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△

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Table of Contents

1 Scope of Document 6

2 Conventions to be used 7

3 Acronyms, Abbreviations and Definitions 8
- 3.1 Acronyms and abbreviations . . . 8
- 3.2 Definitions . . . 8
  - 3.2.1 Clock . . . 8
  - 3.2.2 Global Time Master . . . 8
  - 3.2.3 Time Base . . . 8
  - 3.2.4 Synchronized Time Base . . . 9
  - 3.2.5 Offset Time Base . . . 10
  - 3.2.6 Time Base Provider . . . 10
  - 3.2.7 Time Communication Port . . . 10
  - 3.2.8 Time Domain . . . 10
  - 3.2.9 Time Gateway . . . 11
  - 3.2.10 Time Hierarchy . . . 11
  - 3.2.11 Time Master . . . 12
  - 3.2.12 Time Slave . . . 12
  - 3.2.13 Time Sub-domain . . . 12
  - 3.2.14 Timesync ECU . . . 12
  - 3.2.15 TSP Module / Timesync Module . . . 12
  - 3.2.16 Virtual Local Time . . . 12
  - 3.2.17 Time Correction . . . 13
  - 3.2.18 Rate Correction . . . 15
  - 3.2.19 Offset Correction . . . 15
  - 3.2.20 Jump Correction . . . 15
  - 3.2.21 Rate Adaption . . . 15

4 Use Cases 16

5 Requirements Specification 17
- 5.1 Functional Overview . . . 17
- 5.2 Functional Requirements . . . 17
  - 5.2.1 Common Requirements . . . 17
  - 5.2.2 Time Synchronization over Ethernet . . . 29
  - 5.2.3 Time Synchronization over CAN . . . 34
  - 5.2.4 Time Synchronization over FlexRay . . . 37
- 5.3 Non-Functional Requirements (Qualities) . . . 40

6 References 41

A Change History 42
A.1 Change History of this document according to AUTOSAR Release R24-11 42
A.1.1 Added Requirements in R24-11 42
A.1.2 Changed Requirements in R24-11 42
A.1.3 Deleted Requirements in R24-11 42
A.2 Change History of this document according to AUTOSAR Release R25-11 43
A.2.1 Added Requirements in R25-11 43
A.2.2 Changed Requirements in R25-11 43
A.2.3 Deleted Requirements in R25-11 46
A.3 Change History of this document according to AUTOSAR Release R26-11 46
A.3.1 Added Requirements in R26-11 46
A.3.2 Changed Requirements in R26-11 46
A.3.3 Deleted Requirements in R26-11 47

1 Scope of Document

The purpose of this document is to define the functional and non-functional requirements of the Time Synchronization Protocol.

2 Conventions to be used

The representation of requirements in AUTOSAR documents follows the table specified in [TPS_STDT_00078], see [1, Standardization Template].

The verbal forms for the expression of obligation specified in [TPS_STDT_00053] shall be used to indicate requirements, see [1, Standardization Template].

In scope of this document the IDs in the range of RS_TS_00xxx are used for common requirements (refer to section Common Requirements) and the IDs in the range of RS_TS_20xxx are used for bus specific requirements (refer to sections Time Synchronization over Ethernet, Time Synchronization over CAN, Time Synchronization over FlexRay).

3 Acronyms, Abbreviations and Definitions

3.1 Acronyms and abbreviations

The glossary below includes acronyms and abbreviations relevant to Time Synchronization that are not included in the AUTOSAR Glossary [2].

Abbreviation / Acronym:	Description:
CRC	Cyclic Redundancy Checksum
FV	Freshness Value
FVM	Freshness Value Manager
Pdelay	Propagation / path delay as given in IEEE 802.1AS
Pdelay_Req	Propagation / path delay request message
Pdelay_Resp	Propagation / path delay response message
Pdelay_Resp_Follow_Up	Propagation / path delay Follow-Up message
Timesync	Time Synchronization
Sync	Time synchronization message (Sync)
TS	Time Syncronisation
TSP	Time Synchronization Provider

Table 3.1: Acronyms and Abbreviations

3.2 Definitions

3.2.1 Clock

Definition: A Clock refers to the unit conformed by the combination of a Time Base (either synchronized against an external source or not) and a hardware capable of changing cyclically the electric state of its output (e.g. toggling between two different voltage levels). The frequency of such electric state changes can be adjustable. This hardware could be e.g. part of a microcontroller, or an external electronic component. Likewise the Synchronized Time Base information can be acquired from an external source like a RTC, GPS, Ethernet, etc.

Therefore when talking about a Clock we may refer to either its quality (e.g. rate, accuracy, etc.) or to the Time Base it holds (e.g. time information relative to the Global Position, daylight, etc.) depending on the context that holds the term.

3.2.2 Global Time Master

Definition: A Global Time Master is the global owner and origin for a certain Time Base and on the top of the Time Base hierarchy for that Time Base.

3.2.3 Time Base

Definition: A Time Base is a unique time entity characterized by:

- Progression of time, which denotes how time progresses, i.e. the rate (which in turn is derived from a local quartz oscillator) and absolute changes of the time value at certain point in times (e.g. effects of offset correction in NTP).
- Ownership, which denotes who is the owner of the Time Base. A distributed NTP Time Base e.g. has multiple owners and the progression of time with respect to rate and offset corrections is a result of involving a subset of NTP nodes.
- Reference to the physical world, i.e. whether the Time Base is a relative Time Base counting local operation time of an ECU HW or representing an absolute time like UTC. A Time Base can have more than one reference, e.g. it can be a relative time which, in combination with an offset value, also represents an absolute time.

Examples of Time Bases in vehicles are:

- Absolute, which is based on a GNSS time.
- Relative, which represents the accumulated overall operating time of a vehicle, i.e. this Time Base does not start with a value of zero whenever the vehicle starts operating.
- Relative, starting at zero whenever the ECU HW begins its operation.

A Time Base implies the availability of a Clock.

Special case "Pure Local Time Base":

A Pure Local Time Base is a Time Base with a local scope as it is neither propagated to other nodes nor received from other nodes. A Pure Local Time Base will only locally be set and read. It is therefore possible to have multiple Pure Local Time Bases with the same Time Domain number in various nodes in parallel. A Pure Local Time Base behaves like a Synchronized Time Base since it progresses in time, however it is not synchronized via TSP modules.

3.2.4 Synchronized Time Base

Definition: A Synchronized Time Base is a Time Base existing at a processing entity (actor / processor / node of a distributed system) that is synchronized with Time Bases at different processing entities. A Synchronized Time Base can be achieved by time protocols or time agreement protocols that derive the Synchronized Time Base in a defined way from one or more physical Time Bases (e.g. Network Time Protocol (NTP) or Flexray time agreement protocol). The synchronization will apply to the clock rate and optionally also to the Time Base absolute value.

The synchronization will apply to the clock absolute value and optionally apply also to the clock rate. A Synchronized Time Base allows synchronized action of the processing units. Synchronized Time Bases are often called "Global Time".

More than one Synchronized Time Base can exist at one processing unit, e.g. a NTP node will have the Synchronized Time Base retrieved from NTP in the network cluster but might also have a Synchronized Time Base derived from the time provided by a UTC time server (which is based on a set of atomic clocks). Both Synchronized Time Bases will probably have slightly different rates, and there is no relationship defined between their absolute values.

