FunctionTestSpecElectronics (FTE)
[eLatch - Stellantis]

Functional Testspecification Electronics

eLatch - Stellantis

Specification change history

Changes to this Additional Requirement by
Testing Technology

Version	Changes	GECOS No. / eSign	valid from	Author
00	Create Initial Draft version		01.09.2023	Dominik Schug

Information:
Version 00-09: Development version (all yellow marked or blue written content is tbd)
Version >10: Released version

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FunctionTestSpecElectronics (FTE) [eLatch - Stellantis]

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1 General

This specification describes functional test steps. It defines the minimum test volume of test equipment required by BROSE.

It has to be ensured that all components are tested by an Automatic Optical Inspection System (AOI) before component test (ICT).

It has to be ensured that nominal values of all components are measured by an external component tester (ICT or FPT) before the functional test.

This has to be documented in a test coverage-sheet. All deviations from these requirements have to be documented and released by BROSE.

The DUT must have an NOK status throughout the test process and only when all tests have been passed must the status be set to OK in the very last test step. All tested electronics have to be labelled with a PASS or FAIL label referring to related test result or have to be logged in a traceability system.

It has to be ensured by a traceability system that only PASS tested DUTs are packaged.

All measured values, limits and test results of each test step and each DUT shall be documented in a result file (spread sheet). The result file has to be stored for at least thirtee
n years. (safety critical characteristics for 15 years).

The test system shall be equipped with all locally applicable safety installations.

The concept of functional test system has to be presented by the supplier in design phase. The offers for all test equipment have to be released by BROSE before ordering.

All modifications of test system or test limits at functional tester and component test system (ICT / FPT) have to be documented by the supplier and released by BROSE. This is also essential after SOP.

To ensure and document the quality and stability of the measurement equipment (AOI, component test and EOL) following documents have to be created and provided to BROSE:

- Test coverage-sheet
- MSA / PCA results

FunctionTestSpecElectronics (FTE) [eLatch - Stellantis]

1.1 Project Data

Product:	eLatch
Internal project description:	K-8530
Customer:	Stellantis
Brose Part Number	see 2.4 Variant overview

1.2 Brose Contacts

Function	Name
Project Leader	Steffen Fleischer
Project engineer	Rene Bekendam
Testing technology	Dominik Schug
Quality	Gerald Schmitt
HW development	Mario Reichl
HW layout	Johanna Jäger
SW development	Georgiy Mühlig

1.3 Quoted and other documents

Title	Description
EOL/UDS specification	Codebeamer
Circuit diagram	D80745-xxx
Drawing	F15028-xxx
ICT:	FlashProgrammInfoSheet.pdf
Special & safety characteristics	NOR_BN_586437-XXX
Quality test software	NOR_BN_591007-XXX
Generic Electronic Standard	BN591160-XXX

1.4 Abbreviations

ECU	-	Electronic Control Unit
CAN	-	Controller Area Network
DUT	-	Device Under Test
UDS	-	Unified Diagnostic Services
OK	-	Result is OK
NOK	-	Result is not OK
TBD	-	To Be Defined
PWM	-	Pulse Width Modulation

1.5 AOI

Transfer external	**Individual**
Transfer BROFIS	**Supplier/Service provider/Licencee/Joint-Venture**

All single components shall be tested by AOI for the following criteria:

- Presence
- Position
- Open pins
- Quality of solder joints

Where applicable or technically relevant (e.g. for diodes, Controllers, etc.) the following criteria shall be additionally tested:

- Orientation / Polarity

The actual revision of the IPC-A-610 standard and BN591160-XXX must be met regarding automotive specification.
The criteria for each component shall be listed in the test coverage.

1.6 ICT

All single components shall be tested regarding their respective nominal values within the tolerance, defined in the BOM.
If, for any technical reason, single components cannot be directly measured, they shall be measured at the best possible way. This must be specially marked in the test coverage.
Example: If parallel capacitors cannot be measured, their values shall be measured in sum.
Short and open circuit tests shall be performed.

1.7 Special and safety-critical characteristics

1.7.1 Range of application / preface

The determination of safety-critical and important characteristics is an important precondition for safeguarding the quality of Brose products.

The handling of special and safety-critical and important characteristics are described in Brose standard specifications **BN586437-XXX** and are compulsive for this POT variant.

1.7.2 Special characteristics

1.7.2.1 Definition „special characteristics“

Abstract BN586437-XXX

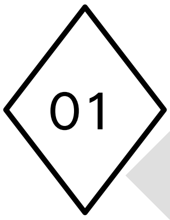
According to IATF 16949 and BN591160-XXX special characteristics are product characteristics or production process parameters that may impact of the safety, the compliance with official regulations, fit, function, performance or the further processing of the product.
At Brose these special characteristics are named as safety-critical and important characteristics. Special characteristics have to be determined and included into the control plan. They have to be incorporated into drawings, specifications, FMEA, control plans or other documents necessary for the control of the production. They may be defined by customer and / or by Brose. The continuity of special characteristics has to be ensured in all documents

1.7.2.2 Marking and illustration

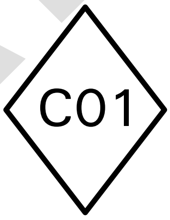
Abstract BN586437-XXX

Important characteristics are marked with a "rhomboid" and a sequential number in the rhomboid directly next to the characteristic. Additional information next to the rhomboid is permitted e.g. SPC. In systems where the rhomboid does not exist, the characteristic is abbreviated with F ("Function Characteristic").
Customer interfaces completely have to be identified an marked with a „C“ (customer) directly before the sequential number.

e.g.



e.g. customer interface



1.7.2.3 Handling of „special characteristics“

See BN586437-XXX

1.7.3 Safety-critical characteristics

1.7.3.1 Definition safety-critical characteristics

Abstract BN586437-XXX

Safety-critical characteristics are those product characteristics or process parameters that may have influence on compliance with legal regulations or on the safety of the product or on safety-relevant functions. Customer-specific requirements have to be considered.

