Automotive Application Recommendation for optical MOST® Components

Surface Mount Device (SMD)

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Content

Preface

This specification was written by RUETZ SYSTEM SOLUTIONS on Base of Version AAR SMD Version 1.1 from RELNETyX AG.

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This specification was made available to the MOST cooperation and can be downloaded from the MOST intranet.

Modifications

Modification guidelines

From the tender procedure or solicitation of quotations all changes are noted in the modification list of the product specification. The modification are done by the responsible person of the development (contact person of the automotive manufacturer) or in co-ordination with him.

Change index
Change description

The last change index is the valid version of the product specification.

All modifications regarding the content in the whole document are written in blue colour. Grammatical and orthographic corrections are not pointed out with blue letters.

Date	Page	Chapter	Editor	Changes
21th October, 2010			Angstenberger Tiederle	New Release (based on AAR 2V1)
07th March, 2011	5		Angstenberger	Current Consumption Sleep Mode
04th November, 2013	15 27 35,36 36		Angstenberger	Detail definition of Fiber Attenuation Add Reference to Precondition in table TP – add Relation to Reference Plane CR – add direct application of chemical

1. General Remarks

1.1. Guidelines

1.1.1. Basic conditions

This product specification contains the requirements for a component described in chapter 2, page 12, based on the MOST Cooperation. It is the binding guideline for the development of the MOST component.

All deviations of the requirements from this product specification must be accepted in written form by the MOST Cooperation or related OEM. It is required to inform the MOST Cooperation if there are ancillary conditions not mentioned in this product specification which are needed for the unrestricted functionality. If there is knowledge for quality or reliability improvements or cost saving alternatives it is also required to inform the MOST Cooperation.

In this product specification mentioned laws, standards and instructions have been observed. The supplier is responsible that all laws, standards and instructions are observed and that the development process is state of the art. It must be considered that the cars which will contain this component will be distributed worldwide.

For the assortment of components and sub-contractors it must be considered that for spare parts a period of supply for 15 years after the end of mass production is guaranteed.

All information and documents which are appropriate to the development are confidential.

The supplier has to generate a data sheet throughout the development process. In this documentation all characteristics (electrical, mechanical) are listed.

For traceability of all activities during the development process an open topics list has to be written down.

The development status of the component is documented by the data mentioned in chapter 1.6 *Documentation (page 9)*.

1.1.2. Evidence of applicability and function

The supplier is engaged to verify the aptitude and the reliable function of the component by suitable Figure tests under the specified conditions.

Therefore the qualification plan, characterization and long term behavior of the component has to be adjusted with the car manufacturer.

1.1.3. Assembly area in the vehicle

Specification of assembly area

The vehicle is sub-divided into different zones for identification of the assembly area. Each assembly area has its own requirements for the MOST component.

Characteristically are:

- Ambient temperature
- Electrical interference
- Mechanical load
- Protection class

Specified assembly areas (sub-divided zones according to SAE J1211 and ISO 16750-4):

Zone 1 Under engine hood, engine / gear unit (engine compartment including partition wall to passenger compartment).

Zone 2 Chassis, door and body cavities.

Zone 3 Vehicle – external mounting area (bumper, cooling unit, etc.)

Zone 4 Internal area (passenger compartment, dashboard, hat rack, console*)

Zone 5 car boot

* console: assembly area with reduced mechanical load.

According to the assembly area a module which includes a MOST component will be installed to zone 2, 4 or 5.

The heating of the control unit itself has also to be considered.

In the chapter 1.1.4.3, page 5, the assembly area of this component will be referenced.

The hardest specification requirements have to be obtained, if there are several assembly areas designated by the car manufacturer.

1.1.4. Environmental conditions from automotive application

1.1.4.1. Electrical Characteristics

Supply voltage

The MOST component will be connected to a stabilized power supply of the control unit.

The MOST component has to achieve the specification without any restrictions in a temperature range of the device from T_u to T_{omax} and within the whole specified power supply range from V_{min} to V_{max} measured at the pins of the MOST component.

Current consumption

Figure 6.1 defines a frame for the maximum current consumption in active mode and stand by mode. The exact values have to be agreed in the supplier chain.

Label	Abbreviation	Transmitter	Receiver	Unit
Current Consumption – working (at V_{typ})	I_{Work}	50	30	mA
Current standby or sleep (at V_{typ})	$I_{CCSleep}$	-.-	30[1] 30/45[2]	µA

Figure 1: Maximum Current consumption for single optical component (transmitter or receiver)

[1]MOST25: 30µA
[2]MOST150: 30µA (-40°C…70°C), 45µA (70°C…95°C)

1.1.4.2. Mechanical Requirements

Abrasion resistance of labels

Markings on the device have to be attached securely to guarantee the identification over the whole period of life.

1.1.4.3. Temperature and humidity

Temperature range

The following schedule lists the assembly areas and the associated temperature limits according to the specification by car manufacturers. The valid assembly area for this component is to be defined along the supplier chain together with the car manufacturer.

- The minimal temperature in active mode of all assembly areas is T_u = -40°C.
- The maximum device temperature T_{omax} is higher than the temperature in the mounting location T_{amb} due to self-heating effect. This has to be considered during design phase.

If there is no other definition given the temperature range for Pigtail-Fiber, Connector and FOT is defined from T_u = -40°C to T_{omax} = +95°C.

Mounting location	Code	T_{Amb}	Comment / Example
Passenger compartment, without special requirements	EZ1	+85°C	No other ECU nearby
Passenger compartment; exposed to radiated heat	EZ2	+90°C	with exposure to heat radiation from other ECU, among other areas also luggage compartment
Passenger Compartment, dash board	EZ1	+85°C	Passenger compartment, dash board without solar radiation.
Luggage compartment – inside	EZ1	+85°C	Including inside area underneath luggage compartment (spare wheel cavity)

Figure 2: Maximum temperature for the assembly areas (Zone partitioning and thermal stress according to SAE J1211 and ISO 16750-4, Annex A)

Advice: The storage temperature range T_{smin} – T_{smax} is equal to the operating temperature range at least –40°C to +100°C, relative humidity < 85%.

Advice: It is possible to get condensation of the MOST component in each assembly area of the car due to climatic influence. For humid sensitive electrical circuits it is necessary to protect the functionality of the MOST component by proper arrangements.

The functionality of the MOST component must be guaranteed in the temperature range of the assembly area within the defined supply voltage range.

According to the assembly areas and the physical limits of the polymer optical fiber the module which contains MOST components will be mounted in the mentioned mounting locations. If there are other requirements than defined in this document, this shall be agreed separately.

1.1.4.4. Temperature profile

The valid temperature profile of the component for the assembly area has to be discussed with the car manufacturer.

The standard profiles are listed in the following schedule. The time of effect is given in % of time of use.

Mounting location	Duration of operation in %			
	Temp. 1 6%	Temp. 2 20%	Temp. 3 65%	Temp. 4 9%
EZ1	-40°C	+23°C	+60°C	+85°C
EZ2	-40°C	+23°C	+60°C	+90°C

Figure 3: Temperature profile according to the assembly areas (temperature distribution)

1.1.4.5. Mission profile of the car

The following schedule is an essential for the life tests and contains the typical life time and operation time for the component, the kilometric performance of the car were the component is assembled and the temperature cycling for the component.

This mission profile is to be seen theoretically and will cover round about 90% of the population of the cars.

Description	Requirement mission profile
Life time	15 years
Operating time (over 15 years)	11.250 hours
Temperature changes per year (the assumption is to have 2 starting sequences per day; the starting temperature will be given from temperature distribution)	730 cycles

Figure 4: Profile of the car

1.1.5. Reliability

The car manufacturer has developed a concept for reduction of field failures by implementation of reliability strategies. This concept has to be used during the development phase and the ramp up phase.

The procedures and the required amount of parts that has to be used for this are to be discussed with the car manufacturer.

1.1.6. Storage capability and packing

1.1.6.1. Storage capability

The storage temperature range is defined in chapter 1.1.4.3 / page 5. A MOST component has to withstand at least these conditions.

The minimal storage duration (without any actions for functional maintenance) is listed in the following schedule. Functional maintenance actions for extended storage duration have been notified to the car manufacturer.

All critical parts in view of delivery (technology change), storage duration, etc. have been classified in the CPM (Critical Parts Management).

The development is engaged to have a CPM.

1.1.6.2. Packing

The packing of the device for delivery to the plants has to be coordinated within the supply chain. The protection against any damage has to be guaranteed. The packing of the device for replacement requirements has to be coordinated with the replacement institution.

In both cases the packing has to be designed to assure the specific requirements for shipping and storing and to secure functional and optical characteristics.

1.1.7. Preparation of ECUs with MOST components

Product development concerning ET-supply (replacement supply) with spare parts:

At the development process of MOST components, requirements for ecological and cost effective conditioning and repair of the device for replacement supply have to be considered. For that reason, actions for replacement- (ET) and post series supply (NSV) have to be described, to guarantee the replacement supply for 15 years after the end of production.

1.1.8. Material recycling

Recycling means utilization of products or parts of products in a cycle. At the development of MOST components, demands for legal, ecological and cost effective utilization have to be considered.

1.1.9. Used Materials

The used materials have to be agreed in the chain of suppliers according to appropriated standards (e.g. EU end of life vehicles directive).

1.2. Development process

The MOST component which will be developed is assembled by the control unit manufacturer. The interest of the car manufacturer for the use of functioning and reliable MOST components will be taken into account with additional actions for quality and reliability covering during the development process. The charges for these additional actions are paid by the particular manufacturer of the device. The recommendation of release is not binding to the car manufacturer.

1.3. Basic conditions for functional and delivery terms

1.3.1. Rollout

The described MOST component is used in control units which have contact to the MOST bus and therefore it is usable for all car models.

The planned sales figures of the MOST components must be coordinated with the control unit manufacturer (quantities per years, distribution of calls or further details).

1.3.2. Milestone plan

1. It has to be a milestone between the car manufacturer (OEM) and the manufacturer of the MOST component.
2. Milestones of the direct development process have no effect.
3. Milestones have to regulate the exchange of information between the manufacturer of the MOST component and the OEM
4. There has to be transfer of documents at each milestone.
5. There has to be a checklist to each milestone

Milestone plan / checklist

M1: Introduction of a concept

M2: Start development

M3: Finish development

M4: Engineering Samples, Characterization

M5: Qualification

M6: Recommendation for release

M7: Release on the part of the OEM

1.3.3. Compliance Test

The compliance test is required by the MOST Cooperation for single components and ECUs in different stages. This corresponding test to this specification is the compliance test for "Full Physical Layer".

To ensure the functionality of MOST products according to the specification this test should be performed as early as possible. It is recommended to do perform compliance at the beginning of the investigation to get the recommendation for release.

1.4. Acceptance procedure

1.4.1. Qualification of the engineering samples

The MOST component is qualified by the developer or manufacturer during the sample phase of the product development process. This will be done independent from the parallel running development of the control unit. As a result of the highly technological challenge additional arrangements for the reliability and quality coverage will be done by an independent institution (ASTH). The intention of these additional arrangements is a recommendation of release for a qualified MOST component.

1.4.2. Serial parts

During the ramp up phase the risks are identified and assessed of all manufacturing processes of the component and will be eliminated by affective arrangements. The related arrangements are documented in the recommendation of release.

The scale of tests can be adjusted and modified by requirements in arrangements with the ASTH on special perceptions during the development phase.

The supplier performs the tests and provides the first samples (D-samples) with complete documentation.

The ASTH inspects the FSTR by documents, the hardware by specification and operating / legal requirements and create a recommendation of releases for the component.

1.5. Sample quantity

The MOST component manufacturer has to deliver sample quantities as discrete components or in cooperation with the control unit manufacturer within a control unit in accordance with the car manufacturer.

Sample quantities will be defined together with the developer from the car manufacturer according to the project time schedule. For the sample delivery the corporate arranged delivery date and sample price is applied. The sample parts are delivered to the recommendation for release institution (ASTH) after the order.

1.6. Documentation

The examination results from the supplier are submitted to the release department of the car manufacturer as a proof of compliance for the product specification defaults.

The data format of the development documentation is agreed with the recommendation for release institution (ASTH).

1.6.1. Hardware documentation

The documentation of the component has to match the product specification and contains the following topics:

- Data of the electrical / optical / mechanical tests
- Construction drawings
- Pin out of the connector
- Specification and datasheets
- Test concept (Functional test, In-circuit-test, Run- / Burn-in etc.)
- Result of the qualification

1.6.2. Documentation of the engineering samples / field

A maintenance history of the part has to be done during the development phase and the serial production including all changes to the hardware. After a change, the documentation has to be updated and the scope of modification has to be documented

An entry in the product history of the part has to include the following elements:

- Modification (what was changed, listing of the changed elements and all sub-positions)
- Reason for the modification
- Date of the modification
- Name of the responsible person for the modification

The maintenance history has to be included into the product specification on demand and on modifications or updating together with the responsible department of the car manufacturer.

1.7. Quality and reliability

The supplier is responsible for the development quality, product quality and production quality. During the ramp up phase all risks of all (production) processes and sequences have to be identified and assessed and have to be eliminated by effective preventive actions.