3.2.5 Offset Time Base

Definition: An Offset Time Base is a Time Base existing at a processing entity (actor / processor / node of a distributed system). An Offset Time Base depends on one particular Synchronized Time Base, therefore it is synchronized with the same Time Base Source as its underlying TBR.

An Offset Time Base holds an offset value relative to the Time Base of its underlying Synchronized TBR. Therefore, it provides to the Application a time base with a value of its underlying Synchronized TBR plus the Offset value it holds. Since an Offset Time Base receives its time value from the same TSP as its underlying Synchronized TBR, it will present the same rate deviation and correction properties.

Note: Offset Time Bases are no longer supported by AUTOSAR.

3.2.6 Time Base Provider

Definition: A Time Base Provider is the role that a TSP module takes for a given Time Base. Therefore a TSP module can contain one or more Time Base providers. Time Base providers are either of type importer or exporter, whereas an importer acts as Time Slave and an exporter acts as Time Master. A Time Gateway consists of one Time Base importer and one or more Time Base exporters for a given Time Base. In order to limit the terminology, importers are denoted as slaves and exporters are denoted as masters.

3.2.7 Time Communication Port

Definition: A Time Communication Port is a physical communication interface (in Classic Platform coverable by the item: Physical Connector) at an ECU HW which is used to transport time information.

3.2.8 Time Domain

Definition: A Time Domain denotes which components (e.g. nodes, communication systems) are linked to a certain Time Base. A Time Domain can contain zero or more Time Sub-Domains. If the timing hierarchy of a Time Domain contains no Time Gate-

ways, i.e. all nodes are connected to the same bus system, then there is no dedicated Time Sub-Domain which otherwise would be equal to the Time Domain itself.

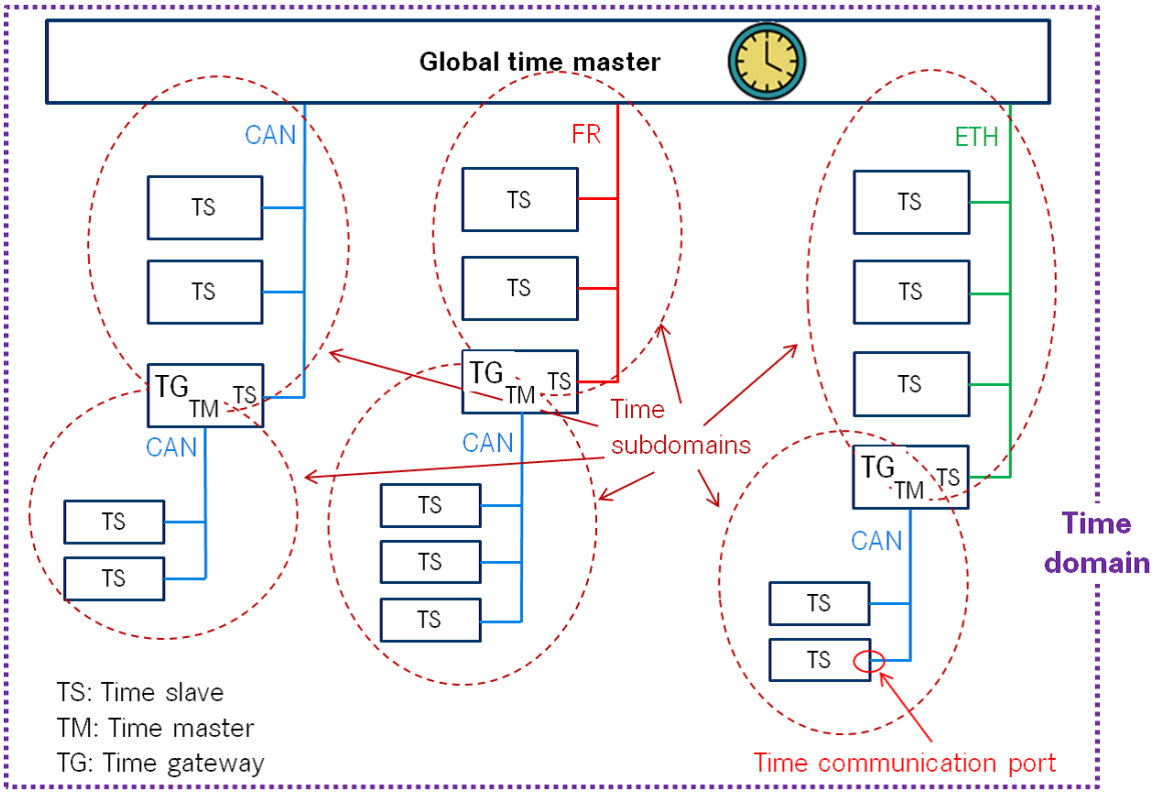


Figure 3.1: Terminology Example

3.2.9 Time Gateway

Definition: A Time Gateway is a set of entities where one entity is acting as Time Slave for a certain Time Base. The other (one or more) entities are acting as Time Masters which are distributing this Time Base to sets of Time Slaves. A Timesync ECU can contain multiple Time Gateways. A Time Gateway can be connected to different types of bus systems (e.g. the slave side could be connected to CAN whereas the master side could be connected to Ethernet).

3.2.10 Time Hierarchy

Definition: The Time Hierarchy describes how a certain Time Base is distributed, starting at the Global Time Master and being distributed across various Time Gateways (if present) to various Time Slaves.

3.2.11 Time Master

Definition: A Time Master is an entity which is the master for a certain Time Base and which propagates this Time Base to a set of Time Slaves within a certain segment of a communication network, being a source for this Time Base.

If a Time Master is also the owner of the Time Base then he is the Global Time Master. A Time Gateway typically consists of one Time Slave and one or more Time Masters. When mapping time entities to real ECUs it has to be noted, that an ECU HW could be Time Master (or even Global Time Master) for one Time Base and Time Slave for another Time Base.

Special case "Pure Local Time Master":

A Pure Local Time Master is an entity which is the master of a Pure Local Time Base and which therefore does not propagate this Time Base to any Time Slave.

3.2.12 Time Slave

Definition: A Time Slave is an entity, which is the recipient for a certain Time Base within a certain segment of a communication network, being a consumer for this Time Base.

3.2.13 Time Sub-domain

Definition: A Time Sub-Domain denotes which components (e.g. nodes) are linked to a certain Time Base, whereas the scope is limited to one communication bus.

3.2.14 Timesync ECU

Definition: A Timesync ECU is an ECU HW which is part of a Time Domain by containing one or more Time Slaves or Time Masters.

3.2.15 TSP Module / Timesync Module

Definition: TSP Modules (Timesync over <BUS> modules) are bus specific modules to receive or transmit time information on bus systems by applying bus specific mechanisms. A TSP module can serve multiple communication buses of the same type.

3.2.16 Virtual Local Time

Definition: The Virtual Local Time is a time which is driven by the OS counter or a hardware clock and which in turn drives a Synchronized Time Base. The associated

Synchronized Time Base has an offset to the Virtual Local Time. For Time Slaves there is usually also a deviation in rate caused by different clock drifts of the HW reference clocks used by Time Master and Time Slave.

The term Virtual Local Time describes a Time Base whose time progresses monotonously without jumps.