Generally, safety-critical parts are components of a vehicle affecting active or passive vehicle safety and subject to the specific regulations and legal provisions of the authorities (e.g. brakes and steering).

A safety-critical characteristic must be defined because of:

- legal requirements,
- requirements of the respective regulatory authorities,
- customer-specific requirements,
- Brose-internal computed, tested and empirical values
- FMEA in consideration of the evaluation of the severity (S $\geq$ 9)

1.7.3.2 Marking and illustration

<u>Abstract BN586437-XXX</u>

Product characteristics and process parameters which have an impact on the safety of a product or a process respectively or the compliance with legal regulations have to be marked with a "D" and a sequential number in the "D" directly next to the characteristic.

Customer interfaces have to be completely identified and according to paragraph 3 in case of a special characteristic have to be marked with a „C" (customer) directly before the sequential number. Documents with a reference to this product characteristics and process parameters also have to be marked with a "D". The identification of safety-critical characteristics in drawings has to be done at the point where the characteristics will be produced, modified or tested.

e.g.

D 01

e.g. customer interface

D C01

1.7.3.3 Handling and archiving of safety-critical characteristics

See BN586437-XXX

1.7.4 Summary special and safety-critical characteristics for this project

<u>Summary</u>

Symbol	Total characteristics

FunctionTestSpecElectronics (FTE)
[eLatch - Stellantis]

D	3
◇	1

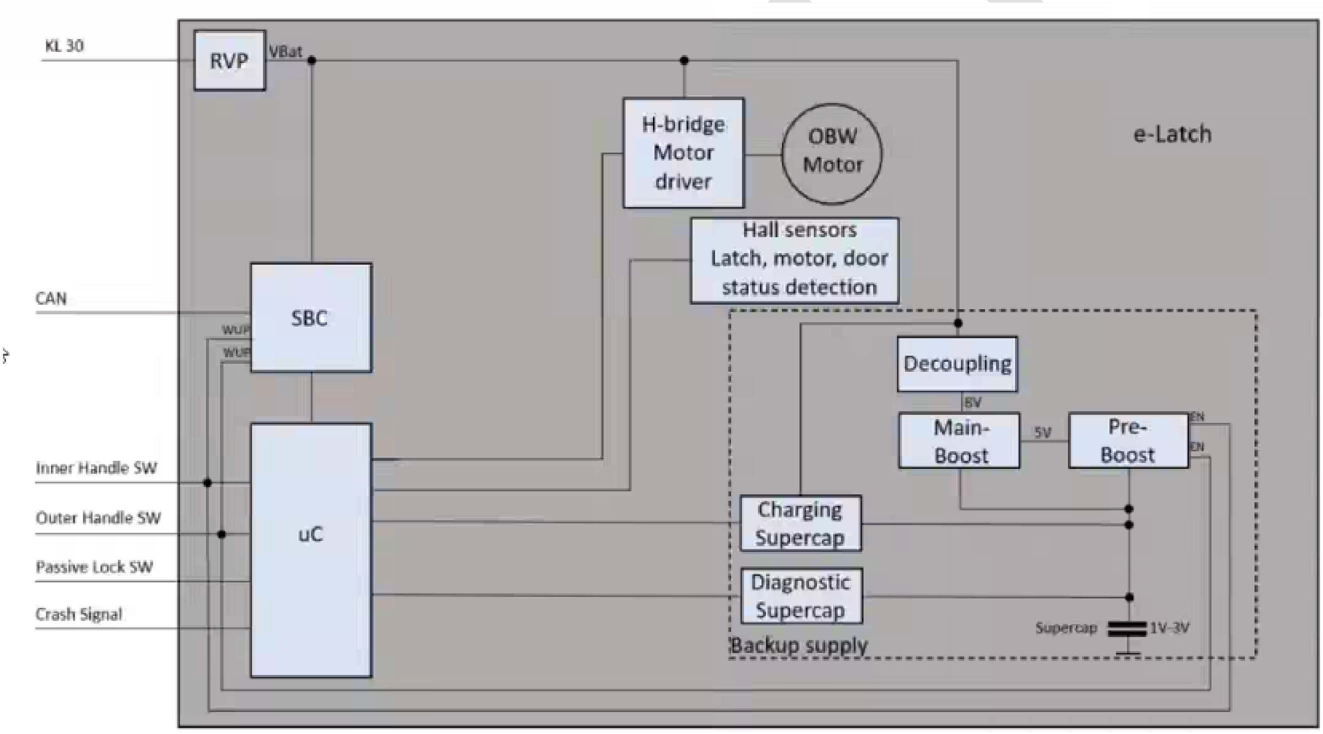
Linking detail:

Characteristic	Number	Process	Process description	Link / Chapter
D	01	EOL	Supercap Circuitry test	5.2
	02	EOL	Hall test	5.10
	03	EOL	Latch motor test	5.11
◇	01	EOL	Sleep current measurement	5.5

2 Product

2.1 Electrical Characteristic

2.1.1 Block diagramm



2.1.2 Connector Layout

Costumer Connector:

Pin	Name	Function	Describtion
1	**CAN_L**	CAN Low signal	Signal
2	**CAN_H**	CAN High signal	Signal
3	**Outer_Handle_Switch_NO**	Input analog	I_{nom} = 0,02 A @ 13V
4	**Outer_Handle_Switch_GND**	Internal GND connection	I_{nom} = 0,02 A @ 13V
5	**Outer_Handle_Switch_NC**	Input analog	I_{nom} = 0,02 A @ 13V
6	**Crash_Signal_Input**	Input digital	I_{nom} = 0,02 A @ 13V
7	**IBH_Switch_GND**	Internal GND connection	I_{nom} = 0,02 A @ 13V
8	**IBH_Switch_NC**	Input analog	I_{nom} = 0,02 A @ 13V
9	N.C.	-	-
10	**KL30**	Power Supply	I_{nom} = 3,5A @ 13,5V Type of output:
11	N.C.	-	
12	N.C.	-	
13	N.C.	-	
14	**IBH_Switch_NO**	Input analog	I_{nom} = 0,02 A @ 13V
15	**Passive_Lock_Switch_NO**	Input digital	I_{nom} = 0,02 A @ 13V
16	N.C.	-	
17	**SCA motor +**	Optional motor output – not in use	Put this line as optional (5A @ 13,5V)
18	**SCA motor -**	Optional motor output – not in use	Put this line as optional (5A @ 13,5V)
19	N.C.	-	
20	**KL31**	GND	I_{nom} = 3,5A @ 13,5V Type of output:

Additional Contacts for connection mechanics:

Connector	Name	Function	Describtion
J1000	**OBW_Motor_+**	Motor Connection	I_{nom} = 1,5 A @ 8V 150ms Type of output: Motor Output
J1001	**OBW_Motor_-**	Motor Connection	I_{nom} = 1,5 A @ 8V 150ms Type of output: Motor Output

Contact for SuperCap:

Pin	Name	Function	Describtion
+	**FastChargePad**	SuperCap Connection	
-	**FastChargePad**	SuperCap Connection	

2.1.3 Current consumption (operating modes during functional test)

Current consumption depends on the status of the electronic; all modes have to be checked min. once a time.

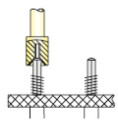
	I_{MIN}	I_{TYP}	I_{MAX}		Status/Description
Sleep current	200	350	500	µA	No Operation, Wakeup by CAN
Wake current	80	100	120	mA	Operation mode, without load, CAN active, no motor operation
Load current (load simulation)		3,5	5	A	OBW Motor

2.1.4 Connection Interfaces

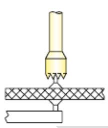
In order to contact the DUT, test needles should be used that contact pins and motor contacts.

Recommendation for Pins:

(aggressiver Innenkegel, selbstreinigend) **Kopfform 19**
Bei dieser modifizierten Form der Kopfform 03 entsteht durch zusätzlich angebrachte Quernuten eine aggressive Kontaktkontur im Zentrum. Dadurch wird bei Kontaktierung auf Bauteilbeinchen und Wire-Wrap-Pfosten ein Maximum an Kontaktsicherheit erreicht.



Recommendation for motor contacts:



Kopfform 06 (Riffel)
Universell einsetzbare Kopfform. Einsatz bei der Prüfung von Stiften jeglicher Art (Messerleisten, Wire-Wrap-Pfosten, Bauteilbeinchen usw.).

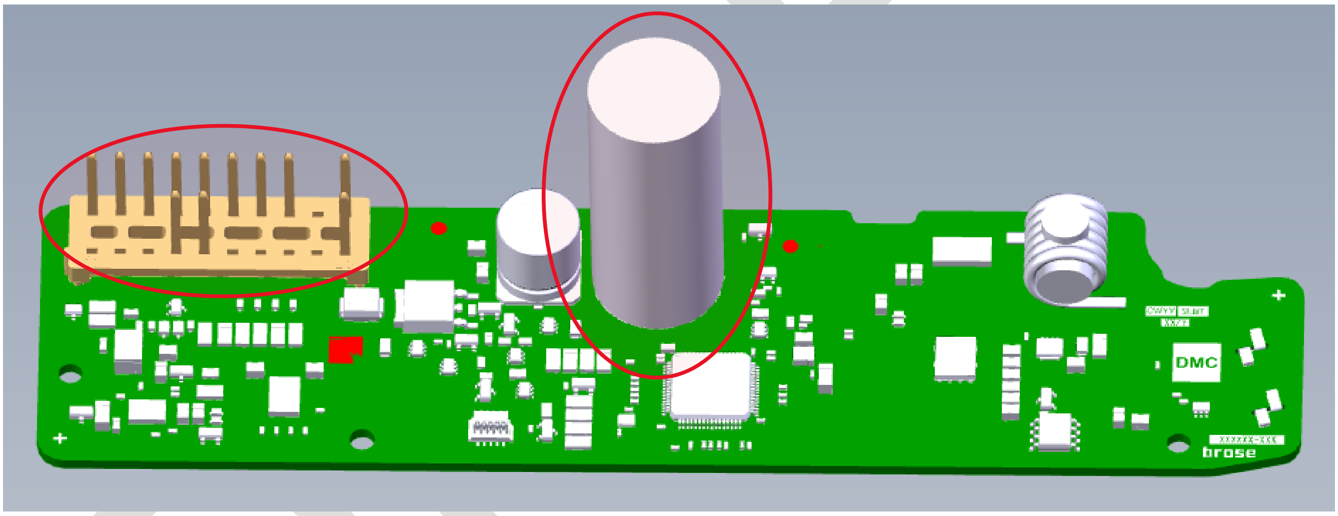
Recommendation for supercap loadpads – not in current layout - (for discharge):

(passiver Dolch) Kopfform 97
Ähnlich Kopfform 91, jedoch mit passiverem Flankenwinkel, speziell zum Kontaktieren von offenen Vias, die mit Lötstopplack gefüllt sind.