The car manufacturer and the institution for recommendation of release is authorised by audits or audit like methods to prove the capability of the supplier (quality management system). The recommendation for release institution is allowed to perform an assessment of the manufacturer within this investigation to get the recommendation.

The qualification procedure concerning the quality of the component demanded by the car manufacturer is described in chapter 0, from page 26 on.

1.7.1. Responsibility for quality and reliability

The development partner / supplier is responsible for the quality of the MOST component which has been developed.

As evidence of the specification compliance ‘automotive qualification’ and the quality of the MOST component the items

- Product development process,
- produce ability,
- correctness,
- Serial production,
- Measurable long term characteristic of product,
- consistency of the test strategy

has been verified. The derived actions and the quality concept has been harmonized with the recommendation for release institution (ASTH).

1.8. Preventive Actions for error avoidance

For the functionality test it is necessary to perform preventive quality concepts for securing of the ‘automotive’ quality during the project phase of the development of the MOST component. Additionally it is also required to secure the long term quality.

A risk analysis has to be done as a completion to the suitability tests and the life time tests during the sample phase defined by the development department. (e.g. ‘Failure mode and error analysis’ (FMEA))

1.8.1. Structured procedure

The supplier is required to perform a structured procedure according to the development phase to limit the risks of potential failures and effects.

The significance/effect of the possible failure in the complete system has to be judged together with the car manufacturer.

1.8.2. Technology assessment

1.8.2.1. Components of risk

1. New MOST components, which are used the first time in an automotive application, are components of risk.
2. Well-Known MOST components, which are inserted under new or changed conditions (e.g. new assembly area in the application), are components of risk.

The limits of the parts have to be determined by analysis and the risks has to be eliminated by preventive actions or technology assessment.

1.8.3. Critical Parts Management – CPM

All MOST components are rated as critical parts and classified in the CPM (critical parts management).

Especially for the after series supply (after sales market) an arrangement for the critical parts has to be defined.

The insert and the qualification of components of risk and critical parts have to be agreed with the car manufacturer and the ASTH.

2. Description of components

2.1. Description of MOST Components

This product specification describes components developed for the optical MOST® bus. For the different functions the following listed names are defined.

Label	Abbr.	Function
Fiber Optical Transceiver	FOT	Electrical/optical and optical/electrical converter
Pigtail-Fiber	PF	Pigtail Fiber with Tx/Rx Ferrule and Female Ferrule
Connector	CON	Connector housing
Ferrule Tx	FTX	Mechanical/optical Interface of Pigtail-Fiber to FOT (Tx)
Ferrules Rx	FRX	Mechanical/optical Interface of Pigtail-Fiber to FOT (Rx)
Female Ferrules	FF	Female Ferrules to connect the MOST Ferrule of the optical wiring harness
Ferrule-Housing	FH	Integrates Female Ferrules and is integrated into the connector
-.-	EOC	Electrical-optical converter – transmitter (signal path from SP1 to SP2)
-.-	OEC	Optical-electrical converter – receiver (signal path from SP3 to SP4)
Fiber Optical Transmitter	Tx	Transmitter
Fiber Optical Receiver	Rx	Receiver

Figure 5: Classification of the devices

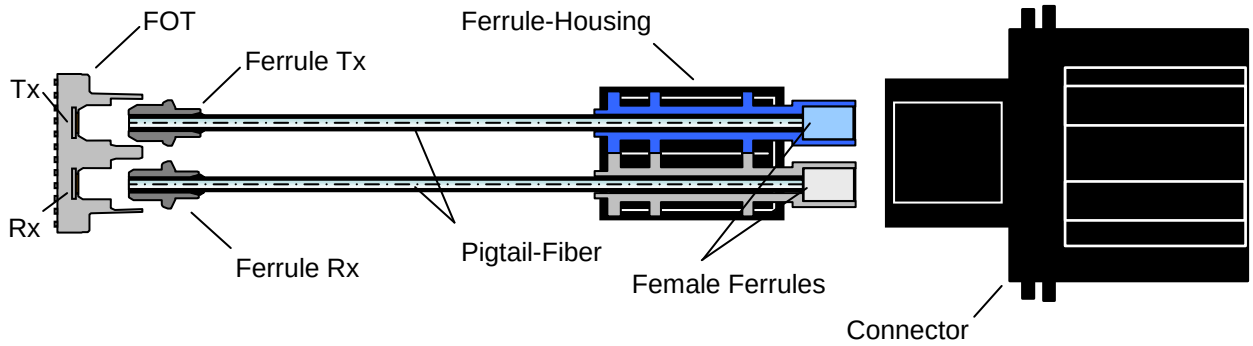

Figure 6: Principle sketch of the pigtail construction

In this document the introduction of optical components for MOST applications is described. If the connector also contains electrical contacts, the regulation and requirements for these electrical connections are also valid. Find the related reference in the reference list (Guide-Con).

2.2. Block diagram

The block diagram shows the functional blocks and components to the environment of this component. It's only for a better understanding of the functionality. Accordingly these are not binding data of the requirements from the car manufacturer.

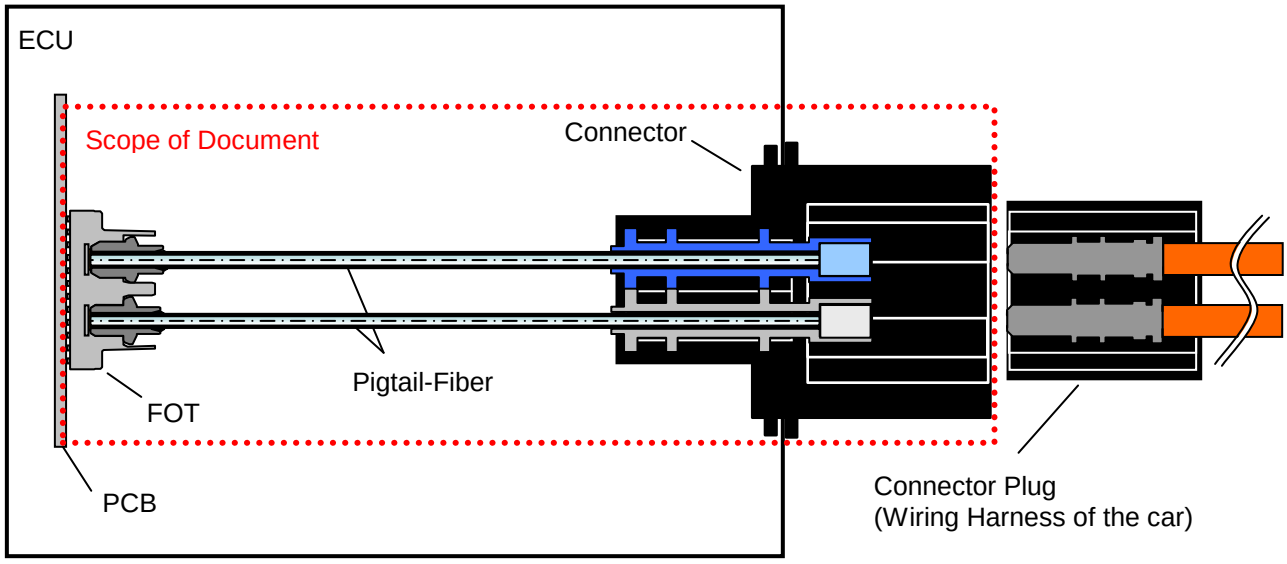

Figure 7: Functional blocks

2.3. Assembly area in the application

The assembly area of the FOT component is in general located as close as possible to the Network Interface Controller (NIC). The Pigtail-Fiber connects the FOT component with the MOST Connector that is located at the housing of the ECU. The minimum specified bending radius of the Pigtail-Fiber has to be considered.

2.4. Function

The MOST component connects the application to the optical Network (MOST). The MOST bus transmits data for telematics, entertainment and infotainment. The MOST bus consists of a optical fiber. The data will be transmitted by light between the different applications. The MOST component changes the information of light into electrical signals and vice versa.

2.4.1. Functional behavior in special situations

The MOST component has to be switched to '*standby*', in case that no data is transmitted via the MOST bus.

2.4.2. Operating safety

The electrical in- and outputs of the MOST component must be short circuit protected. If this is not implemented by the semiconductor (FOT) itself, it must be possible by an external circuit.

2.4.3. Safeness / security

The Connector construction has to assure, that the sensitive optical areas are protected against mechanical exposure.

The Connector construction (Connector, Ferrule-Housing and Female Ferrules) has to assure the correct positioning of the plastic fiber end areas to the FOT to guarantee the required specification according attenuation in the transition range.

2.5. Architecture

The fundamental structure of a MOST bus is a ring structure. The connection between two MOST components is shown in the Figure 8.

2.5.1. Global description

The MOST component transfers optical signals into electrical (receiver) respectively electrical signals into optical (transmitter). The special requirement of the particular specification points SP1 to SP4 are given by the actual MOST specification of the physical layer.

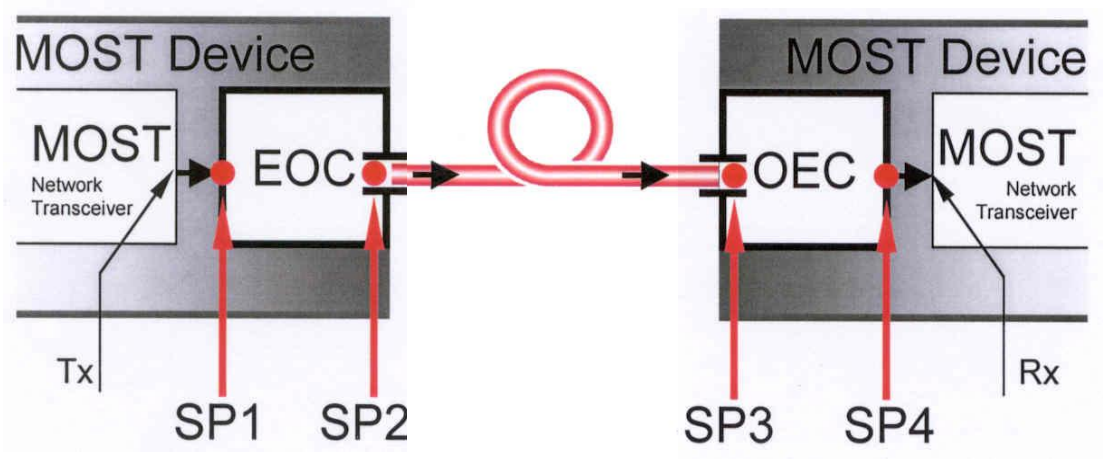

Figure 8: MOST Physical Layer Architecture

2.5.2. Hardware

Any requirements for hardware actions to protect the component against manipulation or external effects have to be discussed with the car manufacturer. All operationally and by law regulated commandments has been considered.

2.6. Design notice

2.6.1. Electrical and optical Interfaces

Electrical and optical interfaces in general have to be designed for no loss of information.

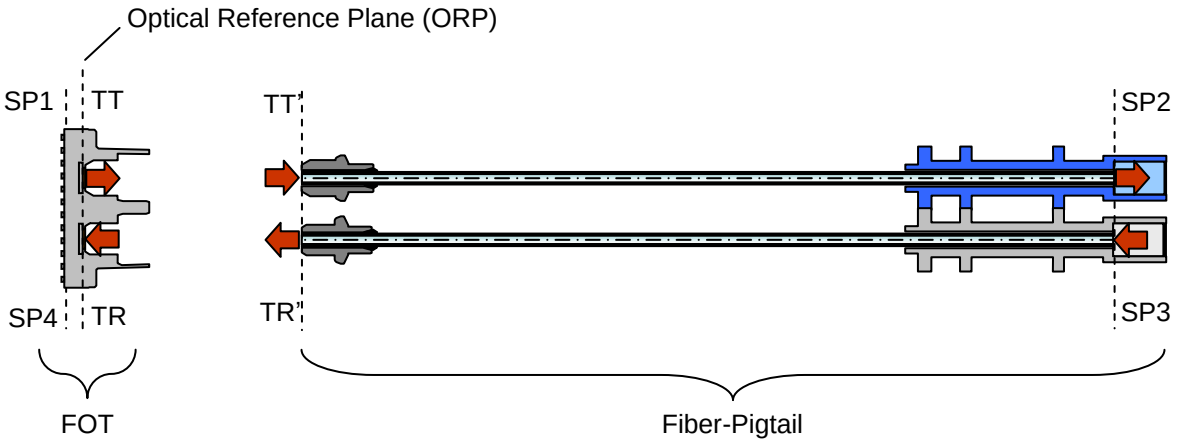

Figure 9: Optical and electrical Interfaces

2.6.1.1. Specification point SP1

The specification point SP1 defines the electrical input parameters for the FOT transmitter and the electrical output parameters for the network interface controller (for example NIC).

2.6.1.2. Specification point SP2

The specification point SP2 defines the optical output parameters for the FOT transmitter at the interface to the wiring harness of the car. (Attention: Output of transmitter FOT is not identical to SP2)

2.6.1.3. Specification point SP3

The specification point SP3 defines the optical input parameters for the FOT receiver at the interface to the wiring harness of the car. (Attention: Input of receiver FOT is not identical to SP3)

2.6.1.4. Specification point SP4

The specification point SP4 defines the electrical output parameters for the FOT receiver and the electrical input parameters for the network interface controller (NIC).