Virtual Local Time Bases are necessary for interpolating:

- local instances of Synchronized Time Bases (in either Master or Slave)
- Pure Local Time Bases

In addition, Virtual Local Time Bases can be used to measure timespans, i.e., for rate correction measurement intervals or timeouts.

Virtual Local Time Bases are based on a hardware clock and can be derived from various sources:

- OS counter
- GPT counter
- Ethernet freerunning counter (used for ingress and egress timestamping)

It is possible to use different Virtual Local Time Bases in parallel.

Although the different counter sources vary regarding tick duration and counter width each derived Virtual Local Time Base has the same width (64 bit) and tick duration (1 ns). To achieve this, it is necessary to count overflows of the counters and to convert counter specific tick durations if required.

3.2.17 Time Correction

Definition: Time Correction in Time Slaves is the process of adjusting the value of the local instance of the Time Base to the value of the Global Time Base. In Time Masters, Time Correction is the process of eliminating the deviation of an Offset Clock compared to its corresponding Synchronized Time Base. Time Correction can be divided into Rate Correction, which corrects rate deviations and Offset Correction, which corrects absolute time deviations. Offset Correction can be furthermore divided into (Offset Correction By) Jump Correction or (Offset Correction By) Rate Adaption.

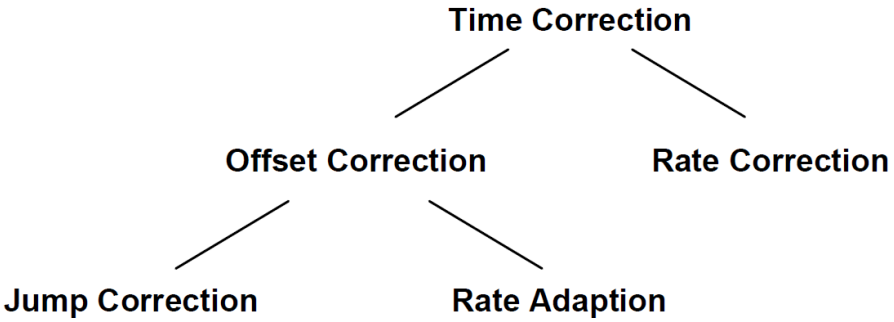


Figure 3.2: Time Correction Hierarchy

Note:

- Rate Deviation: This means that the time progresses at different rates in the local instance of the Time Base and the Global Time Base. Such deviations can occur if, for example, the local hardware reference clock is driven by a crystal whose frequency is off due to manufacturing tolerances and/or thermal effects.
- Time Offset: This means that the local instance of the Time Base and the Global Time Base are not synchronized precisely. Besides an initial offset that is compensated upon synchronization, such deviations occur recurringly due to inaccuracies of the rate of the local hardware reference clock and because of jitter effects, software delays and counter granularities that influence the re-synchronization with the Global Time Base.

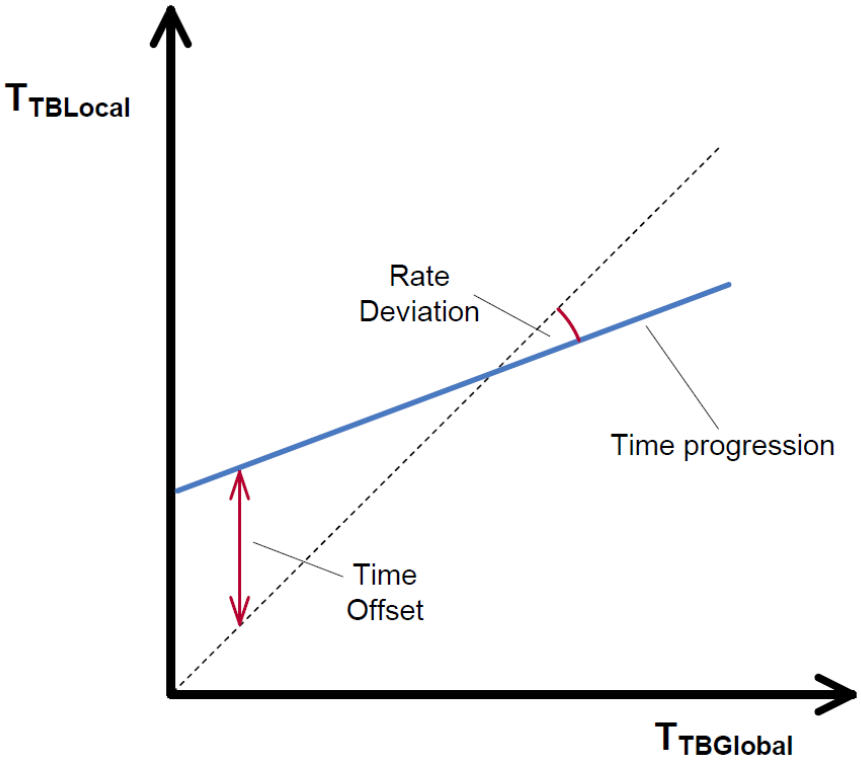


Figure 3.3: Time Deviations RateCorrection

3.2.18 Rate Correction

Definition: Rate Correction corrects the rate-deviation of a local hardware reference clock towards the rate of the Global Time Master's clock. This correction is done by a multiplicative correction factor which is used in addition to the clock's preconfigured rate. Rate Correction determines the correction factor in the scope of a measurement. This correction factor is however not fixed but updated after each successful measurement.

The working principle of Rate Correction is not to adjust the local hardware reference clock in order to let it progress with the correct rate. Instead Rate Correction only corrects the values of the local instance of the Time Base on-the-fly when they are read.

3.2.19 Offset Correction

Definition: Offset Correction corrects absolute time deviations (offsets). Depending on the magnitude of the offset and the configuration of StbM, this correction is either performed by Jump Correction or Rate Adaption. Offset Correction is independent from Rate Correction. It is performed each time the local instance of the Time Base is synchronized to its Global Time Base.

3.2.20 Jump Correction

Definition: Jump Correction corrects absolute time offsets in a single step by adding the offset to the local instance of the Time Base (which is equivalent to taking over the value of the Global Time Base).

3.2.21 Rate Adaption

Definition: Rate Adaption corrects time offsets gradually within a predefined timespan. Hereto, Rate Adaption switches the rate of the local instance of the Time Base temporarily to a different value. This rate is chosen to completely eliminate the offset within the preconfigured timespan.

Like Rate Correction, Rate Adaption does not adjust the local instance of the Time Base (including hardware reference clock). It merely corrects the clock values on-the-fly when they are read.

Note: Rate Adaption and Rate Correction use a similar mechanism. They are however completely independent from each other, i.e. Rate Adaptation may be performed upon Rate Correction without causing interference.

4 Use Cases

This chapter describes the use cases which can be realized by an environment of an ECU HW which implements the Time Synchronization Protocol.

ID	*Name*	*Description*
0001	Pdelay measurement	Measuring of delays between Ethernet messages
0002	Time Synchronization	Time synchronization of different time bases.

Table 4.1: Use Cases for Time Synchronization Protocol Implementation

5 Requirements Specification

5.1 Functional Overview

The Time Synchronization Implementation provides means like network time protocols or time agreement protocols to synchronize its local Time Bases to Time Bases on other nodes.

