalibrationDone is activated*
Alternative sequences	1. The *Robot* is placed on the *GuideLine* of the *PlayField* 2. The *State Ready* is active 3. The *User* presses the *ResetButton* 4. The *LineSensors* are calibrated to the current light conditions 5. The *State LineSensorCalibrationDone is activated*

Reference number	2.3.1.2
Name	*DisplayTeamName*
Short description	The *TeamName* is shown on the *OledDisplay*
Precondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State LineSensorCalibrationDone* is active
Postcondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Error case	none
Actors	*User*
Trigger	The *State LineSensorCalibrationDone* changes from not active to active
Standard sequence	1. The *State LineSensorCalibrationDone* changes from not active to active 2. The *OledDisplay* is cleared 3. The *TeamName* is shown on the *OledDisplay* and not cleared 4. The *State Ready* is activated
Alternative sequences	none

Reference number	2.3.1.3
Name	*DriveLap*
Short description	The *Robot* shows the *CountDown* on the *OledDisplay*, drives to the *StartFinishLine* and then drives one *FullLap*
Precondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Postcondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Error case	There are two independent error cases: • The first *StartFinishLine* is not recognized within 10s • The *FullLap* is not finished within 20s
Actors	*User, PlayField*
Trigger	The *User* presses the *StateButton*
Standard sequence	1. The *User* presses the *StateButton* 2. The *State Running* is activated 3. The *Robot* shows the *CountDown* on the *OledDisplay* 4. The *Robot* starts driving, following the line on the *PlayField* 5. The *Robot* recognizes the *StartFinishLine* 6. The *ShortBeep* is played on the *Buzzer* 7. The *Robot* continues driving, following the line on the *PlayField* 8. The *Robot* recognizes the *StartFinishLine* 9. The *ShortBeep* is played on the *Buzzer* 10. The *Robot* goes to a *FullStop* 11. The *State Ready* is activated
Alternative sequences	none

Reference number	2.3.1.4
Name	*SetParameters*
Short description	Allows the *User* to choose between different *ParameterSets*
Precondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Postcondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The *State Ready* is active
Error case	none
Actors	*User*
Trigger	The *ParamButton* is pressed
Standard sequence	1. The *ParamButton* is pressed 2. The *State Setup* is activated 3. The OledDisplay shows the *ParameterSets* and allows to select one 4. The *User* presses the *ResetButton* 5. The *State Ready* is activated
Alternative sequences	none

Reference number	2.3.1.5
Name	*HandleError*
Short description	Displays an error message on the *OledDisplay* until the *User* resets it
Precondition	All these conditions must be met: • The *Robot* is *PoweredOn* • An error occurred
Postcondition	All these conditions must be met: • The *Robot* is *PoweredOn* • The *Robot* is in *FullStop* • The use case *DisplayTeamName* (2.3.1.2) is activated
Error case	none
Actors	*User*
Trigger	An error occurs
Standard sequence	1. An error occurs 2. The *State Error* is actived 3. The *Robot* goes to a *FullStop* 4. The *AlarmSignal* is played on the *Buzzer* 5. An error message is displayed on the *OledDisplay* 6. The User presses the *ResetButton* 7. The use case *DisplayTeamName* (2.3.1.2) is activated
Alternative sequences	none

2.3.2 Interface

Reference number	2.3.2.1
Name	*InitializeMcu*
Short description	Required system resources and variables are initialized. The *TeamName* is shown on the *OledDisplay*
Precondition	All these conditions must be met: • The MCU must be offline and have no power • The *PowerSwitch* is in the position “OFF”
Postcondition	The *State InitializationDone* is active
Error case	none
Actors	*PowerSwitch, OledDisplay*
Trigger	The *PowerSwitch* is switched from “OFF” to “ON”
Standard sequence	1. All system resources are initialized 2. All system variables are initialized 3. The *TeamName* is displayed 4. The *State InitializationDone* is activated
Alternative sequences	none