2.6.1.5. Test Point TT

The test point TT defines the optical output parameters for the FOT transmitter at the interface to the Tx-Pigtail-Fiber and is located on the optical reference plane (ORP) of the FOT. Test Point TT parameter are identical to SP2 except of the min. Optical Output Power (SP2: -8dBm) and has to be increased by +1.5dB to cover the max. accepted loss of the Tx-Pigtail-Fiber (between TT' and SP2).
Therefore the minimum Optical Output Power at Test Point TT has to be -6.5dBm.

2.6.1.6. Test Point TR

The test point TR defines the optical input parameters for the FOT receiver at the interface from the Rx-Pigtail-Fiber and is located on the optical reference plane (ORP) of the FOT. Test Point TR parameters are identical to SP3 except of the level of minimum sensivity (SP3: -22dBm). This has to be adjusted by -1.5dB to cover the max. allowed loss in the Rx-Pigtail-Fiber (between SP3 and TR').
The the optical input power range for On-State operation at Test Point TR is from -2dBm to -23.5dBm and the switching point to the Off-State operation has to be below -36.5dBm.

2.6.1.7. Test Point TT'

The test point TT' defines the optical input parameters for the TX Fiber. The max. acceptable loss of the Tx-Pigtail-Fiber between TT' and SP2 is ≤1.5dBm. Losses due to fiber recess, fresnel scattering and concentricity deviations of the interfaces are part of the Fiber Pigtail attenuation and have to be considered.

2.6.1.8. Test Point TR'

The test point TR' defines the optical output parameters of the RX Fiber. The max. acceptable loss of the Rx-Pigtail-Fiber between SP3 and TR' is ≤1.5dBm. Losses due to fiber recess, fresnel scattering and concentricity deviations of the interfaces are part of the Fiber Pigtail attenuation and have to be considered.

2.6.2. Mechanical Interface

The optical interface of the FOT (TT/TT' and TR/TR') has to be designed, that the Ferrule Tx only fits into the Tx-Interface of the FOT and the Ferrules Rx only fits into the Rx-Interface of the FOT. The spring/lock mechanism of the FOT has to be designed that the minimum specified retention forces meet the requirements of the corresponding MOST Specification.

After assembly in the car, there will be no additional protection by conservation or varnishing of the MOST component. The surface of the housing, sealing etc. has been designed for the assembly area.

The surface of the solder pins shall be designed for lead free soldering.

The optical interface is described by the transmission loss between the surface of the Pigtail-Fiber to the optical fiber of the wiring harness. For the specification points SP2 to the light transmitting fiber and from the light transmitting fiber to the specification point SP3 the following transmission losses are defined.

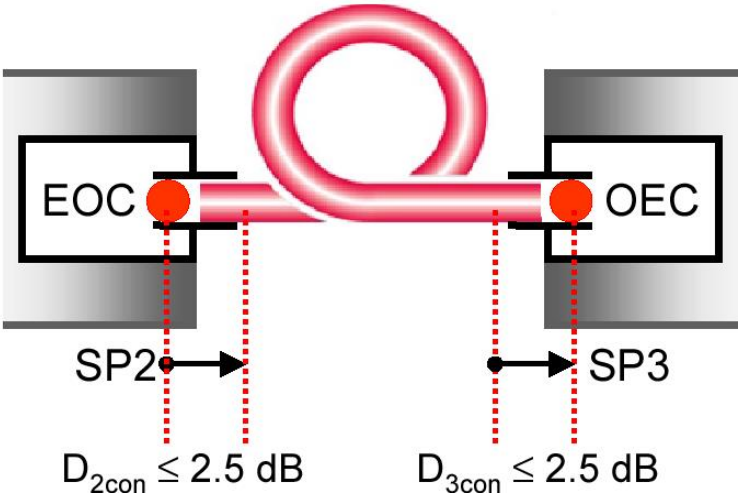

Figure 10: Connector Interface Loss at SP2 and SP3

2.6.2.1. Delivery condition

The delivery of the component take place with protective caps for the contacting within the arranged packaging.(See also in chapter 1.1.6.2 page 7*)*

2.6.3. Transmitter-FOT

2.6.3.1. Maximum optical output power (eye safety)

To avoid any labelling and additional precautions, the Laser Class 1 shall be achieved. Laser Class 1 is defined as safe under reasonably foreseeable conditions of operation including the use of optical instruments for intra-beam viewing. This means that the maximum level of radiation must be less or equal to the accessible emission limits for Class 1. (IEC 60825-1 Safety of Laser Products Part 1 and IEC 60825-2 Safety of Laser Products Part 2)

2.6.4. Receiver-FOT

2.6.4.1. Function of status pin

The condition of the Status pin indicates, if a valid signal is received. In case of receiving light, the status pin is "low". The status pin is useable to switch on the system.
Is the status pin on "high" level, the data output is "disabled (high-Z for MOST150).

3. Recommendation for release procedure

The recommendation for release process is performed by the ASTH together with the manufacturer of the specific component (FOT, Pigtail-Fiber and Connector). During the recommendation for release process, the information is only shared between these 2 partners (covered by NDA). After finalization of this process, the ASTH submits a recommendation for release report (complete report and short form) to the component manufacturer. The recommendation for release report can be used by the component manufacture to apply for a release of the component in between the supply chain.

If there is no other indication this specification describes the procedure of introduction and investigation of a new product from a yet unknown manufacturer.

To get a recommendation for release the following steps are to be done:

A) Information about the manufacturer (see chapter 3.1, page 17)

B) Information regarding the development flow

C) Information about production methods and flow

D) Characterization of component (see chapter 4, page 22)

E) Qualification of component (see chapter 0, page 26)

Additionally to this during ramp up – typically before SOP (start of production) of first application – the following data should be reviewed by the ASTH:

F) Qualification – data for information only (see chapter 5.2.7, page 4)

G) Identification of early failure rate (see chapter 6.2, page 50)

H) Concept for monitoring to ensure a reproducible quality and reliability in mass production (see chapter 6.3, page 50)

For the component classes FOT, Pigtail-Fiber and Connector there are different investigations necessary to get the recommendation for release. This will be described in detail in the following chapters.

Technical changes are to be reviewed from the ASTH as well. This will lead to additional investigations.

3.1. Manufacturer

A manufacturer who wants to deliver components for MOST has to demonstrate the knowledge regarding these products with respect to market segments and quantities.

Additionally to this the rules for automotive components are valid. This includes the requirement for certification of the involved organizations in development and production. This is also valid for other suppliers in the supply chain.

A certification according to ISO9000 series or better according to TS16949 is recommended.

3.2. Development process

The development flow has to be according to the rules of TS16949. The review will be done with a check list.

3.3. Production and production processes

For production processes and developing of processes the rules of TS16949 are applicable. The review of these regulations will be done with a check list.

Additionally to this any changes of production location, single processes and essential tools are to be announced by the manufacturer. This is also valid if a change occurs during the investigation to get the recommendation for release.

Essential changes of processes and sub components will not be handled during a running investigation. All changes are reviewed and judged for the influence of a running investigation from the ASTH. It may be necessary to perform additional tests to ensure the result of the investigation.

3.4. Documents

For the investigation the following documents are to be submitted by the manufacturer:

A) Diagram of production flow

B) Bill of materials

C) Drawing of product – especially the area of optical path

D) Data sheet

E) Application notes (if available)

F) Data of the defined investigations – to be handled in EXCEL format

Any changes shall be announced. This is also valid for the semiconductors

3.5. Result

The judgment of the reviews and the submitted data and reports will be done from an independent institution (ASTH) in a report. The timing for this report is to be agreed between ASTH and the manufacturer. At least at the end of the investigation a detailed report and a short form were worked out. This report will identify the product and will give a statement of the status.

3.5.1. Status of Investigation

The report can be written with the following steps. For each step different minimum criteria (definition in brackets) are valid:

- Work in process (no minimum criterion)
  Investigation started, short term test and/or life time tests not finished or no information available
- Preliminary
  - short term test successfully finished;
  - life time test successfully finished for more than half of the required duration [t/2]
  - characterization successfully finished for more than half of the required quantity [n/2]
  - minor items open,
  - minor risk of failure during remaining time;
  - simultaneous engineering in supply chain can be started.
- Final (all tests successfully finished up to the required duration; all necessary information available)
- Final, for information finished (additionally all tests for information only finished)
- Final, completed (additionally all tests for early failure rate finished)

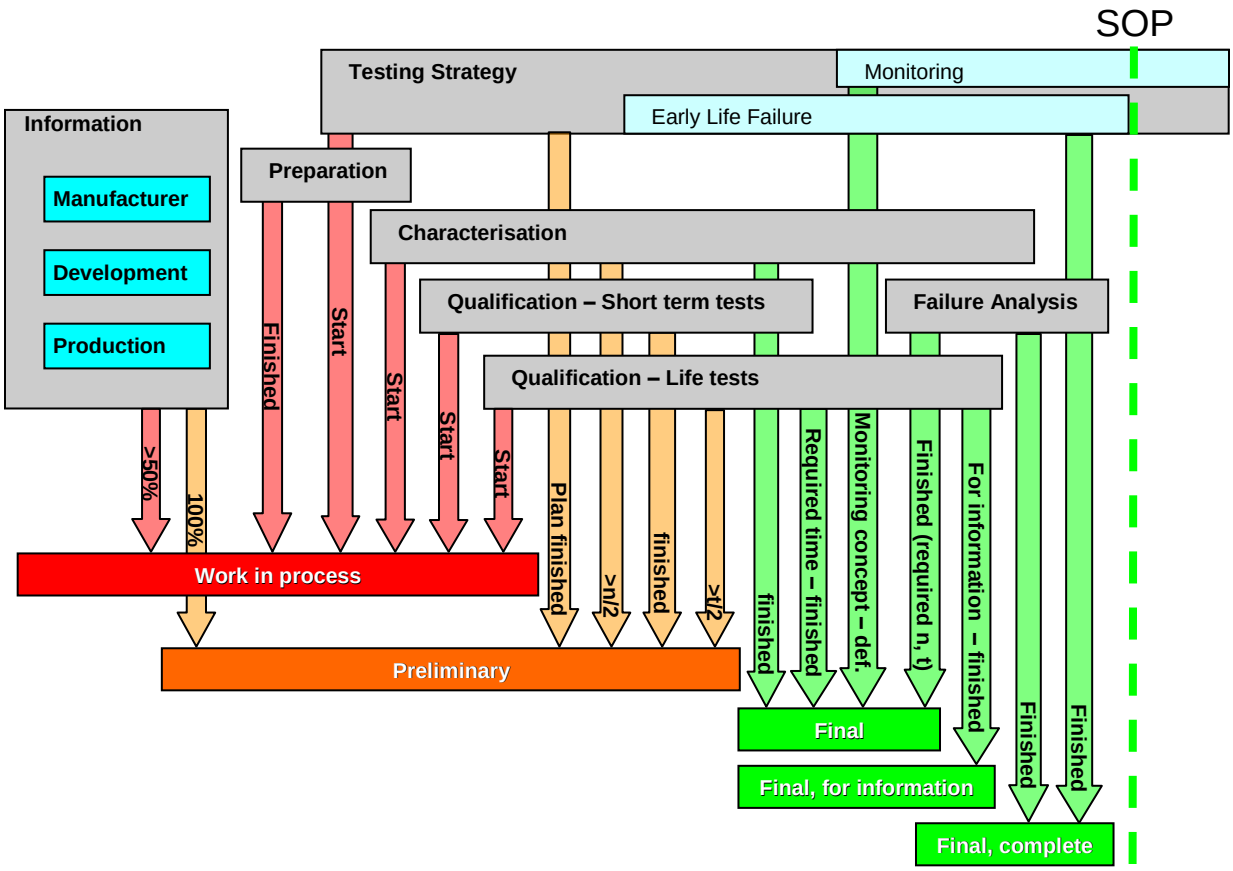

Figure 11: Progress of reports – necessary results

3.5.2. Depth of Investigation

During the investigation there are different steps to be done. The lessons learnt from former investigation shall be taken into account. Different categories are defined as indication for this. The influence for each point of investigation will be documented in each report:

- Not regarded
- Overview
- Detail

	Manufacturer	**Development**	**Production**	**Testing Strategy**	**Characterization / Qualification**
not investigated	no action	no action	no action	no action	no action
Overview	general plan	general plan	general plan	general plan	not applicable
Detail	detail judgment	Assessment at plant	Assessment at plant	Assessment at plant	detail judgment

Figure 12: Depth of investigation

A	fulfilled	no action necessary;	"traffic light color": green
AB	predominantly fulfilled	no action necessary;	"traffic light color": green
B	acceptable (limited fulfilled)	measurement near limit (remark for manufacturer)	"traffic light color": yellow
C	failed	corrective action necessary	"traffic light color": red

3.5.3. Judgment

The judgment of single tests are carried out in 3 steps:

A) Fulfilled

B) Acceptable

C) Incomplete

The following criteria are valid:

At A) Requirement fulfilled with sufficient safety margin
no action necessary
color of letters black
(only if criterion originally not fulfilled): green

At B) Requirement fulfilled with no sufficient safety margin,
action for improvement recommended, but not absolutely necessary
color of letters: yellow

At C) Requirement not fulfilled,
action absolutely necessary
color of letters: red

3.5.4. Comments in document

In the report the progress of investigation to relevant points will be documented.