2.2 Mechanical Characteristic

Top and bottom side of eLatch Stellantis PCBa:

TOP site view:

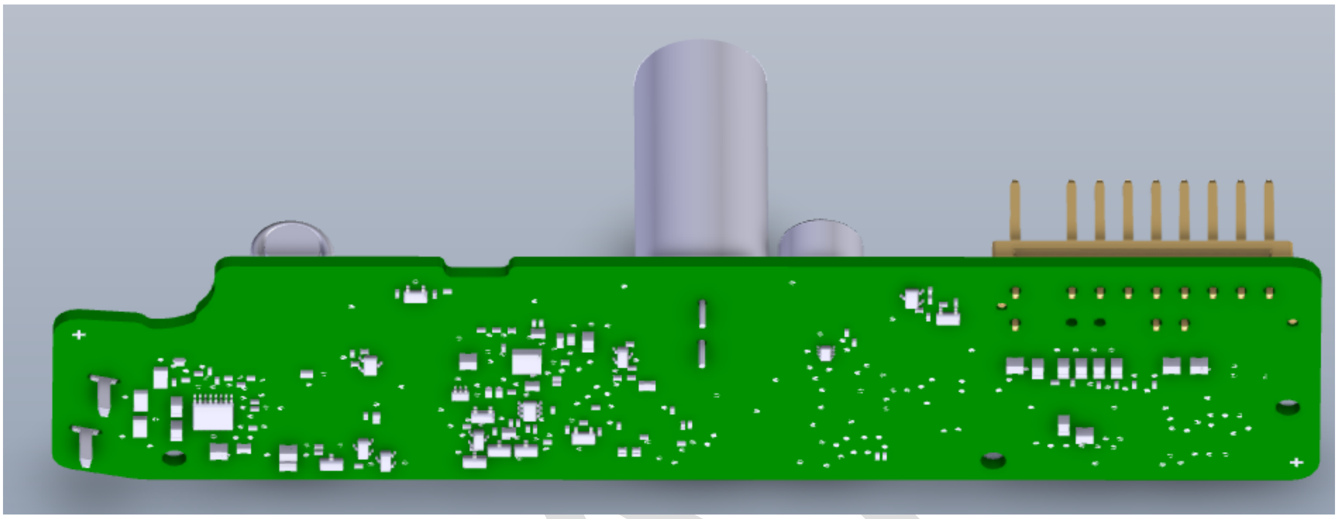


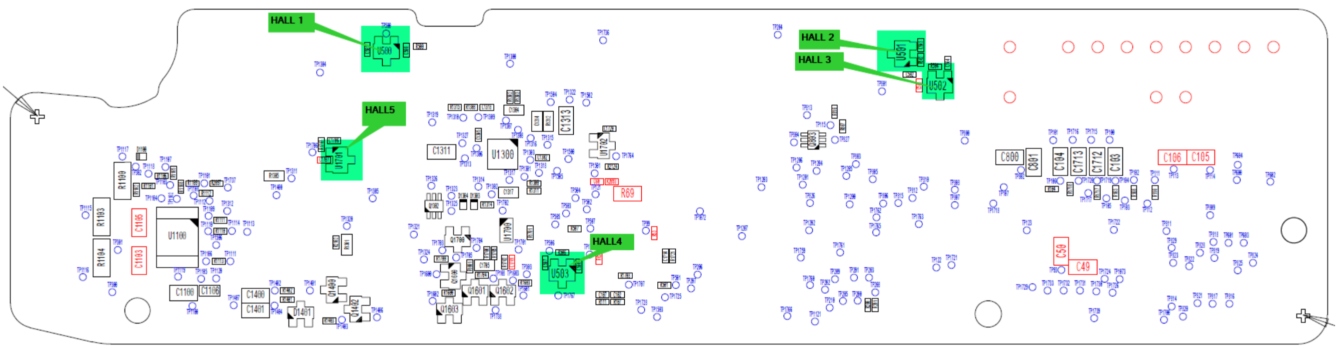
Please note the special features, namely the supercapacitor on the top side, that is assembled as THT.

The EOL must connect the DUT the 10 pin connector strip and the HALL sensors must stimulate on the BOT site.

:

BOT site view:





2.3 Communication Interface

2.3.1 CAN UDS

2.3.1.1 CAN pinning

Connector pin	Description	Funktion
CON1_2	CAN high	CAN high
CON1_1	CAN low	CAN low

2.3.1.2 CAN communication parameter

For communication between the tester and the DUT, a CAN communication is used:
To perform the EOL functions a CAN (CAN FD) protocol is used

Variant	eBike Motor P ECU
Baud rate CAN	**19,2 kbit**

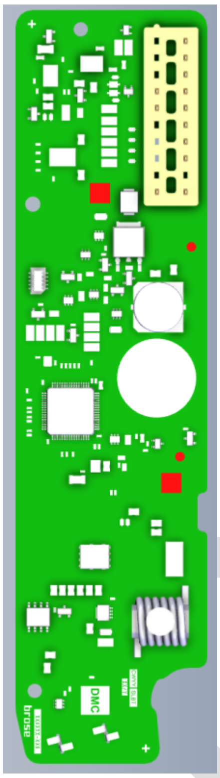
ID / Variant	CAN FD (SBC)	CAN FD (FIT)
UDS Rx ID for Tester	0x100	0x100
UDS Tx ID for Tester	0x101	0x101

The supplier is responsible for the integration of the CAN UDS software (specification will be provided by brose analog to the communication description).
If CAN-UDS functions are changed or expanded, it has to be assured, that all existing variants are executable. This has to be proved.