Reference number	2.3.2.2
Name	*CalibrateLineSensors*
Short description	The *LineSensors* are calibrated to the current light conditions
Precondition	The *State Error* is not active
Postcondition	The *State ReadyToDrive* is active
Error case	none
Actors	*LineSensors, ResetButton*
Trigger	There are two different triggers. Both triggers execute the same standard sequence. The first trigger is: • The *State InitializationDone* is activated The second trigger is: • The *ResetButton* is pressed
Standard sequence	1. The *LineSensors* are calibrated 2. The *State ReadyToDrive* is activated
Alternative sequences	none

Reference number	2.3.2.3
Name	*GetReadyForLap*
Short description	The MCU starts with a *CountDown* from 3 to 0 and the Robot starts moving.
Precondition	The *State ReadyToDrive is* active
Postcondition	The State *Drive1* is active
Error case	There are two independent error cases: • The *StartFinishLine* was not crossed within 10 seconds
Actors	*OledDisplay, DriveMotors, LineSensors*
Trigger	The *StateButton* is pressed
Standard sequence	1. The *CountDown* is displayed 2. As soon as 0 is displayed, the *DriveMotors* are supplied with power 3. The State *Drive1 is* activated 4. The robot follows the *GuideLine*
Alternative sequences	none

Reference number	2.3.2.4
Name	*DriveLap*
Short description	The *Robot* follows the *GuideLine*
Precondition	There are two different sets of preconditions in this use case. All the conditions of one set must be met. The condition sets are mutually exclusive and therefore cannot be both met at the same time. Precondition set 1: • The *State Drive1 is* active
Postcondition	The *State Drive2* is not active
Error case	The *FullLap* is not finished within 20s
Actors	*OledDisplay, DriveMotors, LineSensors*
Trigger	There are two independent triggers: • The *StartFinishLine* has been recognized • The use case *DriveOverGap* (2.3.2.5) is finished
Standard sequence	1. The *StartFinishLine* has been recognized 2. The *Buzzer* emits the *ShortBeep* 3. The *State Drive2 is* activated 4. The *Robot* follows the *GuideLine* 5. The *StartFinishLine* has been recognized again 6. The *Buzzer* emits the *ShortBeep* 7. The *State DisplayTime is* activated
Alternative sequences	1. The use case *DriveOverGap* (2.3.2.5) is finished 2. The *State Drive2 is* activated 3. The *Robot* follows the *GuideLine* 4. The *StartFinishLine* has been recognized again 5. The *Buzzer* emits the *ShortBeep* 6. The *State DisplayTime is* activated

Reference number	2.3.2.5
Name	*DriveOverGap*
Short description	Allows the robot to drive over an interruption in the *GuideLine*
Precondition	All these conditions must be met: • The *State Drive2* is active
Postcondition	The *State Drive2* is active
Error case	*GuideLine* is not recognized within 5s
Actors	*DriveMotors, LineSensors*
Trigger	The *GuideLine* is lost
Standard sequence	1. The *Robot* searches for the *GuideLine* 2. The *GuideLine* has been recognized 3. The use case *DriveLap* (2.3.2.4) is activated
Alternative sequences	none

Reference number	2.3.2.6
Name	*MeasureTime*
Short description	Measures the time of a lap. This use case runs parallel to other use cases.
Precondition	All these conditions must be met: • The *State Drive1* is active
Postcondition	The *State Drive2* is not active
Error case	none
Actors	none
Trigger	The *StartFinishLine* is recognized
Standard sequence	1. The timer is started 2. The *StartFinishLine* is recognized again 3. The timer is stopped
Alternative sequences	none

Reference number	2.3.2.7
Name	*DisplayLapTime*
Short description	Displays the completed lap time
Precondition	The *State Drive2 is* active
Postcondition	The *State ReadyToDrive is* active
Error case	none
Actors	*OledDisplay, DriveMotors*
Trigger	The *State DisplayTime* changes from not active to active
Standard sequence	1. Stops the power supply to the *DriveMotors* 2. Shows the completed lap time on the *OledDisplay* 3. The *ParamButton* is pressed 4. The *State ReadyToDrive* is activated
Alternative sequences	none