To increase the readability of the report the remarks will be written in different colors. For this purpose the following rules are valid:

red written text	open items or questions coming up during the review (answer absolutely necessary to receive recommendation for release)
violet written text	remarks from the ASTH to be taken into account; corrective actions will improve the performance (decision of taking action is in the responsibility of the manufacturer) not mandatory for recommendation
blue written text	Testing or other work not yet finished answer absolutely necessary for recommendation
green written text	information or data delivered on request

3.6. Implementation for Components or process flows

3.6.1. Semiconductor device (FOT)

On the level of semiconductor the following steps are necessary:

A) Information about manufacturer including supply chain for key components

B) Judgment of development flow

C) Judgment of production

D) Agreement about characterization and qualification

E) Characterization (performed by manufacturer)

F) Qualification (performed by manufacturer)

G) Review of results from characterization and qualification

H) Calculation of trends respectively prognostics

I) Judgment of testing strategy

3.6.2. Pigtail-Fiber / Connector

On the level of pigtail-fiber / connector the following steps are necessary:

A) Information about manufacturer including supply chain for key components

B) Judgment of development flow

C) Judgment of principal construction and processes

D) Agreement about characterization and qualification

E) Characterization (performed by manufacturer)

F) Qualification (performed by manufacturer)

G) Review of results from characterization and qualification

H) Calculation of trends respectively prognostics

I) Judgment of testing strategy

J) Interoperability

3.6.3. Necessary Actions

For the different components the following depth of investigation is to be seen as minimum:

	FOT	Pigtail-Fiber/Connector
Manufacturer	overview	overview
Development	overview	overview
Production	detail	overview
Testing Strategy	detail	overview
Characterization / Qualification	detail	detail

3.6.4. Handling of changes

If new components are introduced the following procedure is valid:

- Judgment of degree of change
- Definition of necessary steps
- Performing of the tests
- Judgment of results

The change can be seen in the following categories:

A) Manufacturer

B) Product

C) Environmental conditions, as operating temperature or supply voltage

D) Construction in the area of optical path

If the change can be seen in one of the above mentioned categories a verification according to this specification is necessary.

If an existing product will be changed there will only some tests will be done. The reasons for the choice of tests shall be documented in the report. Every independent institution will describe their procedure in a separate document. This document shall be agreed with the car manufacturer.

If new product IDs are to be defined the additional investigation is to be agreed. This is particularly valid if the changes are forced from technical topics. A comparison between old and new product will be done by an independent institution. If there is no technical reason for additional investigation a document was written to tell the reason for this decision. Additional regulations shall be taken into account. One of these additional regulations is the compliance test given by the MOST Cooperation. Another additional regulation is the handling of changes given by the car manufacturer.

4. Characterization of finished component (CHA)

4.1. General

For the characterization of the electrical respectively optical parameters the rules according to AEC-Q003 (Guideline for Characterization of Integrated Circuits) together with AEC-Q100-009 (Electric Distribution Assessment) are applicable. As minimum requirement the parameter according to the actual MOST Compliance Test of Physical Layer shall be chosen for measurement.

In addition to that, the characterization has to be performed under the following conditions:

A) Characterization at the minimum, maximum and nominal power supply voltage; if there are different supply voltages mentioned in the data sheet these are necessary to be characterized.

B) Characterization at least at TT (-40° C), RT(25° C) and HT(T_{ACT})

C) FOT only(RX): Characterization over the whole specified optical input power range in steps of 3 dB; at least one point of measurement should be below the minimum specified optical input power.

4.2. Performance of characterization

The characterization shall be done with production parts. To determine trends or variations due to life time tests there will be a characterization with some products after the life time tests.

The MOST Physical Layer Specification with the respective Sub Specification is binding for the Parameters that have to be characterized.

The parameters shown in Figure 13 to Figure 17 are derived from the respective MOST Physical Layer Specification and are divided into parameters measured at FOT and Pigtail-Fiber level. The characterization of the connector is covered by the Physical Dimensions (PD) procedure of the connector qualification.

4.2.1. General Procedure

The characterization will be done in the following steps:

1) Definition of parts, applicable limits (USL, LSL), methods of measurement and equipment for characterization (Responsible: manufacturer)
2) Definition of measured parameter (Responsible: manufacturer)
3) Release of characterization procedure including parameters to be reviewed and judged (Responsible: ASTH)
4) Performing of tests (Responsible: manufacturer)
5) Judgment of results (Responsible: ASTH)*
6) Clarification of open points (Responsible: manufacturer)
7) Collecting results, preparing report for recommendation for release (Responsible: ASTH)

* Results of tests shall be delivered to the ASTH in electronic format. Format and content shall be agreed between manufacturer and ASTH.

EOC Parameter {5}

FOT Parameter (EOC)	Condition	SP	Test Point	Remark	Phy Spec
Center wavelength	A), B)	2	TT	{1}	✓
Spectral Width (RMS)	A), B)	2	TT	{1}	✓
Optical output power	A), B)	2	TT	X	✓
Extinction ratio	A), B)	2	TT	X	✓
Rise time	A), B)	2	TT	X	✓
Fall time	A), B)	2	TT	X	✓
Transfered Jitter (via RMS)	A), B)	2	TT	X	✓
Alignment Jitter according to Eye Mask {3}	A), B)	2	TT	X	✓
Overshoot/Undershoot {4}	A), B)	2	TT	X	✓
Bit Error Rate	A), B)	2	{2}	{2}	✓

Figure 13: FOT Parameter (EOC)

FOT Power State Requirements (EOC)	Condition	SP	Test Point	Remark	Phy Spec
Current consumption	A), B)	-.-	-.-	X	-.-
EOC Operating Voltage Range	B)	-.-	SP1-TT	X	✓
EOC Glitch-Safe Voltage Range	B)	-.-	SP1-TT	X	✓
EOC Off Voltage Range	B)	-.-	SP1-TT	X	✓
EOC On frequency range at SP1	A), B)	-.-	SP1-TT	X	✓
EOC Off frequency range at SP1	A), B)	-.-	SP1-TT	X	✓
EOC power on delay	A), B)	-.-	SP1-TT	X	✓
EOC power off delay	A), B)	-.-	SP1-TT	X	✓
Average optical output power for the Off-State	A), B)	-.-	SP1-TT	X	✓

Figure 14: FOT Power State Requirements (EOC)

{X} Have to be tested
{-.-} Not required/not specified
{✓} Specified in related MOST Physical Layer Specification
{1} Have to be guaranteed
{2} The Bit Error Rate defined in the MOST specification shall be valid.
{3} Eye Mask measurement (horizontal/vertical) has to be determined numerically to enable a statistical calculation of the characterization data.
{4} Overshoot/Undershoot has to be measured numerically also to enable a statistical calculation of the characterization data.
{5} LVDS Interface has to be in accordance to TIA/EIA-644-A-2001
A) Condition Supply Voltage (page 22)
B) Condition Temperature (page 22)

OEC Parameter {4}

FOT Parameter (OEC)	Condition	SP	Test Point	Remark	Phy Spec
Transfered Jitter (via RMS)	A), B), C)	4	TR-SP4	X	✓
Alignment Jitter according to Eye Mask {3}	A), B), C)	4	TR-SP4	X	✓
Bit Error Rate	A), B), C)	-.-	-.-	{2}	✓

Figure 15: FOT Parameter (OEC)

FOT Power State Requirements (OEC)	Condition	SP	Test Point	Remark	Phy Spec
Powering On					
Current consumption	A), B)	-.-	-.-	X	✓
Average optical input power range for On-State operation	A), B)	-.-	TR-SP4	X	✓
Frequency range of input at SP3 for On-State operation	A), B)	-.-	TR-SP4	X	✓
OEC power-on delay	A), B)	-.-	TR-SP4	X	✓
P_{ON3} to STATUS falling	A), B)	-.-	TR-SP4	X	✓
STATUS falling to LVDS valid	A), B)	-.-	TR-SP4	X	✓
OEC Operating Voltage Range	A), B)	-.-	TR-SP4	X	✓
Powering Off					
Current consumption in the OFF-State	A), B)	-.-	-.-	X	✓
Average optical input power range for Off-State operation	A), B)	-.-	TR-SP4	X	✓
Frequency range of input at SP3 for Off-State operation	A), B)	-.-	TR-SP4	X	✓
OEC power-off delay	A), B)	-.-	TR-SP4	X	✓
OEC LVDS hold time	A), B)	-.-	TR-SP4	X	✓
Signal off to STATUS rising	A), B)	-.-	TR-SP4	X	✓

Figure 16: FOT Power State Requirements (EOC)

X Have to be tested
-.- Not required/not specified
✓ Specified in related MOST Physical Layer Specification
{1} Have to be guaranteed
{2} The Bit Error mentioned in the MOST specification shall valid due to the design.
{3} Eye Mask measurement (horizontal/vertical) has to be determined numerically to enable a statistical calculation of the characterization data..
{4} LVDS Interface has to be in accordance to TIA/EIA-644-A-2001

A) Condition Supply Voltage (page 22)
B) Condition Temperature (page 22)
C) Condition Input Light Level (page 22)

Pigtail-Fiber Parameter

Pigtail-Fiber Parameter	Condition	SP	Test Point	Remark	Phy Spec
Attenuation of Tx-Fiber	B)	2	TT'-SP2	{1}	-.-
Attenuation of Rx-Fiber	B)	3	SP3-TR'	{2}	-.-

Figure 17: Specific data Pigtail-Fiber

X Have to be tested
-.- Not required/not specified
✓ Specified in related MOST Physical Layer Specification
{1} The attenuation of the Tx-Fiber has to fulfill the MOST Physical Layer Specification at SP2 in combination with the dedicated FOT unit (Tx).
{2} The attenuation of the Rx-Fiber has to fulfill the MOST Physical Layer Specification at SP3 in combination with the dedicated FOT unit (Rx).
B) Condition Temperature (page 22)

4.2.2. Characterization of series parts

The characterization of the device has to be performed with the following quantities (in adaptation to AEC-Q100 – page 24)

- for FOT: 3 Lots, each 30 components
- for Pigtail-Fiber: 1 lot of 30 components

For this characterization at least the parameters in Figure 13, Figure 14 and Figure 15 including the described conditions have to be recorded. The data of the characterization shall be submitted to the ASTH. Characterization data sheets of implemented Components shall also be submitted to the ASTH.

4.2.3. Characterization of parts after life test

This chapter is only valid for FOT.

After finishing the qualification 10 devices from each operating life test HTOL, THB and Temperature cycling (TC or TS) after the required test duration have to be measured according to Figure 13 and Figure 14. That means that there are some fewer parts which will see the duration "for information only".

Conspicuous Devices from the Qualification process shall also be characterized according to Figure 13 and Figure 14 before going into destructive analysis.

5.Qualification

The Qualification procedure acts to test functional and systematic abilities of MOST components. The scope of investigation is due to the opto-electronical and electro-optical converting. The qualification is based on the international standard of the AEC Q100 for semiconductors. To additionally cover the optical characteristics to scope is extended therefore.

5.1. Qualification plan

5.1.1. General

The qualification plan is divided between FOT-qualification, Pigtail-Fiber qualification and Connector qualification.

5.1.1.1. FOT Qualification

For FOT-Devices this investigation has to be done with 3 different lots.

The devices for the Operating Life Tests THB, TC/TS have to pass a preconditioning procedure first. (described with the test PRE)

5.1.1.2. Pigtail-Fiber/Connector Qualification

For Pigtail-Fiber and Connector parts, the qualification is done only with one lot, because there are mainly mechanical processes to manufacture this kind of component.

Detailed description for the specific tests see section chapter 5.2, page 32.