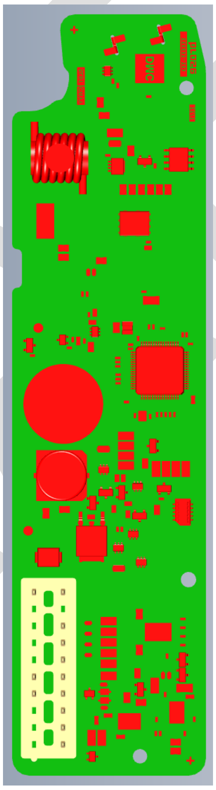
2.4 Variant Overview

Type	Direction	Internal Name	Brose Ident-No.
Driver	Front left	LSMD	G59967-xxx
Passenger	Front right	LSMP	G59980-xxx
Rear left	Rear left	LSMRL	G59982-xxx
Rear right	Rear right	LSMRR	G59983-xxx

left hand:



right hand:



3 Additional Process Steps

3.1 Programming

The microcontrollers have to be flashed before EOL-test. If AOI or ICT/FPT fails, the microcontrollers must not be flashed. The flashing method must be compliant to the respective manufacturer specification. It has to be ensured by adequate measures, that the required data was successfully written.

3.2 Further steps

4 Requirements for Test Device

4.1 Definition of Accuracy

The required accuracy of the measurements can be found in 6.1 Global Parameters

4.2 DC voltage source

0-25 V; 0-10 A

These values are the maximal values from the defined test cases. The DC power supply must be reasonably oversized. The power supply to the ECU must be sensed out up to the ECU, to ensure, the DUT still receives the specified voltage under load.

4.3 Current measurement

The methods for current measurement shall meet the state-of-the-art techniques and be able to measure the average DC and PWM-generated AC currents in different measurement ranges with the requested accuracy. This includes calibrated DC-isolated analog waveform sampling and post-processing on a computer. There shall be used resilient, housed test probes with Force/Sense wires. As interface for the motor contacts resilient test probes (ability to carry the requested load current) with Force/Sense wires shall be used, which can be easily exchanged in case of service and maintenance. Minimum resolution on Amplitude: 12 bit. Minimum Sampling frequency 50 kHz.

4.4 Magnetic Dipoles

In order to stimulate the end stop sensors of the ECU, the hall ICs have to be stimulated by the EOL through magnetic dipoles. This can either be achieved by moving static dipoles over the ECU mechanically, or by an electromagnet conforming to the specification.

Detail Hall interface:

Polarity: south-active
Activation: 10mT
Deactivation: 6mT

4.5 Load replacement

To measure a later motor current, a motor replacement load must be applied between the motor pins. Within this branch, a current measurement must be possible.
The exact specification of this load will be given at a later point in time, however, it will most probably be a combined R/L-load, thus, an inductor and a resistor in series.

The current through the motor must be measured and compared to the value determined by the current measurement shunt inside the ECU.
It is still up to discussion, if this will furthermore be used for a calibration.

4.6 Resistance stimulus

Several inputs of the ECU will require some resistances to be applied towards ECU GND as a multi-value switch or be left open.
The exact values will be defined within the test steps.

4.7 DIO

Digital Inputs and outputs might be required upon request by the test steps. This could also include switching loads. In general, a reasonable amount of “free” ports should be prepared, also to allow future expansion.

4.8 Supercap

The DUT will have a supercapacitor assembled that must be measured, as in 5.2 Supercap Circutry test specified, along the process. The supercap might be required to be connected directly using extra contacts. This might include some functionality for discharging (shorting), and measuring voltage of and current into the capacitor.
Be aware that the product must be delivered with the capacitor discharged!

5 Test Step Description

5.1 Communication Startup — Classification -

5.1.1 General Information

The entry into diagnostic mode has to be done by diagnostic messages according the EOL/UDS specification.
After you have established the UDS session you have to start the EOL mode with Diagnostic Session Control, **0x61 (Brose Extended Session).** For further information, please refer to the project specific EOL/UDS specification.

5.1.2 Preconditions:

ECU must be powered with undervoltage (to avoid automatically Supercap charging) over KL30 / KL31 with **U_{Min}**. CAN interface has to be connected with correct settings.

5.1.3 Test Description:

1. Session CTRL – Enter Brose EOL Ext. Session

Service:	0x10	Session Request
Data:	0x61	Brose EOL Ext. Session

2. Request Seed

Service:	0x27	Security Access
Data:	0x71	Request Seed
	GetSeed 16Bit	

3. Generate Key (AES-128) with a defined pattern

4. SendKey

Service:	0x27	Security Access
Data:	0x72	Send Key

5.1.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive

- Comparison of all measurement values are within the limits

Test NOK:

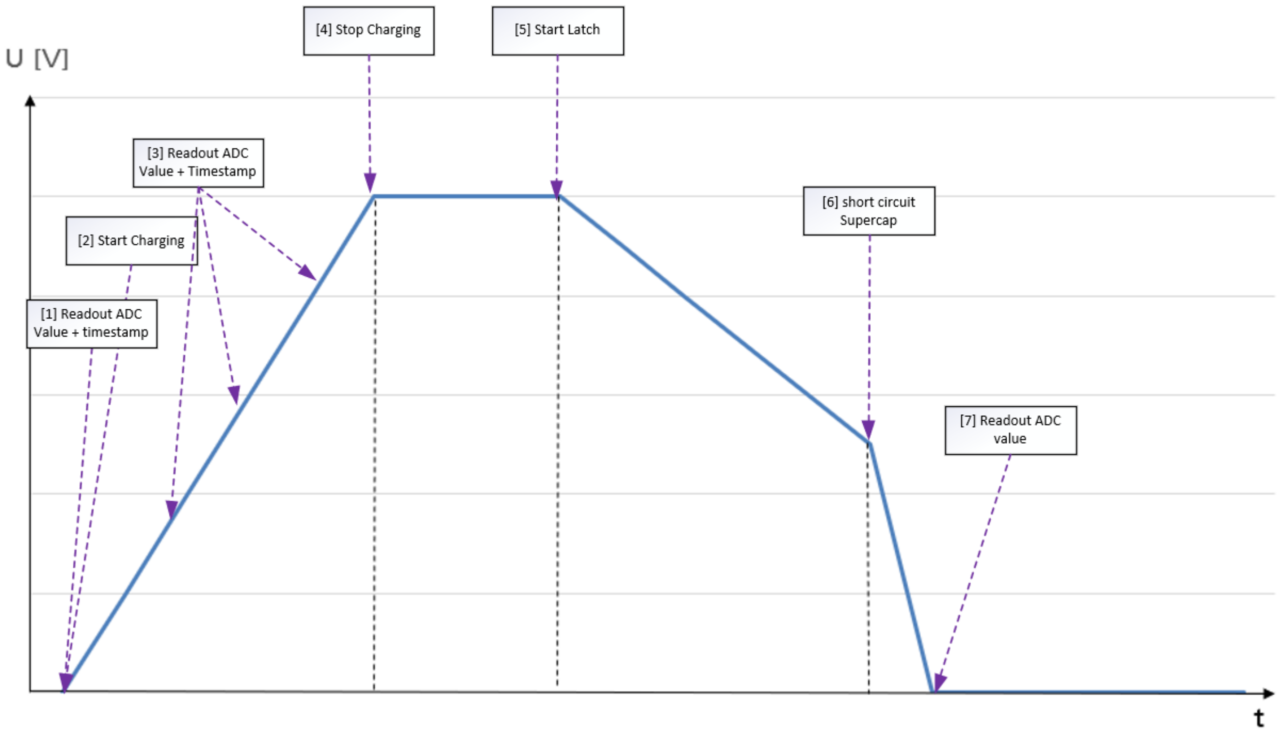
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.1.5 Examples