Modules and applications can consume the time information provided and managed by the Time Synchronization Implemention by reading the time information. Modules and applications, when required to provide time information, can update the Time Base maintained by the Time Synchronization Implementation.

This specification contains time synchronization requirements for classic and adaptive platform. The classic platform splits the implementation of Time Synchronization into 3 bus protocol specific Time Synchronization Provider (TSP) modules (SWS Time Synchronization over Ethernet, over CAN and over FlexRay) and one module, which manages the Time Bases (SWS Synchronized Time-Base Manager). The adaptive platform defines only one module for Time Synchronization (SWS TimeSync), which also includes the Time Synchronization Provider (TSP) part.

5.2 Functional Requirements

5.2.1 Common Requirements

[RS_TS_00002] Independent Maintenance of Time Base ⌈

Description:	The Implementation of Time Synchronization shall always maintain the Time Base, by using different HW clock references (i.e. OS counter, GPT, Ethernet HW clock, etc.). The configuration depends on the capabilities of the HW and whether specific Role of the Implementation of Time Synchronization is enabled / disabled.
Rationale:	Time Base is managed by only one instance within the Global Time cluster.
Dependencies:	–
Use Case:	–
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00003] Initialize Local Time Base with Configurable Value ⌈

Description:	The TS shall initialize the Local Time Base with a configurable startup value
Rationale:	Start up with a known default value.
Dependencies:	–

▽

△

Use Case:	–
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_00004] Initialize Global Time Base with Configurable Value ⌈

Description:	The Implementation of Time Synchronization shall allow configuration of the initialization value of the Global Time Base. The initialization value can be either: - a value from static configuration - a value from non-volatile memory
Rationale:	Start up with a dedicated Time Base value. Resume of time freeze.
Dependencies:	–
Use Case:	–
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00005] Provide Customer Access to Synchronized Time Base ⌈

Description:	The Implementation of Time Synchronization shall allow active customers to have access to the Synchronized Time Base. The Implementation of Time Synchronization shall provide an interface for customers to access the Synchronized Time Base, i.e., to read the current time and the status of the Time Base (i.e. quality characteristics of the Time Base or Clock, like whether or not it is already externally Synchronized, if it presents leap jumps into the Future/Past, rate deviation, etc.). The customers shall always access a Synchronize Time Base via the Implementation of Time Synchronization.
Rationale:	The Implementation of Time Synchronization offers the possibility to the customers to access the definition of time if required.
Dependencies:	–
Use Case:	An `Adaptive Application` wants to know the current definition of time in order to perform a task in a synchronically way to other tasks of other ECUs or Software Components.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00006] Provide Time Information to TSP Modules ⌈

Description:	The Implementation of Time Synchronization shall allow the "Time Synchronization Provider" modules to have access to the time information managed by the Implementation of Time Synchronization module.
Rationale:	Separation of concerns: The Implementation of Time Synchronization does not provide its own time agreement protocol / network time protocol. The Implementation of Time Synchronization leaves this to the TSP modules. However, for the time agreement protocol / network time protocol the TSP modules depend on time information managed by the Implementation of Time Synchronization.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00007] Synchronize Time Slave Base from Time Master ⌈

Description:	If configured as Time Slave for a Time Base, the Implementation of Time Synchronization shall synchronize its Local Time Base against the Global Time provided by the TSP module each time a valid Time Base value from the latter is received. A valid Global Time Base value replaces the value of the Local Time Base.
Rationale:	Rapid time synchronization and correction
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00008] Continuous Maintenance of Time Bases ⌈

Description:	The Implementation of Time Synchronization shall maintain its Time Bases based on a local reference clock. As an example, reference clocks to which the Implementation of Time Synchronization could access, could be: -OS counter -GPT -Ethernet HW clock
Rationale:	- Time Base is managed by only one instance within the Global Time cluster. - Availability of time information. Even if synchronization fails on the bus (for a Time Slave), the module is still able to provide a time value.
Dependencies:	–

▽

△

Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00009] Maintain Synchronization Status of Time Base ⌈

Description:	The Implementation of Time Synchronization shall maintain the synchronization status of a Time Base autonomously. Synchronization status refer to the information regarding leap jumps into the Future/Past, whether or not has the time base been synchronized against an external source, daylight settings, etc.
Rationale:	Allows Time Base qualification.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00010] Allow Master to Set Global Time ⌈

Description:	If configured as Time Master, the Implementation of Time Synchronization shall allow the customer to set the Global Time Base.
Rationale:	Allows Global Time Base adjustment
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00011] Allow Master to Trigger Immediate Time Transmission ⌈

Description:	If configured as Time Master, the Implementation of Time Synchronization shall allow the customer to trigger time transmission by the TSP modules immediately. That is, the TSP modules shall not wait for the next cyclic transmission, but force immediate transmission.
Rationale:	Allows faster re-synchronization.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00014] Read User Data via TSP Modules ⌈

Description:	The Implementation of Time Synchronization shall allow customers to read User Data propagated via the TSP modules. User Data can be used to characterize the Time Base, e.g., regarding the quality of the underlying clock source or regarding the progress of time or regarding the security of the clock source.
Rationale:	Allows usage of User Data as Time Slave.
Dependencies:	–
Use Case:	User of the Time Base can reject the instance of a time base value with quality and/or security issue, based on usage of this time value in a safety and/or security critical function.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00015] Set User Data via TSP Modules ⌈

Description:	If configured as Time Master the Implementation of Time Synchronization shall allow customers to set User Data propagated via the TSP modules. User Data can be used to characterize the Time Base, e.g., regarding the quality of the underlying clock source or regarding the progress of time or the security of the clock source.
Rationale:	Allows usage of User Data as Time Master.
Dependencies:	–
Use Case:	Provider of the Time Base communicates each instance of time base value with quality, security qualifiers. So, the user of Time base can take appropriate action when required.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00016] Notify Customers of Time Base Status Events ⌈

Description:	The Implementation of Time Synchronization shall notify customers (Event Notification Customers) about Time Base related status events.
Rationale:	Immediate information about status change to avoid unnecessary polling.
Dependencies:	–
Use Case:	Status update to application, on (re-)synchronization by TSP modules.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00017] Notify Customers on Elapsed Time Span ⌈

Description:	The Implementation of Time Synchronization shall notify customers, when a time span (relative to a given Time Base and previously defined/set by the customer) has elapsed.
Rationale:	Immediate information, when a given time span has elapsed to avoid unnecessary polling.
Dependencies:	–
Use Case:	Synchronization of actions over the whole network (i.e., Turning different lights on or off at a specific time).
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00018] Support Rate Correction for Time Bases ⌈

Description:	The Implementation of Time Synchronization shall support rate measurement and rate correction for Time Bases.
Rationale:	The precision of Time Bases is improved if the rate deviation (due to clock deviations) between Time Slaves and the Global Time Masters is measured and corrected.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00019] Support Damped Offset Correction ⌈

Description:	The Implementation of Time Synchronization shall support smooth offset correction by applying additional rate correction.
Rationale:	Leaps within the Local Time Base are avoided after resynchronization if the offset between the current value of the Local Time Base and the received value of the Global Time Base is removed smoothly by adding an additional rate correction term instead of applying a hard leap to the Local Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00021] Provide Interfaces to Query Synchronization Status ⌈