5.1.2. FOT Qualification

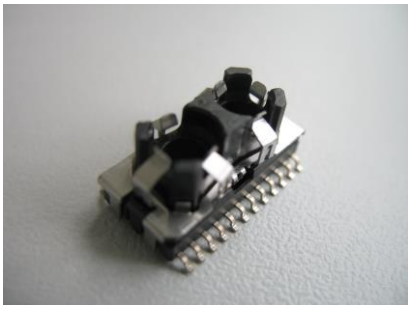

Figure 18: FOT

Qualification Scope:

- Semiconductor
- Mechanical Construction
- Mechanical Interface
- Optical Interface

Semiconductor related tests are based on AECQ100

Preparation

Test	Test Name	Lot/Qty	Note
S	Serialization	All	
EV	External Visual	All	
PD	Physical Dimensions	3/30	
EMO	Electrical, Mechanical, Optical Measurement	All	

Life Time Test

Test	Test Name	Lot/Qty	Parameter	Note
CA	Corrosive Atmosphere	1/10	Meth 4	EN 60068-2-60
THB	Temp. Humidity Biased (including PRE)	3/77	1000h (3000h)	EN 60068-2-67
HTOL	High Temp. Operating Life	3/77	3000h (5000h)	EN 60068-2-2
LTOL	Low Temp. Operating Life	3/77	1000h	EN 60068-2-1
TC	Temperature Cycling (including PRE)	3/77	1000cyc (2000cyc)	EN 60068-2-14
TS (Opt. to TC)	Temperature Shock (including PRE)	3/77	500cyc (1000cyc)	EN 60068-2-14
HTC	Temp. Humidity Cycling	1/26	50cyc (100cyc)	EN 60068-2-38
STT	Stepped Temperature Test	1/5		ISO 16750-4 / 5.2

Functional

Test	Test Name	Lot/Qty	Note
GL	Gate Leakage	1/6	AEC Q100-006
LU	Latch Up	1/6	AEC Q100-004
ESD MM	ESD Machine Model	1/3	AEC Q100-003
ESD CDM (opt. to MM)	ESD Charged Device Model	1/3	AEC Q100-011
ESD HBM	ESD Human Body Model	1/6	AEC Q100-002

Test	Test Name	Lot/Qty	Note
EMC	Electromagnetic Capability	1/1	CISPR25

Manufacturing

Test	Test Name	Lot/Qty	Note
MLD	Moisture Level Definition	2/11	JEDEC STD-20
SD	Solderability	1/15	EN 60068-2-20
RSH	Resistance to Soldering Heat	1/22	JESD-22-B106
BP	Bond Pull	1/5/30w	EN 60749 / 6.2 Meth. B
BS	Bond Shear	1/5/30b	EN 60749 / 6.6

Mechanical

Test	Test Name	Lot/Qty	Note
PIFF	Pressing-in force Ferrule	1/5 +3 HTOL +3 TC	EN 61300-3-11
POFF	Pull-out force Ferrule	1/5 +3 HTOL +3 TC	EN 61300-3-11
DT	Drop Test	1/5	EN 60068-2-32
MS	Mechanical Shock	1/5 CA	ISO 16750-3 / 4.2.2
VR	Vibration Random	1/5	Opt-Auto-Con
VS	Vibration Sinus	1/5	Opt-Auto-Con
D	Dust	1/10	EN61300-2-27

Final Inspection

Test	Test Name	Lot/Qty	Note
EV	External Visual	All	
EMO	Electrical, Mechanical, Optical Measurement	All	

5.1.3. Pigtail-Fiber Qualification

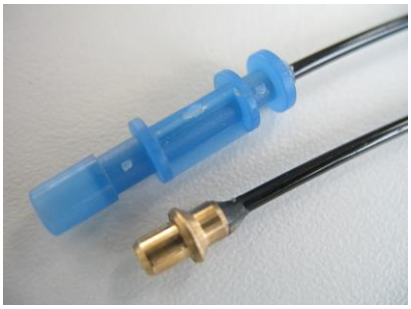

Figure 19: Pigtail-Fiber

Qualification Scope:

- Mechanical Interface/Physical Dimensions
- Optical Interface/Surface
- Attachment of Ferrule to Fiber

Fiber has to be qualified according to LWL-Bulk "Fiber optics in motor vehicles; Test guideline for LWL bulk stock"

Preparation

Test	Test Name	Lot/Qty	Note
S	Serialization	All	
EV	External Visual	All	
PD	Physical Dimensions	1/30	
EMO	Mechanical, Optical Meas-urement	All	Key Parameter: Attenuation / Mechanical Dimensions

Life Time Test

Test	Test Name	Lot/Qty	Parameter	Note
CA	Corrosive Atmosphere	1/10	Meth 4	EN 60068-2-60
THB	Temp. Humidity Biased	1/26	500h (1500h)	EN 60068-2-67
TC	Temperature Cycling	1/26	500cyc (1000cyc)	EN 60068-2-14
TS (Opt. to TC)	Temperature Shock	1/26	250cyc (500cyc)	EN 60068-2-14
HTC	Temp. Humidity Cycling	1/26	50cyc (100cyc)	EN 60068-2-38

Mechanical

Test	Test Name	Lot/Qty	Note
WP	Wire Pulling	1/5	EN 61300-2-4
DOSF	Draw out Strength Ferrule	1/3 each	EN 61300-2-4

Climate

Test	Test Name	Lot/Qty	Note
CR	Chemical Resistance	1/3	Opt-Auto-Con
TP	Thermal Pistoning	1/3	EN 61300-2-18

Final Inspection

Test	Test Name	Lot/Qty	Note
EV	External Visual	All	
EMO	Mechanical, Optical Measurement	All	Key Parameters: (optical Attenuation, Physical Dimensions)

Characterization

Test	Test Name	Lot/Qty	Note
CHR	Characterization	1/30	According to Chapter 0
CHL	Characterization after Life	Each 5	According to Chapter 0

5.1.4. Connector Qualification

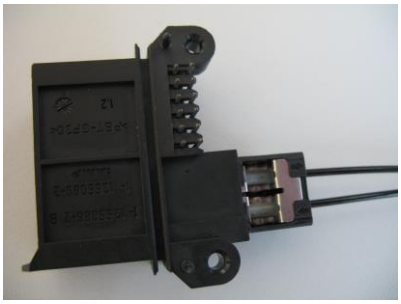

Figure 20: Connector

Qualification Scope:

- Mechanical Interface/Physical Dimensions
- Attachment of Ferrule-Housing to connector

Connector has to be qualified according to Opt-Auto-Con "Plug connectors in motor vehicles; test guideline"

Preparation

Test	Test Name	Lot/Qty	Note
S	Serialization	All	
EV	External Visual	All	
PD	Physical Dimensions	1/30	
EMO	Electrical, Mechanical, Optical Measurement	All	

Life Time Test

Test	Test Name	Lot/Qty	Parameter	Note
TC	Temperature Cycling	1/26	500cyc (1000cyc)	EN 60068-2-14
TS (Opt. to TC)	Temperature Shock	1/26	250cyc (500cyc)	EN 60068-2-14

Mechanical

Test	Test Name	Lot/Qty	Note
DSFH	Draw-out strength ferrule-housing	1/5	EN 61300-2-4
D	Dust	1/10	EN 61300-2-27
MS	Mechanical Shock	1/5	ISO 16750-3 / 4.2.2
VR	Vibration Random	1/5	Opt-Auto-Con
VS	Vibration Sinus	1/5	Opt-Auto-Con
PFR	Plugging Frequency	1/10	Opt-Auto-Con
AP	Angular Plugging	1/5	Opt-Auto-Con
DSC	Draw-out strength connector	1/5	Opt-Auto-Con

Final Inspection

Test	Test Name	Lot/Qty	Note
EV	External Visual	All	
EMO	Electrical, Mechanical, Optical Measurement	All	

Characterization

Test	Test Name	Lot/Qty	Note
CHR	Characterization	1/30	Mechanical Dimensions
CHL	Characterization after Life	Each 10	Mechanical Dimensions

5.1.5. Definition of the temperature range

Because of the characteristics of the components the defined Temperature range (Grade 0 to 4) is not applicable.

5.1.5.1. Definition of temperatures for testing

The lower testing temperature limit for all tests is equal to the minimal operating temperature

T_U = - 40°C

For the upper testing temperature limit there is a difference between active and passive tests

T_{ACT} = T_{omax} if FOT active

T_{PAS} = T_{omax} + 10°C if FOT passive

The assumed increase of 10°C is typical for the internal heat dissipation from the active use of the FOT. For passive tests with this assumption the total temperature is to be tested.

5.1.5.2. Requirements for higher temperatures

If the maximum operating temperature is greater than T_{omax}=+100°C the maximum temperature limit of the used materials, e.g. the fiber (POF) is to be taken into account. These limits are to be considered when defining the limits of testing temperatures.

A deviation of those temperature limits for testing has to be discussed with the car manufacturer. For the construction of pigtail the temperature behavior of the FOT (self-heating) shall be taken into account.

It is to be recognized that the standard fiber in the wiring harness of the car is capable to withstand a steady state temperature of +85°C. This means that in operating mode over the whole temperature range the temperature at SP2 and SP3 will not exceed this temperature.

5.1.5.3. Relevant parameters during qualification

Basically it is necessary to consider all electrical and optical parameter for the analysis. There are a few parameters which are of special interest during the qualification phase. These parameters are defined in the chapter EMO (chapter 5.2.9., page 58) together with the acceptance criteria.

5.2. Qualification loads

5.2.1. Preparation

S (Serialization)

Reference:	AEC Q100-009 (chapter 3.4)
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	All
Explanation:	For traceability of the tests and measurements and especially to investi gate drift of parameters, it is necessary to have an individual number for all devices.

EV (External Visual)	
Reference:	AEC Q100; JESD-22 B101 EN 61300-3-1
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	All
Acceptance criterion:	All devices at each measurement point shall be judged as okay. Deviations from testing, also during life time tests, shall not derate the functionality.
Explanation:	All devices. Distinctive parts shall be documented by photos.

PD (Physical Dimensions)	
Reference:	JESD-22 B100
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	3 Lots / 10 devices
Acceptance criterion:	All devices within the given tolerance; additionally to this the regulations for capable processes are valid
Explanation:	Definition of manufacturing tolerances also for different tools or different places in the tools.

REF (Reference parts)	
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	7 devices
Acceptance criterion:	Deviations from the tests, also for life time tests have no influence to the functionality
Explanation:	Reference samples for comparison with samples after completion of life testing.

RR (Reference parts for ASTH)	
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	3 devices
Acceptance criterion:	Deviations from the tests, also for life time tests have no influence to the functionality
Explanation:	Reference parts with no environmental stress have to be delivered to the recommendation for release institution, that the ASTH is able to get an independent judgment.

5.2.2. Electrostatic loads

These tests are valid to define the behavior of the MOST components regarding the electrostatic performance. On one hand the resistance during production will be defined for the different levels of production within the supply chain. This is valid for the FOT. These tests shall be performed without mounting onto a printed circuit board.

On the other hand the requirements for the whole ECU should be tested in an early stage of development to detect and correct potential weak points within the development cycle. For this test the component shall be in normal operation that means for instance supply voltage shall be applied; therefore the mounting onto a printed circuit will be done.

ESD-HBM (Electrostatic discharge – Human body model)

Contact discharge

Reference:	AEC-Q100-002 JESD22-A114
Category:	FOT
Quantity:	3 each voltage level
Additional Requirements: each tion after again	Number of pulses: 3 each voltage level (1 positive, 1 negative pulse; pin combination; if the components are within electrical specifica- the stress they can be used for the next level of stress R = 1,5 kΩ C = 100pF U = ±500V / ±1kV / ±2kV (level H1C) U = ±4kV (for information only) All pins open EMO initial and after every voltage level
Acceptance criterion: level	all devices are electrically within the specification after level H1C (this is valid as long as the technology is capable to withstand this level in general)
Explanation: of	Test to verify the resistance to human contact discharge at the assembly the device.

ESD-MM (Electrostatic discharge – Machine Model)

Contact discharge

Reference:	AEC-Q100-003 JESD22-A115
Category:	FOT
Quantity:	3 each voltage level
Additional Requirements:	3 pulses for each voltage level R = 10kΩ - 10MΩ (only for testing) C = 200pF U = ±100V / ±200V / ±400V (level M3) U = ±800V (for information only) All connector pins open EMO initial and after every voltage level
Acceptance criterion:	all devices are electrically within the specification after level M3.
Explanation:	Test to ensure electrostatic resistance to machine handling during the assembly of the device.

ESD-CDM (Electrostatic Discharge – Charged device model) *optional to ESD-MM*

Contact discharge

Reference:	AEC-Q100-011
Category:	FOT
Quantity:	3 each voltage level and pin
Additional Requirements:	3 pulses for each voltage level R = 1Ω current measurement resistor C = 4pF / 30pF U = ±250V / ±500V (level C2) U = ±1000V (for information only) All connector pins open

	EMO initial and after every voltage level
Acceptance criterion:	all devices are electrically within the specification after level C2.
Explanation	Test of ESD resistance with the field induced charged device model.

EMC (Electromagnetic compatibility)

Reference:	EN 55025; CISPR25
Category:	FOT
Quantity:	1
Additional requirements:	- grid-bound radiation: 150 kHz – 110 MHz - antenna radiation: 30MHz – 1GHz
Acceptance criterion:	emission to be in the same range as comparable existing products
Explanation:	There are no limits specified in the instruction. Actual series products are used for reference.

LU (Latch-up)

Reference:	AEC-Q100-004; JESD78
Category:	FOT
Quantity:	1 Lot / 6 Devices
Additional requirements:	applicable for NMOS, CMOS, bipolar, and all variations and combinations of these technologies. Class 2 / Level A Temperature: +85°C Operating mode: active EMO: Initial, Final
Acceptance criterion:	all devices are electrically within the specification after class 2 / level C2 testing.
Explanation:	Use of data from the wafer process possible

GL (Gate Leakage)

Reference:	AEC-Q100-006
Category:	FOT
Quantity:	1 Lot / 6 Devices
Additional requirements:	Applicable for NMOS and CMOS or similar technologies Temperature: +155°C Power supply: +20kV Operating mode: passive EMO: Initial, Final
Acceptance criterion:	all devices are electrically within the specification after testing
Explanation:	Sensitivity test of parasitic electro-thermal gate leak current. Use of data from the wafer process possible.