5.2 Supercap Circuitry test   Classification D

5.2.1 General Information

In order to test the supercap, **various actions must be started during the entire test sequence** in order to use test time efficiently. The test includes loading the supercap, calculating the value by loading and then the supercap must be discharged again!
The supercap can be discharged by the latch test, but to ensure that it is completely discharged, it must be short-circuited.



5.2.2 Preconditions:

ECU must be powered with undervoltage (to avoid automatically Supercap charging) over KL30 / KL31 with **U_{Min}**. CAN interface has to be connected with correct settings.

5.2.3 Test Description:

1. Read out ADC value **CAP**$_{\text{Unload}}$ and timestamp

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE32	Read Analog Inputs
Data Byte0:	0x01	Data Select V_Supercap

2. Allow the ECU to load the Supercap via UDS Command FE52

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE52	Charge Supercap Command
Data Byte0:	0xFFFF	Charge Time (max)

3. Read out ADC values **CAP**$_{\text{Charge1}}$ and timestamps repeatedly [e.g. after each teststep]

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE32	Read Analog Inputs
Data Byte0:	0x01	Data Select V_Supercap

4. Stop Charging and calculate supercap parameters
5. Perform 5.11 Latch motor test
6. Short circuit Supercap via *Fast_charge_pad* and *Fast_charge_pad_negat*
7. Read out ADC to ensure no load at Supercap

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE32	Read Analog Inputs
Data Byte0:	0x01	Data Select V_Supercap

5.2.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.3 Read/Verify SW Version and Production Data **Classification -**

5.3.1 General Information

The serial number must be read out which is inside the Electronic production data. The identification of Electronic production data is 40 bytes HEX.
The software version numbers are an important attribute of the DUT. In the course of the test it must be ensured that the correct software version numbers are used.

5.3.2 Preconditions:

ECU must be powered over KL30 / KL31 with **U_{Nom}**. CAN interface has to be connected with correct settings.

5.3.3 Test Description:

1. ECU wakeup / Start EOL mode according UDS specification
2. Verify ECU mask and version, Read ECU Identification and SW-Version

1. Verify SW Version

Service ID:	0x22	Read by ID – Service
ID-Byte:	0xFD22	Application SW version

2. Verify ECU Identification String

Service ID:	0x22	Read by ID – Service
ID-Byte:	0xFD28	ECU Identification String

3. Start Routine "Read Data by ID"

Service ID:	0x22	Read by ID – Service
ID-Byte:	0xFD40	Electronic Production Data

Data Bye	Description	Example (HEX)
1-3	CAN Response	0x62 FD 40
4-7	Supplier Location (Brose Serbia Belgrade	30 31 30 32 "0102"
8-9	Line EOL ID (ICT ID)	
10-11	Production Date (Year)	32 33 "23"
12-13	Production Date (Month)	30 31 "01"
14-15	Production Date (Day)	30 32 "02"
16-24	Brose SAP Number	
25-26	Panel Position	30 32 "02"
27-35	ECU Serial Number	
36-43	Reserved	FF

5.3.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.3.5 Examples

-

5.4 Wake Current measurement **Classification -**

5.4.1 General Information

The measurement monitors the correct current consumption in normal operating mode – microcontroller is in operating mode.

5.4.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.4.3 Test Description:

1. Measure ECU operating current: $\mathbf{I_{operating}}$

5.4.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.4.5 Examples

-

5.5 Sleep Current measurement Classification ◊

5.5.1 General Information

The current consumption must be measured in the Sleep Mode without load.

5.5.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.5.3 Test Description:

1. Init Inputs / Loads: Make sure that all inputs are open and outputs are inactive
2. Send Sleep Command:

Routine ID:	0xFE21	Sleep Request
Data Byte 1:	0x01	Rapid Sleep

3. Wait 50ms
4. Measure ECU sleep current: $\mathbf{I_{Sleep}}$

5.5.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.5.5 Examples

-

5.6 Self Test BIST

Classification -

5.6.1 General Information

The internal self test is triggered and/or its result read out. All internal self tests must pass. As Tests might run a little longer, try performing this test after a long sequence of tests without reset.