Description:	The Implementation of Time Synchronization shall provide interfaces to query the synchronization status.
Rationale:	To avoid that other components are affected by unsynchronized time information, the synchronicity of the clocks is available and identifiable by the customer.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00024] Store Time Base Value at Shutdown (Master) ⌈

Description:	If configured as Time Master, the Implementation of Time Synchronization shall support storage of the last Global Time value to non-volatile memory at shutdown.
Rationale:	Startup with a dedicated Time Base value. Support of time freeze.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00025] Provide Fault Detection Mechanisms ⌈

Description:	The Implementation of Time Synchronization shall provide fault detection mechanisms. It must detect the following state changes: - Loss/Re-Establishment of Synchronized Time Bases - Errors during customer / provider call
Rationale:	Part of the vehicle dynamic subsystem must guarantee a concurrent execution of their distributed functionality. If a synchronization loss is detected, the subsystem must trigger appropriate counteractions.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00026] Provide API per Time Base Resource Type ⌈

Description:	The Implementation of Time Synchronization shall provide a different and specific API for each type of Time Base Resource.
Rationale:	The customer will be provided with a specific API which sets the boundaries of the possible interaction with the Time Base according to its type of Time Base Resource. In this way, the customer cannot try to interact with the Time Base as if it were i.e. a Master Time Base, when it is actually a Slave Time Base.
Dependencies:	–
Use Case:	–
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00037] Configurable Customer Interaction Modes ⌈

Description:	The configuration of Time Synchronization Implementation shall allow the interaction with different types of customers. The Synchronized Time-Base Manager is a service that should provide a time base (if requested) in such a way : 1. it triggers interfaced SW-C and BSW (this functionality is currently limited to OS Schedule Tables) 2. it provides the time base on demand when the customer asks for it 3. it notifies customers on time base related events The customer shall have the possibility to choose the desired interaction with the Synchronized Time-Base Manager.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_00029] Configurable as Vehicle-Wide Time Master ⌈

Description:	Per supported Time Base the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a (vehicle wide) Time Master with respect to Global Time Synchronization.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00030] Configurable as Time Slave ⌈

Description:	Per supported Time Base the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a Time Slave with respect to Global Time Synchronization.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00031] Configurable as Time Gateway ⌈

Description:	If configured as Time Gateway, the TBM shall route Time Base information from one vehicle network to another one. That means, the a Time Sync Module on one vehicle network is configured as slave and another Time Sync Module on the other network is configured as master. The Time Base Manager shall forward the Time Base information from the slave to the master.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00032] Trigger Registered Customers ⌈

Description:	If OS is configured as triggered customer, the Synchronized Time-Base Manager shall periodically synchronize the corresponding schedule table(s) to the configured Time Bases.
Rationale:	Allows Global Time Base adjustment
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_00033] Use 1 ns Resolution Time Format ⌈

Description:	The Implementation of Time Synchronization shall use independently of the Timesync modules the same time format, which is compatible to IEEE 802.1AS and allows for a resolution of 1ns. **Note:** The actual resolution of the time value for a Time Base depends on the Timesync module capabilities. The Implementation of Time Synchronization adjusts the time value as needed. **Note:** Some Timesync modules transmit time formats with 4 instead of 6 bytes for the seconds part of the time.
Rationale:	Time Base harmonization between all buses regarding design of Global / Local Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_00034] Provide Measurement Data to Applications ⌈

Description:	To allow detailed comparison of a Local Time Base to the corresponding Global Time Base, TS shall provide a recording mechanism of Time Base relevant data for Time Slaves and Time Masters.
Rationale:	–
Dependencies:	–
Use Case:	• During development measurement support is required to validate the precision of Time Bases • Monitoring of raw timing data for Time Validation
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00035] Provide System Service Interface to Applications ⌈

Description:	The Synchronized Time-Base Manager shall be located in the AUTOSAR Service Layer and provide its services to customers in the application and in the BSW. It provides its services via a Standardized AUTOSAR Interface to customers in the application and via a standardized C-API to customers in the BSW.
Rationale:	A Synchronized Time is required by customers in application and in the BSW.
Dependencies:	–
Use Case:	An application SW-C wants to get informed about the current value of a Time Base
Supporting Material:	–

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AppliesTo:	CP

⌋

[RS_TS_00038] Copy Time Base on User Request ⌈

Description:	For Synchronized Time Bases, the Time Synchronization shall upon user request copy Time Base information (time value, User Data, ...) from a Source Time Base to a Destination Time Base.
Rationale:	Copying Time Bases without loss of precision.
Dependencies:	–
Use Case:	Reverse Time Synchronization, Local Fallback
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00039] Provide Freshness Value to TSP Modules ⌈

Description:	The implementation of Time Synchronization module shall allow the Time Synchronization Provider (TSP) modules to have access to FV managed by Freshness Value Manager (FVM) SWC.
Rationale:	Separation of concerns: The implementation of Time Synchronization module does not manage the FV. It provisions required interfaces to FVM SWC and TSP modules for the FV communication between them.
Dependencies:	–
Use Case:	Addition of FV to Integrity Check Value (ICV) calculation secures the time information against the replay attacks.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_00040] Monitoring of the Synchronization Protocol ⌈

Description:	The Time Synchronization implementation shall monitor the synchronization process with integrity and report detected faults in the time synchronization process. Additional information: Integrity level needs typically to be at least ASIL B.
Rationale:	
Dependencies:	–
Use Case:	
Supporting Material:	ISO 26262; IEEE 802.1AS

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AppliesTo:	CP, AP

⌋

[RS_TS_00041] Monitoring of the Time Progression ⌈

Description:	The Time Synchronization implementation shall monitor the progression of Global Time with integrity and report detected faults in time progression. Additional information: Integrity level needs typically to be at least ASIL B
Rationale:	
Dependencies:	–
Use Case:	
Supporting Material:	ISO 26262
AppliesTo:	CP, AP

⌋

[RS_TS_00042] Ensure Continuous Time Progression in Errors ⌈

Description:	If a fault in time synchronization or progression of a validated Time Base has been detected, then the Time Synchronization implementation shall switch-over to a fallback Time Base that is able to continue extrapolating the validated Time Base seamlessly.
Rationale:	
Dependencies:	–
Use Case:	
Supporting Material:	IEEE 802.1AS
AppliesTo:	CP, AP

⌋

[RS_TS_00043] Provide Time and Integrity Info to SWCs/Apps ⌈

Description:	The Time Synchronization implementation shall provide. • information on the integrity • and the synchronized time of the validated Time Base atomically to SWCs/Applications with integrity. Additional information: Integrity level needs typically to be at least ASIL B.
Rationale:	
Dependencies:	–
Use Case:	

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Supporting Material:	ISO 26262
AppliesTo:	CP, AP

⌋

5.2.2 Time Synchronization over Ethernet

[RS_TS_20047] Trigger Time Base Synchronization Transmission ⌈

Description:	If configured as Time Master for a time base the Timesync over Ethernet module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: • Cyclic triggering • Immediate triggering on demand
Rationale:	Time Synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20048] Support IEEE 802.1AS and AUTOSAR Extensions ⌈

Description:	The Timesync over Ethernet module shall support IEEE 802.1AS [6], chapter 11 in terms of Sync, Follow_Up (time synchronization) and Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up (delay measurement) as well as AUTOSAR extensions belonging to the Addressing scheme and message format.
Rationale:	Time Synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20069] Provide Read/Write Access to Bus-Specific Parameters ⌈

Description:	Per supported Synchronized Time Base the Time Synchronization Implementation shall provide read / write access to bus protocol specific parameters.