5.2.3. Climatic loads

TP (Thermal Pistoning)

Reference:	EN 61300-2-18 Measurement according to EN 61300-3-23
Category:	Pigtail-Fiber

Quantity:	5
Additional requirements	Temperature = T_{PAS} Humidity = 50% Duration = 24h
Acceptance criterion:	all devices are without visual damage; mechanical drift between reference surface and fiber surface <0,03mm (initial and final measurement)
Explanation	Test of the expansion behavior of fiber surface to optical reference plane in direction of fiber over the specified temperature range.

CR (Chemical Resistance)

Reference:	Opt-Auto-Cont P7.1 in addition to this ISO 16750-5
Category:	Pigtail-Fiber
Quantity:	3 Devices per chemical
Additional requirements:	plugged connection 5 min dipping or apply chemicals directly to optical interface afterwards store 48 h at 50° C spill with water and dry EMO initial, final Visual inspection
Acceptance criterion:	all devices are without visual damage in the area of optical path no additional optical attenuation
Explanation:	Test of Pigtail-Fiber surface (surface to the optical wiring harness). Requirements for anticorrosion protection at housing, mounting and interconnections for MOST components. Chemicals for testing: • Cold cleaner undiluted commercial available (chemical L according to ISO16750-5, Annex A) • Penetrating oil, e.g. "WD40" (without paraffin) • Antifreeze fluid, undiluted, commercial available (chemical H according to ISO 16750-5, Annex A) • Spirit undiluted (chemical Y according to ISO 16750-5, Annex A) Examples of commercial available products are listed in the appendix 9.1, page 72.

5.2.4. Climate and Mechanical Interference

The devices under test have to withstand the mechanical tests without any damage. Before and after the test the components have to be checked by functionality and by mechanically damages. All damages that can't prevent by construction have to be visibly at the outside.

After the finishing the tests the component has to fulfil the limits defined in the specification.

STT (Stepped Temperature Test)

Reference:	ISO 16750-4 / 5.2
Category:	FOT
Quantity:	1 Lot 5 Devices
Additional requirements:	FOT with assembled Test-Pigtail-Fiber Start at RT (room temperature) in 5-degree steps down to lowest specified temperature, then up to highest specified temperature, then back to room temperature.

	At each 5-degree temperature level a function check is required at minimal supply voltage V_{min} and at maximum supply voltage V_{max}. Operating mode: active during any step EMO: Initial, Final
Acceptance criterion:	all devices show no values outside the specification during the whole test; no increase in optical attenuation (no short time increase) the functionality of all test specimens remains within the specification after finishing the test.
Explanation:	To guarantee the function over the whole temperature range.

MS (Mechanical Shock)

Reference:	Opt-Auto-Cont P 6.2, ISO 16750-3 / 4.2.2 ,Additionally EN 60068-2-27 MOST150 FO-Transceiver Drawing	
Category:	FOT, Connector	
Quantity:	FOT: Connector:	1 Lot / 5 Devices out of Corrosive Atmosphere (CA) 1 Lot / 5 Devices
Additional requirement:	FOT:	Test with Pigtail-Fiber and assembled Tx/Rx Ferrule (Ferrules Tx/Rx according to MOST Drawing). Influences of additional fixtures (e.g. additional weight of bending protection) have to be considered.
	Connector:	Test with assembled Pigtail-Fiber and Ferrule-Housing
	Acceleration: 30g Duration: 6msec Pulse shape: half-sinusoidal Number of shocks: 50 per direction Direction: ±X, ±Y, ±Z Humidity: uncontrolled Operating mode: passive EMO: Initial, Final	
Acceptance criterion:	all devices show no values outside the specification	
Explanation:	Test of the mechanical stability of the construction (transportation)	

VS (Vibration Sinus)

Reference:	Opt-Auto-Cont / P 6.3, additionally EN60068-2-6 / EN60068-2-47, MOST150 FO-Transceiver Drawing	
Category:	FOT , Connector	
Quantity:	1 Lot / 5 Devices	
Additional requirements:	FOT:	Test with complete assembled Pigtail (FOT+Pigtail-Fiber+Connector) mounted on a PCB. Influences of additional fixtures (e.g. additional weight of bending protection) have to be considered. Pigtail-Fiber with Tx/Rx Ferrule (Ferrules Tx/Rx according to MOST Drawing). Scope: mechanical Interface between FOT and Pigtail-Fiber
	Connector:	Test with complete assembled Pigtail (FOT+Pigtail-Fiber+Connector) mounted on a PCB. Influences of additional fixtures (e.g. additional weight of bending protection) have to be considered. Scope: mechanical Interface between Connector and Ferrule-Housing

Device mounted onto printed circuit board
Length of Pigtail-Fiber: 160mm

Severity:
Frequency: f = 15 bis 28,6Hz, Amplitude s = 1,52mm
Frequency: f = 28,6 bis 500Hz, acceleration a = 5g
Duration: at 25°C 24h each direction
at T_U 20h Z-direction {2}
at T_{PAS} 20h Z-direction {2}
Humidity: uncontrolled
Operating mode: passive
EMO: Initial, Final

Acceptance criterion: all devices show no values outside the specification

Explanation: Test of the mechanical stability of the coupling fiber to the FOT.
{2} Z-direction: Perpendicular to printed circuit board plane

VR (Vibration Random)

Reference: EN 60068-2-64, MOST150 FO-Transceiver Drawing

Category: FOT, Connector

Quantity: 1 Lot / 5 Devices

Additional requirements:

FOT: Test with complete assembled Pigtail (FOT+Pigtail-Fiber+Connector) mounted on a PCB. Influences of additional fixtures (e.g. additional weight of bending protection) have to be considered.
Pigtail-Fiber with Tx/Rx Ferrule (Ferrules Tx/Rx according to MOST Drawing).
Scope: mechanical Interface between FOT and Pigtail-Fiber

Connector: Test with complete assembled Pigtail (FOT+Pigtail-Fiber+Connector) mounted on a PCB. Influences of additional fixtures (e.g. additional weight of bending protection) have to be considered.
Scope: mechanical Interface between Connector and Ferrule-Housing

Device mounted onto printed circuit board
Length of Pigtail-Fiber: 160mm

Freq f [Hz]	power density [(m/s²)²/Hz]
10	10,0
50	10,0
66,7	1,0
100	1,0
1000	0,1

effective value of acceleration: 26,9 m/s2 (changed values from GS95006-7)

Duration:
at 25°C 8h each direction
at TU 8h Z-direction {2}
at TACT 8h Z-direction {2}

Humidity: uncontrolled
Operating mode: active
EMO: Initial, Final

Acceptance criterion: all devices show no values outside the specification.

Explanation: Test of spontaneous, vibration caused failures in operation mode.
{2} Z-direction: Perpendicular to printed circuit board plane

5.2.5. Manufacturing

MLD (Moisture Level Definition)

Reference:	JEDEC STD-20
Category:	FOT
Quantity:	2 Lots / 11 Devices (per each test level)
Additional requirement:	Preconditioning: Bake (T_{PAS}, 24h) Moistening: Time and Humidity according to level definition (JEDEC STD-20 Tab. 5-1) Solder Simulation: 2 runs using solder bath test specimen mounted on printed circuit, without any copper layer temperature: maximum specified temperature according to data sheet (measured according to definition in data sheet. Duration: 5s
Acceptance criterion:	all devices show no values outside the specification
Explanation: the	If the device is specified for lead free soldering, it has to be compliant to effective regulations.

SD (Solderability)

Reference:	EN 60068-2-58 / test according to chapter 8.1.2.1
Category:	FOT
Quantity:	1 Lot / 15 Devices
Additional requirement:	The device has to be specified for lead free soldering class 3. Preconditioning: 4h steam ageing
Acceptance criterion:	faultless wetting
Explanation:	Test of workability if standard soldering technique is used.
Remark:	The solder material shall be specified in the data sheet which fulfils the specification. Lead free soldering shall be mentioned in the data sheet.

PFR (Plugging Frequency)

Reference:	EN 61300-2-2
Category:	Connector
Quantity:	1 Lot / 10 Devices
Additional requirement:	Connector with assembled Pigtail-Fiber (SP2/SP3) Test with wiring harness connector-plug Process: automatic Speed: 25mm/min Counts: 100 Operating mode: passive existing locking mechanism shall be used EMO: Initial, Final force-path-diagram for first and last cycle
Acceptance criterion:	no damage; no increase of optical attenuation
Explanation:	Test of the multiple plugging behavior.

AP (Angular Plugging)

Reference:	Opt-Auto-Cont / P 4.1
Category:	Connector
Quantity:	1 Lot / 5 Devices
Additonal requirement:	Connector with assembled Pigtail-Fiber (SP2/SP3) Test with wiring harness connector-plug Process: manual Operating mode: passive EMO: Initial, Final
Acceptance criterion:	no damage; no increase of optical attenuation
Explanation:	Proof of the possibility to damage the connector by angular plugging during connecting or disconnecting
Remark:	the maximum angle with no damage shall be mentioned in the data sheet

RSH (Resistant to soldering heat – Reflow soldering technique)

Reference:	EN 60068-2-58 / test according to chapter 8.1.2.2 J-STD-20
Category:	FOT
Quantity:	1 Lot / 22 Devices
Additional requirement:	Temperature profile according to J-STD-20 EMO: Initial, Final
Acceptance criterion:	no damage; no increase of optical attenuation
Explanation:	Proof of the damage of components caused by the soldering process (maximum temperature / time stress). The device has to be specified for lead free soldering, it has to be compliant to the effective regulations.

BP (Bond Pull Strength)

Reference:	EN 60749 / 6.2 Meth. B MIL-STD-883 Meth 2011 Conditon C or D
Category:	FOT
Quantity:	1 Lot / 5 Devices (minimum) / 30 bond wires (minimum)
Acceptance criterion:	no values below the specified limit
Explanation:	Proof of the bonding process (Use of Data from the production)

BS (Bond Shear Strength)

Reference:	AEC-Q100-001 EN 60749 / 6.6
Category:	FOT
Quantity:	1 Lot / 5 Devices / 30 bonds
Acceptance criterion:	no values below the specified limit
Explanation:	Proof of the bonding process (Use of Data from the production)

5.2.6. Mechanical loads

The devices under test have to withstand the mechanical tests without damage. Before and after the test the components have to be checked by functionality and by mechanically damages. All damages that can't prevent by construction have to be visibly at the outside.

After finishing the non-destructive tests the components have to fulfil the limits defined in the specification. The limits of regarding specification shall be fulfilled if the destructive tests are defined.

For connectors with electrical connections additionally to this specification the requirements from the working group of connectors (Guide-Con) or comparable other customer specifications are valid.

D (Dust)

Reference:	EN 61300-2-27
Category:	FOT, Connector
Quantity:	1 Lot / 10 Devices
Additional requirement:	FOT: FOT assembled with Pigtail-Fiber Rx/Tx Connector: Connector assembled with Pigtail-Fiber in Ferrule-Housing. Wiring harness plug connected Duration: 5sec dust flow, 20min. storage Count: 15 cycles Material: Arizona-dust EMO: Initial, Final Visual inspection
Acceptance criterion:	no damage; no increase of optical attenuation; penetration of dust into the connector is allowed
Explanation:	Proof of sensitivity against dust

WP (Wire Pulling)

Reference:	EN 61300-2-4
Category:	Pigtail-Fiber
Quantity:	1 Lot / 5 Devices
Additional requirements:	Process: automatically Force: 30N Temperature: +25°C Duration: 30sec EMO: Initial, Final
Acceptance criterion:	no damage; no increase of optical attenuation
Explanation:	Non-destructive test of the assembled Pigtail-Fiber with a defined force; The fixture of the test setup has to be attached to clamp the Ferrules

DOSF (Draw-Out Strength Ferrules)

Reference:	EN 61300-2-4
Category:	Pigtail-Fiber
Quantity:	1 Lot / 10 Devices (each Ferrule)
Additional requirement:	Process: automatic Speed: 25mm/min Operating mode: passive

	Force-Path-Diagram
Acceptance criterion:	retention force > 30N
Explanation:	Destructive test to proof the assembly of the Ferrule to the Pigtail-Fiber. One side of the fixture of the test setup has to be attached to clamp the Ferrule, the other side has to be attached to the Fiber. Definition of the maximum force.

DSC (Draw Out Strength Connector)

Reference	Opt-Auto-Con
Category	Connector
Quantity	1 Lot / 5 Devices
Additional requirement	Connector with assembled Pigtail-Fiber Test with wiring harness connector-plug Temperature: RT Process: automatic Speed: 25mm/min Operating mode: passive Force-Path-Diagram
Acceptance criterion	retention force > 60N
Explanation	Proof of the draw-out strength of the connector with locking mechanism. The locking mechanism has to withstand at least a force of 60 N.

DSFH (Draw Out Strength Ferrule-Housing)

Reference:	Opt-Auto-Con
Category:	Connector
Quantity:	1 Lot / 5 Devices
Additional requirement:	Connector with assembled Pigtail-Fiber in Ferrule-Housing Temperature: RT Process: automatic Speed: 25mm/min Operating mode: passive Force-Path-Diagram
Acceptance criterion:	retention force > 60N
Explanation:	Proof of the draw-out strength of the Ferrule-Housing from the connector. The mechanism has to withstand at least a force of 60 N.