Reference number	2.3.2.8
Name	*HandleError*
Short description	Displays an error message on the *OledDisplay*
Precondition	An error occurred
Postcondition	The *State ReadyToDrive* is active
Error case	none
Actors	*OledDisplay, Buzzer, DriveMotors, ResetButton*
Trigger	An error occurs
Standard sequence	1. The State *Error is active* 2. Stops the power supply to the Drive*Motors* 3. The *AlarmSignal* is played on the *Buzzer* 4. An error message is displayed on the *OledDisplay* 5. The ResetButton is pressed 6. The State *ReadyToDrive* is actived
Alternative sequences	none

Reference number	2.3.2.9
Name	*SetParameters*
Short description	Allows parameters to be adjusted during runtime
Precondition	The *State Error* is not active
Postcondition	The *State ReadyToDrive is* active
Error case	none
Actors	*OLED-Display, ParamButton*
Trigger	The *ParamButton* button has been pressed
Standard sequence	1. The *State Setup* is activated 2. The *OledDisplay* shows the *ParameterSets* and allows to select one 3. The *User* presses the *ResetButton* 4. The *State ReadyToDrive* is activated
Alternative sequences	none

3 Requirements

3.1 Functional Requirements

3.1.1 The *Robot* shall start driving 3s after the operator presses the *StateButton*.

3.1.2 The *Robot* shall *CountDown* before the *Robot* starts driving

3.1.3 After pressing the *StateButton* the *Robot* shall detect the *StartFinishLine* in 10s or less

3.1.4 If the *Robot* does not detect the *StartFinishLine* in 10s or less the *Robot* shall detect an error

3.1.5 If the *Robot* detects the *StartFinishLine* the *Robot* shall do ALL of the following steps

- emit a *ShortBeep* via *Buzzer*
- start the time measurement for the lap

3.1.6 If the *Robot* detects the *StartFinishLine* again the *Robot* shall do ALL of the following steps

- stop any motion
- emit a *ShortBeep* via *Buzzer*
- end the time measurement for the lap
- display the measured time for the lap on the *OledDisplay*

3.1.7 The *Robot* shall complete one lap in 20s or less

3.1.8 If the *Robot* does not complete a lap in less than 20s the *Robot* shall detect an error

3.1.9 If the *Robot* leaves the *GuideLine*, the robot shall *Redetect* the track in 5s or less

3.1.10 If the *Robot* does not *Redetect* the *GuideLine* in less than 5s the Robot shall detect an error

3.1.11 If the *Robot* detects an error the *Robot* shall do the following steps in order

- stop any motion
- emit the *AlarmSignal* via *Buzzer*
- display the error reason on the *OledDisplay*

3.1.12 When the *ResetButton* is pressed while the *Robot* detects an error the *Robot* shall clear the error message from the *OledDisplay* AND displays the *TeamName*

3.1.13 When the *Robot* is *PoweredOn* the Robot shall display the *TeamName* on the *OledDisplay* for at least 2s

3.1.14 During the competition the only changes to the software shall be the selection of a predefined list of *ParameterSets* via the *ParamButton*

3.1.15 When the *Robot* is *PoweredOn* the *Robot* shall calibrate the *LineSensors*

3.1.16 When the *ResetButton* is pressed, while the *Robot* is not detecting an error the *Robot* shall calibrate the *LineSensors*

3.2 Non-Functional Requirements

3.2.1 The software shall be hardware independent

3.2.2 The programmer shall write the software in the programming language C

3.2.3 The *Robot* shall run during daytime- or officelight conditions

3.2.4 The *Robot* shall start the competition on the *GuideLine*

3.2.5 The *Robot* shall be powered on when it is positioned on the *GuideLine*

3.2.6 The software shall at most use 80% of the available flash memory