5.6.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.6.3 Test Description:

1. **Read BIST results MCU:**

Service ID:	0x22	ReadDataByID
Routine Type:	0x01	Start Routine
Routine ID:	0xFE2A	BIST

2. **Tester stores and evaluates the received values**
   - ROM check result
   - RAM check result
   - NVRAM parameter check result

5.6.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.6.5 Examples

-

5.7 Supply Voltage ADC measurement — Classification -

5.7.1 General Information

The internal voltage measurement must be checked by applying a defined input voltage **U_{Nom}**, measuring it externally and comparing it with the internally measured ADC value.

5.7.2 Preconditions:

ECU must be powered over KL30 / KL31 with **U_{Nom}**. CAN interface has to be connected with correct settings.

5.7.3 Test Description:

1. Adjust **U_{Nom}** voltage
2. Wait 100 ms
3. Send Command:

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE32	Read Analog Inputs
Data Byte0:	0x00	Data Select

Receive: **$ADCU_{BAT\_NOM}$**

4. Tester receives and stores measurement value

5.7.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

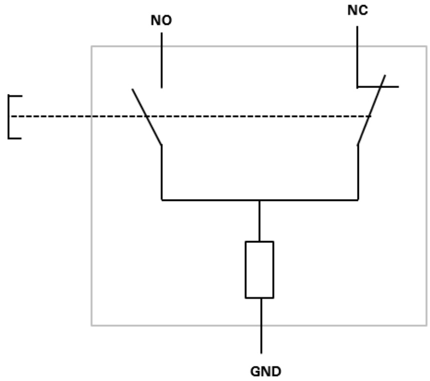
5.7.5 Examples

-

5.8 Analog Input test — Classification -

5.8.1 General Information

Test of a resistance-encoded input.
Several resistance values are applied between the Outer Handle Switch, IBH SW and ECU GND, while an internal value is read using diagnostics. The test passes if all values lie within specified limits.



5.8.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.8.3 Test Description:

1. Read Analog Input
   Routine ID: 0xFE32 Read Analog Inputs
   Data Byte 1: 0xtbd
   Receive: **OH-SW_ADC1**
2. Connect the resistor 1100 Ohm on Outer Handle Switch to GND
3. Read Analog Input
   Routine ID: 0xFE32 Read Analog Inputs
   Data Byte 1: 0xtbd
   Receive: **OH-SW_ADC2**

4. Monitoring and analysis current
   $\mathbf{I_{OH\text{-}SW1}}$; $\mathbf{I_{OH\text{-}SW2}}$

5. Disconnect the resistor
6. Read Analog Input

Routine ID:	0xFE32	Read Analog Inputs
Data Byte 1:	0xtbd	
Receive:	**IBH-SW_ADC1**	

7. Connect the resistor 1100 Ohm on IBH-SW to GND
8. Read Analog Input

Routine ID:	0xFE32	Read Analog Inputs
Data Byte 1:	0xtbd	
Receive:	**IBH-SW_ADC2**	

9. Monitoring and analysis current

$I_{IBH\text{-}SW1}$; $I_{IBH\text{-}SW2}$

10. Disconnect the resistor

5.8.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.8.5 Examples

-

5.9 Digital Input test

Classification -

5.9.1 General Information

An active-high digital input is applied in a pattern to the pin and the state of the digital pin read back using diagnostics.
All digital inputs of the DUT have to be stimulated with HIGH/LOW patterns. The patterns have to be chosen in a way that possible shorts between neighboured lines (consider plug layout) can be identified. The relevant pins and their properties for this test result from the pin description. A low level at the input results in a logical 0. After the test all inputs need to be deactivated.

5.9.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.9.3 Test Description:

Set Input to high state in a pattern defined in table below

				Pattern 1	Pattern 2
Byte	**Bits**		**PIN**		
3	2-3	CrashSignalInput	6	0	1
3	4-5	Passive Lock Switch	15	1	0

1. Stimulate Pattern1
2. Verify Pattern1

   Routine ID: 0xFE30 Read Digital Input
   Data Byte 1: 0x00 Data Select
   Receive: **CrashSignal**$_{P1}$, **PassiveLock**$_{P1}$
3. Stimulate Pattern2
4. Verify Pattern2

   Routine ID: 0xFE30 Read Digital Input
   Data Byte 1: 0x00 Data Select
   Receive: **CrashSignal**$_{P2}$, **PassiveLock**$_{P2}$

5.9.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.9.5 Examples

-

5.10 Hall test

Classification D

5.10.1 General Information

A magnetic field is applied to each of the Hall effect sensors in a pattern. Either series magnets can be used, when they are physically moved over the hall sensors, or alternatively, an electromagnet. The state of the sensors, that will be represented by ADC value ranges, is read back using diagnostics.

5.10.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings. Hall Sensor stimulation must be in correct position.

5.10.3 Test Description:

Stimulate the magnet in a pattern defined in table below

			Pattern 0	Pattern 1	Pattern 2
Bits	**Desc**	**Component**			
0	Hall OBW Gear Switch	U500	0	0	1
1	Hall Claw 1 Switch	U501	0	1	0
2	Hall Claw 2 Switch	U502	0	1	1
3	Hall Pawl Switch	U503	1	0	0
4	Hall Stall Switch	U1701	1	0	1

1. Stimulate Pattern1
2. Verify Pattern1

Routine ID:	0xFE30	Read Digital Input
Data Byte 1:	0x02	
Receive:	$\mathbf{HALL1_{P1}}$, $\mathbf{HALL2_{P1}}$, etc.	

3. Stimulate Pattern2
4. Verify Pattern2

Routine ID:	0xFE30	Read Digital Input
Data Byte 1:	0x02	
Receive:	$\mathbf{HALL1_{P2}}$, $\mathbf{HALL2_{P2}}$, etc.	

Go on with all Pattern and receive all Signals.