PIFF (Press-in Force Ferrule)

Reference	EN61300-3-11, MOST150 FO-Transceiver Drawing
Category	FOT
Quantity	1 Lot / 5 devices each (Rx/Tx) + 3 devices out of HTOL (after 3000h) + 3 devices out of TC/TS (1000cyc)
Additional requirement	Pigtail-Fiber with Tx_{min}, Tx_{max}, Rx_{min} and Rx_{max} Ferrule (according to MOST150 FO-Transceiver Drawing) Ferrules Material: Brass and Plastic (conform to series application) Temperature: RT Process: automatic Speed: 25mm/min Repeat: 5x Operating mode: passive

	Force-Path-Diagram
Acceptance criterion	press-in force min: 2N; max: 6N
Explanation	Proof of the press-in force of the mechanical interface (spring/lock mechanism) of the FOT with Ferrules Tx/Rx.

POFF (Pull-out Force Ferrule)

Reference	EN61300-3-11, MOST150 FO-Transceiver Drawing
Category	FOT
Quantity	1 Lot / 5 devices each (Rx/Tx) + 3 devices out of HTOL (after 3000h) + 3 devices out of TC/TS (1000cyc)
Additional requirement:	Pigtail-Fiber with Tx_{min}, Tx_{max}, Rx_{min} and Rx_{max} Ferrule (according to MOST150 FO-Transceiver Drawing) Ferrules Material: Brass and Plastic (conform to series application) Temperature: RT Process: automatic Speed: 25mm/min Repeat: 5x Operating mode: passive Force-Path-Diagram
Acceptance criterion	pull-out force min: 5N; max: 15N
Explanation	Proof of the pull-out force of the mechanical interface (spring/lock mechanism) of the FOT with Tx/Rx-Ferrule

DT (Drop Test)

Reference:	EN 60068-2-32 Opt-Auto-Con P 6.4
Category:	FOT
Quantity:	1 Lot / 5 Devices
Additional requirement:	Drop height: 1200mm Number of drops: 1 per direction Direction: ±X, ±Y, ±Z Operating mode: passive EMO: Initial, Final
Acceptance criterion:	no damage; no increase of optical attenuation. All damages that can't prevent by construction have to be visibly at the outside.
Explanation:	Resistance of the component against drops during transport or assembly.

5.2.7. Operating Life

The sample size for operating life test is defined according to the quantity of AEC Q-100.

In all operating life tests two different levels are defined:

- Required: up to this duration there are no failures allowed; that means all measurement shall be within the specification limits
- For information only: during this time there may be some failures or violation of the specification. This time is to demonstrate the robustness of the product.

The additional data at end of life (data "for information only") for the required time and quantities shall be available at least half year after release of final report of recommendation for release.

PRE (Preconditioning)

Reference:	JEDEC-STD-20
Category:	FOT
Quantity:	Applicable for THB, TS/TC
Additional requirement:	Preconditioning Bake (T_{PAS}, 24h) Moistening: Time and Humidity according to defined moisture level (MSL) JEDEC STD-20b Tab: 5-1) Solder Simulation: 1 run through solder bath test specimen mounted on printed circuit board without copper layer Temperature: maximum allowed temperature (measurement according to data sheet) Duration: 5s
Acceptance criterion:	no damage; no increase of optical attenuation
Explanation:	Preconditioning is performed for all devices of the operating life test in advance: Optional a comparable treatment could be agreed with the ASTH. If the device is specified for lead free soldering, it has to be compliant to the effective regulations.
Remark:	In the data sheet it shall be mentioned whether the product can be assembled in a lead free soldering process

CA (Corrosive Atmosphere)

Reference:	EN 60068-2-60 / Meth 4
Category:	FOT, Pigtail-Fiber
Quantity:	1 Lot / 10 Devices
Additional requirement:	no preconditioning of the products Temperature: +25°C Humidity: 75% Flow rate: 1m³/h Gases: SO_2 0,20ppm H_2S 0,01ppm NO_2 0,20ppm Cl_2 0,01ppm Duration: 14 days EMO: Initial, Final
Acceptance criterion:	no damage or corrosion; no increase of optical attenuation
Explanation:	Proof of influence on the optical path caused by corrosive atmosphere. Generic approach or fulfilled tests on material level are allowed.

THB (Temperature humidity bias)

Reference:	EN 60068-2-67
Category:	FOT, Pigtail-Fiber
Quantity:	3 Lots / 77 Devices (FOT) 1 Lot / 26 Devices (Pigtail-Fiber)
Additional requirement:	Temperature: +85°C Humidity: 85% Duration FOT: 1000h required 3000h for information only Duration Pigtail-Fiber: 500h required 1500h for information only Operating mode: FOT (active), Pigtail-Fiber (passive) EMO and visual check:

	Initial, 300h, 500h (each 500h)
Acceptance criterion:	no damage; no suspicious behaviour
Explanation:	Proof of humidity has an influence on function

HTOL (High temperature operating life test)

Reference:	EN 60068-2-2
Category:	FOT
Quantity:	3 Lots / 77 Devices
Additional requirement:	Temperature: T_{ACT} Duration FOT: 3000h required 5000h for information only Operating mode: active EMO and external visual: Initial, 300h, 500h (each 500h)
Acceptance criterion:	no damage; no suspicious behavior
Explanation:	Influence of permanent high temperature on function, drift of semiconductor parameter.

LTOL (Low temperature operating life test)

Reference:	EN 60068-2-1
Category:	FOT
Quantity:	3 Lots / 77 Devices
Additional requirement:	Temperature: T_U Duration: 1000h required EMO and external visual: Initial, 300h, 500h, 1000h
Acceptance criterion:	no damage; no suspicious behavior
Explanation:	Influence of permanent low temperature on function, embrittlement of the housing even if product is not in operation

TC (Temperature Cycling)

Active (FOT only):

Reference:	EN 60068-2-14
Category:	FOT
Quantity:	3 Lots / 77 Devices (FOT)
Additional requirement:	Temperature min.: TU Temperature max.: TACT Temperature change of chamber: < 10K/min Soak time: minimum 15 min. Humidity: uncontrolled Cycles: 1000 required 2000 for information only Cycles Operating mode: active, stand by (intermittent); see Figure 20 EMO and external visual: Initial, 200, 500 (each 500) cycles

Acceptance criterion:	no damage; no suspicious behavior
Explanation:	Influence of temperature cycling on the device (behavior of housing compounds)
Remark:	The products shall really reach the defined minimum and maxi-mum temperature.

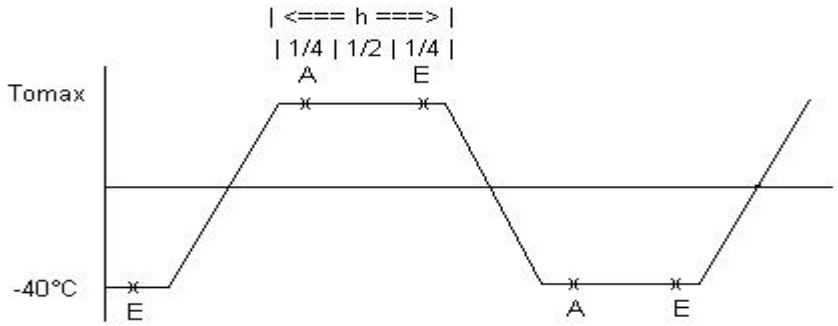

Figure 21:Temperature and switching profile:

Passive (FOT: optional to active):

Reference:	EN 60068-2-14	
Category:	FOT, Pigtail-Fiber, Connector	
Quantity:	3 Lots / 77 Devices (FOT) 1 Lot / 26 Devices (Pigtail-Fiber, Connector)	
Additional requirement:	FOT:	Scope: housing compounds
	Pigtail-Fiber:	Scope: mechanical Interface between Ferrules and Fiber
	Connector:	Test with assembled connector: (Pigtail-Fiber+Ferrule-Housing+Connector) Scope: mechanical Interface between Connector and Ferrule-Housing, Housing compounds

Temperature min.: T_U
Temperature max.: T_{PAS}
Temperature change in the chamber: <10K/min
Soak time: 15 min.
Humidity: uncontrolled

Cycles FOT:	1000	required
	2000	for information only
Cycles Pigtail-Fiber/Connector:	500	required
	1000	for information only

Operating mode: passive

EMO and external visual:
FOT: Initial, 300, 500 (each 500) cycles
Pigtail-Fiber/Connector: Initial, 500, (1000) cycles

Acceptance criterion:	no damage; no suspicious behaviour
Explanation:	Influence of temperature cycling on the device (behaviour of housing compounds).

TS (Temperature shock) *optional to TC*

Reference:	EN 60068-2-14
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	3 Lots / 77 Devices (FOT) 1 Lot / 26 Devices (Pigtail-Fiber, Connector)

Additional requirement:	FOT:	Scope: FOT-housing
	Pigtail-Fiber:	Scope: mechanical Interface between Ferrules and Fiber
	Connector:	Test with assembled connector: (Pigtai-Fiber+Ferrule-Housing+Connector) Scope: mechanical Interface between Connector and Ferrule-Housing, Housing compounds

Air to Air chamber
Temperature min.: T_U
Temperature max.: T_{PAS}
Transfer time from one chamber to the other: <10sec
Soak time: minimum 15 min.
Humidity: uncontrolled

Cycles FOT:	500	required
	1000	for information only
Cycles Pigtail-Fiber/Connector:	250	required
	500	for information only

Operating mode: passive

EMO and external visual:
FOT: Initial, 200, 300, 500 (1000) cycles
Pigtail-Fiber/Connector: Initial, 250 (500) cycles

Acceptance criterion: no damage; no suspicious behavior

Explanation: This test is used as an accelerated proof for the resistance to temperature changes and is applicable for time-critical projects (has to be agreed with the ASTH)

Remark: Used chamber is normally an elevator

HTC (Temperature humidity cycling)

Reference: EN 60068-2-38

Category: FOT, Pigtail-Fiber

Quantity: 1 Lot / 26 Devices

Additional requirement: FOT assembled with Test Pigtail-Fiber
Temperature min.: -10°C
Temperature max.: +65°C
Humidity: 95%±2%
Duration: 24h each cycle

Cycles:	50	required
	100	for information only

Operating mode: active
EMO and external visual:
Initial, 25, 50, 100 cycles

Acceptance criterion: no damage; no suspicious behavior

Explanation: Proof of the behavior in humid conditions at the transition to low temperatures

5.2.8. Destructive analysis

DPA (Destructive Physical Analysis)

Reference: MIL-STD 883 Meth 2013

Category: FOT, Pigtail-Fiber, Connector

Quantity: only failure devices

Explanation: In case of failure: opening the device; examinations of root cause.

CS (Cross Section)

Reference:	MIL-STD-883 Meth 2018
Category:	FOT, Pigtail-Fiber, Connector
Quantity:	only failure devices
Explanation:	Critical parts of the device shall be examined in case of failure.

LRP (Reference parts after operating life test for ASTH)

Category:	FOT, Pigtail-Fiber, Connector
Quantity:	For each life test 2 devices
Acceptance criterion:	no change during tests, also for whole life time shall have no degradation for functionality
Explanation:	After completion of testing, samples from all branches shall be sent to the ASTH.

5.2.9. Appraisal of Results

EMO (Electrical, mechanical and optical measurement)

Category: FOT, Pigtail-Fiber, Connector

Quantity: All

Additional requirements:

Parameter FOT:

TX:

- Optical output power P_{opt2} in operating mode
- Timing Parameter e.g. jitter or pulse width distortion out of Eye-Mask measurement (numerical)
- Current consumption Icc in operating mode

RX:

- Timing parameter at low limit of sensitivity, e.g. jitter or pulse width distortion out of Eye-Mask measurement (numerical)
- Current consumption Icc in operating mode

Parameter Pigtail-Fiber:

TX-Fiber:

- Optical attenuation of TX-Fiber

RX-Fiber:

- Optical attenuation of RX-Fiber

Parameter Connector:

- Connector Key-Dimensions

Acceptance Criteria: The following maximum changes in performance are acceptable (compare son initial versus final measurement)

Optical output power/Sensitivity:	±0,5dB (±1,0dB for life time tests)
Optical attenuation of Fiber	±0,5dB (±1,0dB for life time tests)
Timing parameter:	±10%
Current consumption active:	±10%

Mechanical dimensions have to be within the MOST Specification and meet the capability requirements.

	Mechanical damage that could ultimately result in an operational failure is also not acceptable.
Explanation:	Documentation of samples after the test procedure, electrical, mechanical and optical measurements for judgment of specimen and drift during test (if applicable)
Remark:	The measurement accuracy / reproducibility is to be checked before starting the characterization or qualification measurements and shall be part of the delivery to the ASTH. For all cases where the criteria is "no additional attenuation allowed" the measurement is to be taken into account.

CHL (Characterization after operating life)

Category:	FOT, Pigtail-Fiber
Quantity:	FOT: THB, TC, HTOL, each 10 Pigtail-Fiber: THB, TC, each 5
Parameter:	according to chapter 4, page 22 Characterization
Acceptance criterion:	no damage; no suspicious change between original characterization and characterization after life time tests
Explanation:	Characterization of operating life samples according to chapter 3 characterization. A deviant procedure has to be discussed with the ASTH.