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Rationale:	Some applications require access to protocol specific parameter.
Dependencies:	–
Use Case:	Applications running RTP with IEEE 1733 require access to IEEE 802.1as protocol parameters.
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20066] Peer-to-Peer Delay Support over Ethernet ⌈

Description:	The Timesync over Ethernet module shall support measuring the peer-to-peer delay using the IEEE 802.1AS peer-to-peer delay mechanism. The Timesync over Ethernet module shall set the peer-to-peer delay to a static (configurable) value, • which shall be used if the peer-to-peer delay mechanism is not used, • or which shall be used as an initial value in case the IEEE 802.1AS peer-to-peer delay mechanism is used
Rationale:	Time Synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20051] Synchronization Error Handling over Ethernet ⌈

Description:	The Timesync over Ethernet module shall detect and handle errors in synchronization protocol / communication (e.g. Transceiver Link State Lost).
Rationale:	Error handling / detection for synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20052] Time Master Role Configuration over Ethernet ⌈

Description:	Per supported Time Domain the configuration of the Time Synchronization Implementation shall allow to enable / disable the functionality of a Time Master with respect to Global Time Synchronization.

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Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20053] Time Slave Role Configuration over Ethernet ⌈

Description:	Per supported Time Domain the Implementation of the Time Synchronization configuration shall allow to enable / disable the functionality of a Time Slave with respect to Global Time Synchronization.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20054] Time Gateway Information Propagation ⌈

Description:	If configured as part of a Time Gateway, the Ethernet Time Synchronization module shall evaluate and propagate Time Gateway relevant information.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20058] Provide Time Synchronization Precision Data ⌈

Description:	The Timesync over Ethernet module shall capture and provide measurement data for Time Synchronization relevant parameters (e.g. Link Delay).
Rationale:	Allow detailed analysis of the Time Synchronization mechanisms
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20059] Access All Communication Ports for Time Sync ⌈

Description:	The Timesync over Ethernet module shall access Time Synchronization relevant data belonging to each communication port. This includes the local Ethernet Controller, all Ports of local and external Switches.
Rationale:	Allow detailed calculation along to a HW passage of Time Synchronization messages.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20060] Provide Time Base after Valid Ethernet Sync ⌈

Description:	If configured as Time Slave, the Timesync over Ethernet module shall provide a Time Base after reception of a valid protocol information (Sync + Follow_Up message). This time base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
Rationale:	Synchronization of Local Time Base to Global Time Base.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20061] Protect Time Synchronization Protocol over Ethernet ⌈

Description:	The Timesync over Ethernet module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
Rationale:	Detection of wrong protocol sequences and data.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20062] Support User-Specific Data in Time Protocol over Ethernet ⌈

Description:	The Ethernet Time Synchronization Provider module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.

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Rationale:	Allows usage of user specific data.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20071] Enable Time Sync in Peer-to-Peer and Multidrop Topologies ⌈

Description:	The Timesync over Ethernet module shall enable time synchronization on peer-to-peer topologies as originally targeted by 802.1AS as well as on multidrop topologies (e.g. 10BASE-T1S) which are relevant in the automotive sector
Rationale:	–
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20072] Secure Time Synchronization Protocol over Ethernet ⌈

Description:	The Timesync over Ethernet module shall support the means to secure the Time Synchronization protocol against manipulation of the time information (integrity, authenticity).
Rationale:	Integrity and authenticity failure of the global time results into • False time • Accuracy degradation These impacts reduce the vehicle availability / robustness.
Dependencies:	–
Use Case:	• Protection of authenticity and integrity of the time information on Ethernet bus. • Detection and Reporting of unauthentic and tampered time information on Ethernet bus.
Supporting Material:	–
AppliesTo:	CP, AP

⌋

[RS_TS_20075] Calculate Local-to-Master Clock Rate Ratio ⌈

Description:	A Time Slave of the Timesync over Ethernet protocol shall calculate the rate ratio of the local clock to the Time Master's clock.
Rationale:	Accurate syntonization/synchronization of the local clock to master clock
Dependencies:	–
Use Case:	
Supporting Material:	[3, IEEE 802.1 AS] • chapter 10.2.4.6 "neighborRateRatio", • chapter 11.2.15.2.3 "computePdelayRateRatio" • and chapter 11.4.4.3.6 "cumulativeScaledRateOffset"
AppliesTo:	CP, AP

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5.2.3 Time Synchronization over CAN

[RS_TS_20031] Trigger Time Sync Transmission over CAN ⌈

Description:	If configured as Time Master for a Time Base the Timesync over CAN module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: • Cyclic triggering • Immediate triggering on demand
Rationale:	Time Synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20032] Provide Time Base after Valid CAN Sync Message ⌈

Description:	If configured as Time Slave, the Timesync over CAN module shall provide the Time Base after reception of valid Timesync/TS mesages. This Time Base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
Rationale:	Synchronization of Local Time Base to Global Time Base
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20033] Protect Time Sync Protocol over CAN ⌈

Description:	The Timesync over CAN module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
Rationale:	Detection of wrong protocol sequences and data.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20034] Detect Timeout and Integrity Errors in CAN Sync Protocol ⌈

Description:	The Timesync over CAN module shall monitor the Time Synchronization protocol for timeout and integrity (e.g. sequence counter, CRC).
Rationale:	Error handling / detection for Time Synchronization protocol
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20035] Support Precise Time Measurement over CAN ⌈

Description:	The Timesync over CAN module shall support a protocol for precise time measurement and synchronization over CAN, which is made up of a sequence of a SYNC (synchronization) and a FUP (follow-up) message to achieve higher precision.
Rationale:	Basic Time Synchronization mechanism.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20037] Support User-Specific Data in CAN Time Protocol ⌈

Description:	The Timesync over CAN module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.
Rationale:	Allows usage of user specific data.
Dependencies:	–
Use Case:	

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Supporting Material:	–
AppliesTo:	CP

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[RS_TS_20038] CAN Time Sync Role Configuration ⌈

Description:	The CAN Timesync/TS configuration shall allow the Implementation of Time Synchronization for CAN to fulfill 3 different roles: - Time Master - Time Slave - Time Gateway with respect to Global (vehicle wide) Time synchronization. In each role specific functionality is enabled / disabled
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20068] Support Classic CAN and CAN FD Messages ⌈

Description:	The Timesync over CAN module shall use message formats for classic CAN and extended message formats for CAN FD which allows to transmit more than 8 bytes in a CAN frame.
Rationale:	Optimization for CAN FD by using longer CAN messages.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20070] Support Hardware and Software Timestamping over CAN ⌈

Description:	The Timesync over CAN module shall support time synchronization with and without hardware timestamping support by the CAN hardware.
Rationale:	Hardware timestamping increases precision of the Global Time, but not all CAN hardware supports hardware timestamping.
Dependencies:	–
Use Case:	Time Synchronization over CAN
Supporting Material:	CIA 603 standard