5.10.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.10.5 Examples

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5.11 Latch motor test

Classification D

5.11.1 General Information

Connect the motor replacement load to the motor clamps; internally, the ECU drives the motor with a PWM-controlled MOSFET-H-bridge of which the motor current is measured through a shunt towards GND.

Using diagnostics, drive the motor into both directions, with different specified currents. Measure the current through the replacement load and using diagnostics, obtain the ADC reading of the shunt. Check both for deviations.

5.11.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.11.3 Test Description:

1. **Start Motor in open direction**:

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE43	Motor CTRL Run
Data Byte0:	0x00	Latch Motor
Data Byte1+2:	0x7FFF	Infinite movement in open dir.
Data Byte3+4:	0xFFFF	don't care
Data Byte5:	0xFF	

2. External measurement of motor current $\mathbf{I_{Motor\_open}}$

3. Readout phase current from DUT

Routine ID:	0xtbd	
Data Byte0:	0x01	Motor Current measurement

4. Stop Motor
5.
6. **Start Motor in rewind direction**:

Service ID:	0x31	Start Routine
Routine Type:	0x01	Start Routine
Routine ID:	0xFE43	Motor CTRL Run
Data Byte0:	0x00	Latch Motor

Data Byte1+2:	0x8000	Infinite movement in rewind dir.
Data Byte3+4:	0xFFFF	don't care
Data Byte5:	0xFF	

7. External measurement of motor current

   I_{Motor_rewind}

8. Readout phase current from DUT

Routine ID:	0xtbd	
Data Byte0:	0x01	Motor Current measurement

5.11.4 Expected Results:

Test OK:

- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:

- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.11.5 Examples

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5.12 NTC measurement Classification -

5.12.1 General Information

An NTC sensor is mounted on the DUT. In order to test its function, the ADC value is read out and compared with the ambient temperature.
Hint: This test step must be performed at the beginning of the test sequence to avoid the influence of heating from the test.

5.12.2 Preconditions:

ECU must be powered over KL30 / KL31 with $\mathbf{U_{Nom}}$. CAN interface has to be connected with correct settings.

5.12.3 Test Description:

1. Check ambient temperature in the testsystem
2. Read Analog Input

Routine ID:	0xFE32	Read Analog Inputs
Data Byte 1:	0xtbd	
Receive:	$\mathbf{ADC_{NTC}}$	

3. Calcutlate the Difference

5.12.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.12.5 Examples

-

5.13 Read and Erase DTC

Classification -

5.13.1 General Information

At the very end of the EOL test, before writing the production data, we check the ECU for expected and unexpected DTCs using diagnostics. Expected DTCs can be deleted from the ECU, unexpected DTCs will cause the test to fail.

5.13.2 Preconditions:

tbd

5.13.3 Test Description:

1. Execute Routine:

Routine ID:	0xFE2B	Clear Data Logger
Data Byte 1:	0x01	Data select: DTC Logger

5.13.4 Expected Results:

Test OK:
- All single steps are OK
- All CAN UDS Responses are positive
- Comparison of all measurement values are within the limits

Test NOK:
- At least one single step is NOK
- At least one CAN UDS Response is negative
- At least one comparison of a measurement value against the limits is NOK

5.13.5 Examples

-

6 Annex

6.1 Global Parameters

Reference	Description	Value	Tolerance
U_{Nom}	Set value of nominal battery voltage / test voltage	13.5V	±0.1V
U_{Min}	Set value of undevoltage	9V	±0.1V
U_{Max}	Set value of overvoltage	16V	±0.1V
I_{Limit}		6A	
T_{Test}	Test temperature	23°C	±5K

6.2 Parameter and Limits

6.2.1 Limits in "5.2 Supercap circuitry test"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
CAP_{Unload}				
$CAP_{Charge1}$				

6.2.2 Limits in "5.4 Wake Current Measurement"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$I_{operating}$	CAN communication on / not actuating	80mA	100mA	120mA

6.2.3 Limits in "5.5 Sleep Current Measurment"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
I_{Sleep}	Current while sleep mode	200µA	350µA	500µA

6.2.4 Limits in "5.6 Self Test BIST"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
ROM Check	Data Byte 0; Data Bit 0-1		0x00	
RAM Check	Data Byte 0; Data Bit 2-3		0x00	
NVRAM Check	Data Byte 0; Data Bit 4-5		0x00	

6.2.5 Limits in "5.7 Supply Voltage ADC measurement"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$ADCU_{BAT\_NOM}$			tbd	

6.2.6 Limits in "5.8 Analog Input Test"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
OH-SW_ADC1			tbd	
OH-SW_ADC2			tbd	
IBH-SW_ADC1			tbd	
IBH-SW_ADC1			tbd	

6.2.7 Limits in "5.9 Digital Input Test"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$CrashSignal_{P1}$			tbd	
$PassiveLock_{P1}$			tbd	
$CrashSignal_{P2}$				
$PassiveLock_{P2}$				

6.2.8 Limits in "5.10 Hall Test"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$HALL1_{P1}$	ADC Data bit 0-1			
$HALL1_{P2}$	ADC Data bit 2-3			

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$HALL2_{P1}$				
$HALL2_{P2}$				

6.2.9 Limits in "5.11 Latch motor test"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
I_{Motor_open}			1,5A	
ADC_{Motor_open}			tbd	
I_{Motor_rewind}			tbd	
ADC_{Motor_rewind}			-1,5A	

6.2.10 Limits in "5.12 NTC measurement"

Limits				
Reference	**Description**	**min.**	**typ**	**max.**
$T_{ambient}$		20°C	23°C	30°C
ADC_{NTC}	ADC value recalculated to Temperature in °C	20°C	23°C	30°C
T_diff	**($T_{ambient}$ - ADC_{NTC})**	-6°C	0	+10°C

6.3 Calculation Parameter

Reference	**Description**	**Chapter**