REP (Report)

Category:	FOT, Pigtail-Fiber, Connector
Quantity:	All
Explanation:	Documentation of test specimen, used equipment, electrical, mechanical and optical measurements, for evaluation of capability of specimen and drift during tests.

6. Ramp-Up

6.1. Limits and sensible parameters

The limits for end of line testing in mass production shall be calculated on the basis of characterization data.

If there are any sensitive parameters detected during the qualification procedure additional tests are necessary to ensure reproducible quality and reliability from ramp up of mass production.

6.2. Early life failure rate (ELFR)

This chapter is only valid for FOT.

Besides the FOT-Qualification in chapter 5.2, Early Life Failure-Rate Test (ELFR) with 3 different lots each 800 samples has to be performed according to AEC-Q100-8 within the scope of the series qualification. (Operation mode active 48h at T_{ACT}).

The used samples are able to be processed after the test.

The results of the ELFR-Test have to be available at least 3 month after the start of the FOT production.

6.3. Concept for monitoring

Monitoring is defined here as periodic tests of functional parameters and reliability data. The concept which shall be established has the goal to proof the performance. This performance was defined during qualification testing. With this procedure a reproducible quality and reliability shall be proven and therefore guaranteed.

The monitoring concept shall be established for the whole production time and shall be available at least before starting the ramp up. In this concept the know-how from development, qualification, characterization and the production experience shall be used.

In this concept also the handling of retained samples shall be defined.

7.Volume production

The requirements from general qualification systems (e.g. TS16949 or ISO9000) shall be basis of production system. This is also valid for the control production processes done with SPC methods and the establishing of the monitoring concept.

7.1. Functional test

The supplier is engaged to develop a functional test procedure (standard tests of the supplier production), that is state of the art with the maximum test depth for the component. The functional test procedure has to be optimized during the development process, so that it is possible to eliminate all additional tests for consistency.

The functional test procedure has to be discussed with the car manufacturer and with the producing factory.

All gaps in the functional test procedures have to be pointed out.

7.2. Electrical system test of production and service

The complexity and the test depth (test equipment etc.) will be defined by the developer in co-operation with the car manufacturer.

7.3. Emergency plan

In case of interruption of power supply, lack of working resources, defect of important production tools or field returns there shall be emergency plans to satisfy the requirements of the customer in terms of delivery times and quantities.

7.4. Change of production facility

All changes regarding processes, semi-finished or production locations are to be announced within the supply chain.

Especially any change for the FOT as well as in front-end and back end (assembly) has to be done according to the regulations of AEC-Q100.

8. Additional information

8.1. Abbreviations and Definitions

Abbreviation	Explanation
AAR	**A**utomotive **A**pplication **R**ecommendation
active	Working mode: supply voltage on; Tx emitting modulated light
ASTH	**A**utomotive A**s**sessmen**t** **H**ouse (independent company which investigates the technical performance of the product with the mandate of car manufacturer)
CON	**Con**nector
CPM	**C**ritical **P**arts **M**anagement
D-Sample	D-Samples are manufactured with mass production tools under mass production conditions. Products manufactured under these conditions have full functionality and can be fully judged. All requirements for quality and reliability are given reproducible. For D-samples the only missing point is the EMPB for being mass production part.
EMPB	First sample measurement report
EMV / EMC	**E**lectro**m**agnetic **C**ompatibility
EOC	**E**lectric **O**ptical **C**onverter
ESD	**E**lectro **S**tatic **D**ischarge
ET	Spare Part
EZ	Assembly area in the car
FF	**F**emale **F**errule
FH	**F**errule **H**ousing
FRX	**F**errule **R**x
FTX	**F**errule **T**x
FMEA	**F**ailure **M**ode **a**nd **E**rror **A**nalysis
FOT	**F**iber **o**ptical **T**ransceiver
FTA	**F**ailure **T**ree **A**nalysis
Release Department of OEM	Department or responsible Person at the car manufacturer
Manufacturer	Supplier of investigated product in total responsible for the product
HT	**H**igh **T**emperature – normally maximum operating temperature
IP	**I**nternational **P**rotection
ISO	**I**nternational **O**rganization for **S**tandardization
I_{Work}	Current Consumption – Working
I_{Sleep}	Current Consumption – sleep or stand by mode
Customer	User of the product either TIER1 or OEM
LSL	**L**ower **S**pecification **L**imit according to data sheet of manufacturer
MOST	**M**edia **O**riented **S**ystems **T**ransport
NIC	**N**etwork **I**nterface **C**ontroller

Abbreviation	Explanation
OEC	**O**ptical **E**lectric **C**onverter
OEM	**O**riginal **E**quipment **M**anufacturer – here Car manufacturer
n.a.	**N**ot **a**pplicable
PAT	**P**art **A**verage **T**est
PF	**P**igtail-**F**iber
rH	**r**elative **H**umidity
RT	**R**oom **T**emperature (23°C ± 5°C)
Rx	**R**eceiver
SAE	**S**ociety of **A**utomotive **E**ngineers
SMT	**S**urface **M**ount **T**echnology
SOP	**S**tart **o**f **P**roduction
T_{ACT}	Upper testing **t**emperature when FOT is **act**ive
T_{AMB}	**T**emperature – **Amb**ient Environmental temperature of ECU within the mounting location in the car
TIER1	Producer of unit and direct supplier to the OEM
T_{omax}	maximum operating temperature
T_{omin}	minimum operating Temperature
T_{PAS}	Upper testing **t**emperature when FOT is **pas**sive
Transceiver	Word coming from combining **Trans**mitter and Re**ceiver**
T_{smax}	maximum storage temperature
T_{smin}	minimum storage temperature
TT	Low Temperature (during testing)
T_u	minimum operating temperature
Tx	Transmitter
USL	**U**pper **S**pecification **L**imit according to data sheet of manufacturer
V_{min}, V_{typ}, V_{max}	Minimal, typical and maximal supply **V**oltage of Component

Document	Title of Document	Source
	Checklist for MOST Physical Layer Design	www.mostcooperation.com
	MOST Physical Layer Basic Specification	www.mostcooperation.com
	MOST150 oPHY Automotive Physical Layer - Sub-Specification -	www.mostcooperation.com
	MOST Specification of Physical Layer (MOST25)	www.mostcooperation.com
	MOST Compliance Test Of Physical Layer	www.mostcooperation.com
Opt-Auto-Cont	Wiring Harnesses in Motor Vehicles - Fiber optics Optical vehicles contacting BMW: GS95006-6-3	www.mostcooperation.com
Guide-Con	Wiring harnesses in motor vehicles - Plug connectors BMW: GS95006-7-1 Audi: VW75174	www.mostcooperation.com

Document	Title of Document	Source
LWL-Bulk	Fiber optics in motor vehicles; Test guideline for LWL bulk stock BMW: GS95006-6-2	
AEC Q100	Stress test qualification for integrated circuits	www.aecouncil.com
AEC Q101	Stress test qualification for automotive grade discrete semiconductors	www.aecouncil.com
TS16949	Special requirements using ISO 9001:2000 for mass production and spare parts manufacturing in automotive market	
ISO 16750-1	Road vehicles – Environmental conditions and testing for electrical and electronics equipment; Part 1 – General	
ISO 16750-4	Road vehicles – Environmental conditions and testing for electrical and electronics equipment; Part 4 – Climatic loads	
ISO 16750-5	Road vehicles – Environmental conditions and testing for electrical and electronics equipment; Part 5 – Chemical loads	
EN 55025 / CISPR25	Radio disturbance characteristics for the protection of receivers used on board vehicles, boats and on devices – Limits and methods of measurement	
EN 60068-2-1	Cold Environmental Testing; Part 2: Tests; Tests A: Cold	
EN 60068-2-2	Environmental Testing; Part 2: Tests; Tests B: Dry heat	
EN 60068-2-6	Environmental Testing; Part 2-6: Tests; Test FC: Vibration (sinusoidal)	
EN 60068-2-14	Environmental Testing; Part 2-14: Tests; Test N: Change of temperature	
EN 60068-2-20	Basic environmental testing procedures; Part 2-20: Tests; Test T: Test methods for solderability and resistance to soldering heat of leaded devices	
EN 60068-2-27	Basic environmental testing procedures; Part 2-27: Tests; Test EA and guidance: Shock	
EN 60068-2-32	Basic environmental testing procedures – Part 2-32: Tests – Test ED: Free fall	
EN 60068-2-38	Basic environmental testing procedures – Part 2-38: Tests – Test Z/AD: Composite temperature/humidity cyclic test	
EN 60068-2-60	Basic environmental testing procedures – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test	
EN 60068-2-64	Basic environmental testing procedures – Part 2-64: Tests – Test Fh: Vibration, broad-band random (digital control) and guidance	
EN 60068-2-67	Environmental testing - Part 2: Tests; test Cy: Damp heat, steady state, accelerated test primarily intended for components	
EN 60749	Semiconductor devices - Mechanical and climatic test methods	

Document	Title of Document	Source
EN 61300-2-2	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-2: Tests – Mating durability	
EN 61300-2-4	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fiber / cable retention	
EN 61300-2-6	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-6: Tests – Tensile strength of coupling mechanism	
EN 61300-2-18	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-27: Tests – Dry heat – High temperature endurance	
EN 61300-2-20	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-27: Tests – Dry heat – High temperature endurance	
EN 61300-2-23	Fiber Optic Interconnecting Devices and Passive Components. Basis Test and Measurement Procedures. Part 2-23: Tests. Sealing For Non-Pressurized Closures of Fiber Optic Devices.	
EN 61300-2-27	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-27: Tests – Dust – Laminar flow	
EN 61300-3-1	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-1: Examinations and measurements - Visual examination	
EN 61300-3-23	Fiber optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-23: Examination and measurements – Fiber position relative to ferrule end face	
DIN 40050- 9	Road vehicles; Degrees of protection (IP-code); Protection against foreign objects, water and contact; Electrical equipment	
JEDEC STD-20	Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices	http://www.jedec.com/
JESD22-A114	Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)	http://www.jedec.com/
JESD22-A115	Electrostatic Discharge (ESD) Sensitivity Testing Machine Model (MM)	http://www.jedec.com/
JESD22-B100	Physical Dimensions	http://www.jedec.com/
JESD22-B105	Lead Integrity	http://www.jedec.com/
JESD22-B106	Thermal Shock	http://www.jedec.com/
JESD78	IC Latch-Up Test	http://www.jedec.com/
IEC 60825-1	Safety of laser products – Part 1: Equipment classification, requirements and user's guide	
IEC 60825-2	Safety of laser products – Part 2: Safety of optical Fiber communication systems (OFCS)	
MIL-STD 883	Test Method Standard – Microcircuits	

Document	Title of Document	Source
TIA/EIA-644-A-2001)	Electrical Characteristics of Low-Voltage Differential Signaling (LVDS) Interface Circuits	

9. Appendix

9.1. Commercial products for the chemical resistance test

	Manufacturer	Type
Creeping Oil	WD-40 Company California USA	WD-40
	Caramba GmbH	Super Caramba
Anti-Freeze	Drive Joy	V9350-0502
	BASF	Glysantin G03
Cold Cleaner	Chemische Werke Kluthe	Haku 1025/400
	Allied Electronics	Degreaser 827B

9.2. Index

9.2.1. Qualification tests

Abbr.	Category	Description	page
EMC	Short Term Tests	Electromagnetic compatibility	35
EMO	Preparation	Electrical, mechanical and optical measurement	48
ESD-CDM	Short Term Tests	Electrostatic Discharge – Charged device model	34
ESD-HBM	Short Term Tests	Electrostatic discharge – Human body model	34
ESD-MM	Short Term Tests	Electrostatic discharge – Machine Model	34
EV	Preparation	External Visual	33
GL	Short Term Tests	Gate Leakage	35
HTC	Life Time Tests	Temperature humidity cycling	47
HTOL	Life Time Tests	High temperature operating life test	45
LRP	Life Time Tests	Reference parts after operating life test for ASTH	48
LTOL	Life Time Tests	Low temperature operating life test	45
LU	Short Term Tests	Latch-up	35
MLD	Short Term Tests	Moisture Level Definition	39
MS	Short Term Tests	Mechanical Shock	37
PD	Short Term Tests	Physical Dimensions	33
PFR	Short Term Tests	Plugging Frequency	39
PIFF	Short Term Tests	Press-in Force Ferrule	42
POFF	Short Term Tests	Pull-out Force Ferrule	43
PRE	Life Time Tests	Preconditioning	44
REF	Short Term Tests	Reference parts	33
REP	-.-	Report	49
RR	Short Term Tests	Reference parts for ASTH	33
RSH	Short Term Tests	Resistant to soldering heat – Reflow soldering technique	40
S	Preparation	Serialization	32
SD	Short Term Tests	Solderability	39
STT	Short Term Tests	Stepped Temperature Test	36
TC	Life Time Tests	Temperature Cycling	45
THB	Life Time Tests	Temperature humidity bias	44

Abbr.	Category	Description	page
TP	Short Term Tests	Thermal Pistoning	35
TS	Life Time Tests	Temperature shock	46
VR	Short Term Tests	Vibration Random	38
VS	Short Term Tests	Vibration Sinus	37
WP	Short Term Tests	Wire Pulling	41

9.2.2. Figures