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AppliesTo:	CP

⌋

[RS_TS_20073] Secure Time Synchronization Protocol over CAN ⌈

Description:	The Timesync over CAN module shall support the means to secure the Time Synchronization protocol against manipulation of the time information (integrity, authenticity).
Rationale:	Integrity and authenticity failure of the global time results into • False time • Accuracy degradation These impacts reduce the vehicle availability / robustness.
Dependencies:	–
Use Case:	• Protection of authenticity and integrity of the time information on CAN bus. • Detection and Reporting of unauthentic and tampered time information on CAN bus.
Supporting Material:	–
AppliesTo:	CP

⌋

5.2.4 Time Synchronization over FlexRay

[RS_TS_20039] Trigger Time Sync Transmission over FlexRay ⌈

Description:	If configured as Time Master for a Time Base the Timesync over FlexRay module shall support two ways to trigger the transmission of the Time Synchronization protocol sequence: • Cyclic triggering • Immediate triggering on demand
Rationale:	Time Synchronization protocol.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20040] Provide Time Base after Valid FlexRay Sync Message ⌈

Description:	If configured as Time Slave, the Timesync over FlexRay module shall provide a Time Base after reception of a valid protocol information (SYNC message). This Time Base is forwarded to the Implementation of Time Synchronization to update the Local Time Base.
Rationale:	Synchronization of Local Time Base to Global Time Base
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20041] Protect Time Sync Protocol over FlexRay ⌈

Description:	The Timesync over FlexRay module shall support means (e.g. sequence counter, CRC) to protect the Time Synchronization protocol against corruption of the time information.
Rationale:	Detection of wrong protocol sequences and data.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20042] Detect Timeout and Integrity Errors in FlexRay Sync Protocol ⌈

Description:	The Timesync over FlexRay module shall monitor the Time Synchronization protocol for timeout and integrity (e.g. sequence counter, CRC).
Rationale:	Error handling / detection for synchronization protocol
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20043] Support Precise Time Measurement over FlexRay ⌈

Description:	The Timesync over FlexRay module shall support a protocol for precise time measurement and synchronization over FlexRay, which is made up of a sequence of SYNC (synchronization) messages.
Rationale:	Basic Time Synchronization mechanism.
Dependencies:	–

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Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20045] Support User-Specific Data in FlexRay Time Protocol ⌈

Description:	The Timesync over FlexRay module shall support transmission / reception of user specific data via the time measurement and synchronization protocol.
Rationale:	Allows usage of user specific data.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20046] FlexRay Time Sync Role Configuration ⌈

Description:	The configuration for Time synchronization over FlexRay shall allow the Implementation of Time Synchronization to fulfill 3 different roles: - Time Master - Time Slave - Time Gateway with respect to Global (vehicle wide) Time synchronization. In each role specific functionality is enabled / disabled.
Rationale:	Support of specific communication port role in a given Time Domain.
Dependencies:	–
Use Case:	
Supporting Material:	–
AppliesTo:	CP

⌋

[RS_TS_20074] Secure Time Synchronization Protocol over FlexRay ⌈

Description:	The Timesync over FlexRay module shall support the means to secure the Time Synchronization protocol against manipulation of the time information (integrity, authenticity).
Rationale:	Integrity and authenticity failure of the global time results into • False time • Accuracy degradation These impacts reduce the vehicle availability / robustness.
Dependencies:	–

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Use Case:	• Protection of authenticity and integrity of the time information on FlexRay bus. • Detection and Reporting of unauthentic and tampered time information on FlexRay bus.
Supporting Material:	–
AppliesTo:	CP

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5.3 Non-Functional Requirements (Qualities)

[RS_TS_00027] Provide Bus-Independent Customer Interface ⌈

Description:	The TS shall provide a bus independent customer interface and time format. The resolution of the received Time Base might vary depending on the origin bus. In such cases, the TS adjusts the time value property. If the ECU HW is configured as Time Master, reading the Time Base value is furthermore possible.
Rationale:	Hide bus / physical layer specific details to decouple applicaiton / customers from the lower layers.
Dependencies:	The TSP modules will do the conversion to a bus independent time format.
Use Case:	
Supporting Material:	–
AppliesTo:	CP, AP

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6 References

[1] Standardization Template
AUTOSAR_FO_TPS_StandardizationTemplate

[2] Glossary
AUTOSAR_FO_TR_Glossary

[3] IEEE 802.1AS-2011 - IEEE Standard for Local and metropolitan area networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks, Rev. 2011

A Change History

Please note that the lists in this chapter also include constraints and specification items that have been removed from the specification in a later version. These constraints and specification items do not appear as hyperlinks in the document.

A.1 Change History of this document according to AUTOSAR Release R24-11

A.1.1 Added Requirements in R24-11

none

A.1.2 Changed Requirements in R24-11

Number	Heading
[RS_TS_00014]	The Implementation of Time Synchronization shall allow customers to read User Data propagated via the TSP modules.
[RS_TS_00015]	The Implementation of Time Synchronization shall allow customers to set User Data propagated via the TSP modules.
[RS_TS_00037]	The configuration of the Time Synchronization implementation shall allow the interaction with different types of customers
[RS_TS_00039]	The implementation of Time Synchronization shall provide Freshness Value (FV) to TSP modules required to secure the time information
[RS_TS_20068]	The Timesync over CAN module shall support classic CAN and CAN FD
[RS_TS_20072]	The Timesync over Ethernet module shall support means to secure the Time Synchronization protocol
[RS_TS_20073]	The Timesync over CAN module shall support means to secure the Time Synchronization protocol
[RS_TS_20074]	The Timesync over FlexRay module shall support means to secure the Time Synchronization protocol

Table A.1: Changed Requirements in R24-11

A.1.3 Deleted Requirements in R24-11

Number	Heading
[RS_TS_00012]	The Implementation of Time Synchronization shall allow customers and TSP modules to read the offset value of an Offset Time Base
[RS_TS_00013]	The Implementation of Time Synchronization shall allow the customers and TSP modules to set the offset value of an Offset Master Time Base

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Number	Heading
[RS_TS_20036]	The Timesync over CAN module shall use the time measurement and synchronization protocol to transmit and receive an offset value
[RS_TS_20044]	The Timesync over FlexRay module shall use the time measurement and synchronization protocol to transmit and receive an offset value
[RS_TS_20063]	The Timesync over Ethernet module shall use the Time Synchronization protocol for Synchronized Time Bases to transmit and receive Offset Time Bases

Table A.2: Deleted Requirements in R24-11

A.2 Change History of this document according to AUTOSAR Release R25-11

A.2.1 Added Requirements in R25-11

none

A.2.2 Changed Requirements in R25-11

Number	Heading
[RS_TS_00002]	The Implementation of Time Synchronization shall maintain its own Time Base independently of the acting role.
[RS_TS_00003]	The TS shall initialize the Local Time Base with a configurable startup value
[RS_TS_00004]	The Implementation of Time Synchronization shall initialize the Global Time Base with a configurable startup value.
[RS_TS_00005]	The Implementation of Time Synchronization shall allow customers to have access to the Synchronized Time Base
[RS_TS_00006]	The Implementation of Time Synchronization shall provide time information to TSP modules
[RS_TS_00007]	The Implementation of Time Synchronization shall synchronize the Time Base of a Time Slave, on reception of a Time Master value
[RS_TS_00008]	The Implementation of Time Synchronization shall continuously maintain its Time Bases based on a Time Base reference clock
[RS_TS_00009]	The Implementation of Time Synchronization shall maintain the synchronization status of a Time Base
[RS_TS_00010]	The Implementation of Time Synchronization shall allow customer on master side to set the Global Time
[RS_TS_00011]	The Implementation of Time Synchronization shall allow customers on master side to trigger time transmission by the TSP module
[RS_TS_00014]	The Implementation of Time Synchronization shall allow customers to read User Data propagated via the TSP modules.

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Number	Heading
[RS_TS_00015]	The Implementation of Time Synchronization shall allow customers to set User Data propagated via the TSP modules.
[RS_TS_00016]	The Implementation of Time Synchronization shall notify customers about status events
[RS_TS_00017]	The Implementation of Time Synchronization shall notify customers about elapsed pre-defined time span.
[RS_TS_00018]	The Implementation of Time Synchronization shall support rate correction
[RS_TS_00019]	The Implementation of Time Synchronization shall support damping offset correction
[RS_TS_00021]	The Implementation of Time Synchronization shall provide interfaces to query the synchronization status
[RS_TS_00024]	The Implementation of Time Synchronization shall support storage of the Time Base value at shutdown if configured as Time Master
[RS_TS_00025]	The Implementation of Time Synchronization shall provide fault detection mechanisms
[RS_TS_00026]	The Implementation of Time Synchronization shall provide to the customers a specific API per type of Time Base Resource
[RS_TS_00027]	The TS shall provide a bus independent customer interface
[RS_TS_00029]	The configuration of the Time Synchronization implementation shall allow the implementation to behave as a (vehicle wide) Time Master
[RS_TS_00030]	The configuration of the Time Synchronization implementation shall allow the implementation to behave as a Time Slave
[RS_TS_00031]	The configuration of the Time Synchronization implementation shall allow the implementation to behave as a Time Gateway
[RS_TS_00032]	The Implementation of Time Synchronization shall trigger registered customers
[RS_TS_00033]	The Implementation of Time Synchronization shall use a time format with a resolution of 1 ns
[RS_TS_00034]	The Implementation of Time Synchronization shall provide measurement data to the application
[RS_TS_00035]	The Implementation of Time Synchronization shall provide a system service interface to applications
[RS_TS_00036]	The Implementation of Time Synchronization shall provide a bus independent customer interface
[RS_TS_00037]	The configuration of the Time Synchronization implementation shall allow the interaction with different types of customers
[RS_TS_00038]	The Implementation of Time Synchronization shall copy Time Base information upon user request
[RS_TS_00039]	The implementation of Time Synchronization shall provide Freshness Value (FV) to TSP modules required to secure the time information
[RS_TS_00040]	Monitoring of the Synchronization Process Monitoring
[RS_TS_00041]	Global Time Progress Monitoring
[RS_TS_00042]	Continuous Time Progression Assurance in Error Cases

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Number	Heading
[RS_TS_00043]	Providing Relevant Information to SWCs/Adaptive Applications
[RS_TS_20031]	The Timesync over CAN module shall trigger Time Base Synchronization transmission
[RS_TS_20032]	The Timesync over CAN module shall provide the Time Base after reception of a valid Timesync/TS messages
[RS_TS_20033]	The Timesync over CAN module shall support means to protect the Time synchronization protocol
[RS_TS_20034]	The Timesync over CAN module shall detect and handle timeout and integrity errors in the Time Synchronization protocol
[RS_TS_20035]	The Timesync over CAN module shall support a protocol for precise time measurement and synchronization over CAN
[RS_TS_20037]	The Timesync over CAN module shall support user specific data within the time measurement and synchronization protocol
[RS_TS_20038]	The Timesync over CAN module configuration shall allow the Implementation of Time Synchronization for CAN to support different roles for a Time Base
[RS_TS_20039]	The Timesync over FlexRay module shall trigger Time Base Synchronization transmission
[RS_TS_20040]	The Timesync over FlexRay module shall provide a Time Base after reception of a valid protocol information
[RS_TS_20041]	The Timesync over FlexRay module shall support means to protect the Time Synchronization protocol
[RS_TS_20042]	The Timesync over FlexRay module shall detect and handle timeout and integrity errors in the Time Synchronization protocol
[RS_TS_20043]	The Timesync over FlexRay module shall support a protocol for precise time measurement and synchronization over FlexRay
[RS_TS_20045]	The Timesync over FlexRay module shall support user specific data within the time measurement and synchronization protocol
[RS_TS_20046]	The configuration for Time synchronization over FlexRay shall allow the Flex Ray Time Synchronization module to support different roles for a Time Base
[RS_TS_20047]	The Timesync over Ethernet module shall trigger Time Base Synchronization transmission
[RS_TS_20048]	The Timesync over Ethernet module shall support IEEE 802.1AS as well as AUTOSAR extensions
[RS_TS_20051]	The Timesync over Ethernet module shall detect and handle errors in synchronization protocol / communication
[RS_TS_20052]	The configuration of the Time Synchronization over Ethernet module shall allow the module to work as a Time Master
[RS_TS_20053]	The configuration of the Time Synchronization over Ethernet module shall allow the module to work as a Time Slave
[RS_TS_20054]	The Implementation of the Time Synchronization shall evaluate and propagate Time Gateway relevant information
[RS_TS_20058]	The Timesync over Ethernet module shall provide the precision of Synchronized Time Bases

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Number	Heading
[RS_TS_20059]	The Timesync over Ethernet module shall access all communication ports belonging to Time Synchronization
[RS_TS_20060]	The Timesync over Ethernet module shall provide a Time Base after reception of a valid protocol information
[RS_TS_20061]	The Timesync over Ethernet module shall support means to protect the Time Synchronization protocol
[RS_TS_20062]	The Timesync over Ethernet module shall support user specific data within the time measurement and synchronization protocol
[RS_TS_20066]	The Timesync over Ethernet module shall support measuring the peer-to-peer delay using the IEEE 802.1AS peer-to-peer delay mechanism.
[RS_TS_20068]	The Timesync over CAN module shall support classic CAN and CAN FD
[RS_TS_20069]	The TimeSync over Ethernet module shall provide read / write access to bus protocol specific parameters
[RS_TS_20070]	The Timesync over CAN module shall support hardware and software timestamping
[RS_TS_20071]	The Timesync over Ethernet module shall enable time synchronization on peer-to-peer and multidrop topologies
[RS_TS_20072]	The Timesync over Ethernet module shall support means to secure the Time Synchronization protocol
[RS_TS_20073]	The Timesync over CAN module shall support means to secure the Time Synchronization protocol
[RS_TS_20074]	The Timesync over FlexRay module shall support means to secure the Time Synchronization protocol
[RS_TS_20075]	Rate Ratio Calculation

Table A.3: Changed Requirements in R25-11

A.2.3 Deleted Requirements in R25-11

none

A.3 Change History of this document according to AUTOSAR Release R26-11

A.3.1 Added Requirements in R26-11

none

A.3.2 Changed Requirements in R26-11

none

A.3.3 Deleted Requirements in R26-11

Number	Heading
[RS_TS_00036]	The Implementation of Time Synchronization shall provide a bus independent customer interface

Table A.4: Deleted Requirements in R26-11