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Contents

1	Introduction and overview	5
1.1	Protocol purpose and objectives	5
1.2	Applicability of the protocol	6
1.2.1	Constraints and assumptions	6
1.2.1.1	Adaptation in case of asymmetric approach	6
1.2.2	Limitations	6
1.3	Dependencies	7
1.3.1	Dependencies to other protocol layers	7
1.3.2	Dependencies to other standards and norms	7
1.3.3	Dependencies to the Application Layer	7
2	Use Cases	8
3	Protocol Requirements	9
3.1	Requirements Traceability	9
4	Definition of terms and acronyms	10
4.1	Acronyms and abbreviations	10
4.2	Definition of terms	10
5	Protocol specification	12
5.1	Specification of the security solution	12
5.1.1	Basic entities of the security solution	12
5.1.2	Authentication of I-PDUs	15
5.1.3	Verification of I-PDUs	16
5.1.3.1	Successful verification of I-PDUs	18
5.1.3.2	Skipping Authentication for Secured I-PDUs at SecOC	18
5.1.3.3	Error handling and discarding of reception	18
5.2	Error detection	19
5.3	Security Profiles	19
5.3.1	Overview of security profiles	19
5.3.2	SecOC Profile 1 (or 24Bit-CMAC-8Bit-FV)	20
5.3.3	SecOC Profile 2 (or 24Bit-CMAC-No-FV)	20
5.3.4	SecOC Profile 3 (or JASPAR)	20
6	Configuration parameters	22
7	Protocol usage and guidelines	27
8	References	28
A	Change history of AUTOSAR traceable items	29
A.1	Change History of this document according to AUTOSAR Release R23-11	29
A.1.1	Added Specification Items in R23-11	29

A.1.2 Changed Specification Items in R23-11 29
A.1.3 Deleted Specification Items in R23-11 29

1 Introduction and overview

Authentication and integrity protection of sensitive data is necessary to protect correct and safe functionality of the vehicle systems - this ensures that received data comes from the right ECU and has the correct value.

The [SecOC](#) protocol as described in this document provides a mechanism to verify the authenticity and freshness of PDU based communication between ECUs within the vehicle architecture. The approach requires both the sending ECU and the receiving ECU to implement a [SecOC](#) module.

To provide message freshness, the [SecOC](#) module on the sending and receiving side get freshness from an external Freshness Manager for each uniquely identifiable [Secured I-PDU](#), i.e. for each secured communication link.

On the sender side, the [SecOC](#) module creates a [Secured I-PDU](#) by adding authentication information to the outgoing [Authentic I-PDU](#). The authentication information comprises of an [Authenticator](#) (e.g. Message Authentication Code) and optionally a Freshness Value. Regardless if the Freshness Value is or is not included in the Secure I-PDU payload, the Freshness Value is considered during generation of the [Authenticator](#). When using a Freshness Counter instead of a Timestamp, the Freshness Counter should be incremented by the Freshness Manager prior to providing the authentication information to the receiver side. On the receiver side, the [SecOC](#) module checks the freshness and authenticity of the [Authentic I-PDU](#) by verifying the authentication information that has been appended by the sending side [SecOC](#) module. To verify the authenticity and freshness of an [Authentic I-PDU](#), the [Secured I-PDU](#) provided to the receiving side [SecOC](#) should be the same [Secured I-PDU](#) provided by the sending side [SecOC](#) and the receiving side [SecOC](#) should have knowledge of the Freshness Value used by the sending side [SecOC](#) during creation of the [Authenticator](#).

1.1 Protocol purpose and objectives

The [SecOC](#) protocol aims for resource-efficient and appropriate authentication mechanisms for critical data on the level of PDUs. The authentication mechanisms shall be seamlessly integrated with the current AUTOSAR communication systems. The impact with respect to resource consumption should be as small as possible in order to allow protection as add-on for legacy systems. The specification is based on the assumption that mainly symmetric authentication approaches with message authentication codes (MACs) are used. They achieve the same level of security with much smaller keys than asymmetric approaches and can be implemented compactly and efficiently in software and in hardware. However, the specification provides the necessary level of abstraction so that both, symmetric approaches as well as asymmetric authentication approaches can be used.

1.2 Applicability of the protocol

The `SecOC` protocol is used in all ECUs where secure communication is necessary.

1.2.1 Constraints and assumptions

1.2.1.1 Adaptation in case of asymmetric approach

Although this document consequently uses the terms and concepts from symmetric cryptography, the `SecOC` protocol supports both symmetric and asymmetric cryptographic algorithms. In case of an asymmetric approach using digital signatures instead of the MAC-approach described throughout the whole document, some adaptations must be made:

1. Instead of a shared secret between sender and (all) receivers, a key pair consisting of public key and secret key is used. The secret (or private) key is used by the sender to generate the signature, the corresponding public keys is used by (all) receiver(s) to verify the signature. The private key must not be feasibly computable from the public key and it shall not be assessable by the receivers.
2. In order to verify a message, the receiver needs access to the complete signature / output of the signature generation algorithm. Therefore, a truncation of the signature as proposed in the `MAC` case is NOT possible. The parameter `SecOCAuthInfoTruncLength` has to be set to the complete length of the signature.
3. The signature verification uses a different algorithm then the signature generation. So instead of "rebuilding" the `MAC` on receiver side and comparing it with the received (truncated) `MAC` as given above, the receiver / verifier performs the verification algorithm using the `DataToAuthenticator` (including full counter) and the signature as inputs and getting a Boolean value as output, determining whether the verification passed or failed.

1.2.2 Limitations

The protocol specification aims to ensure compatibility between AP and CP, and it assumes the communication is realized over ethernet.

Depending of the communication paradigm between AP and CP, the functionality of the protocol is limited. In the case of SOME/IP, the protocol will not support separate transmission of Authentic PDU and Cryptographic PDU and will not support usage of part of the payload as freshness information. (the details are described in the chapter Configuration Parameters.)

1.3 Dependencies

1.3.1 Dependencies to other protocol layers

The interaction of `SecOC` with the lower layer of the communication stack will depend on the on the platform architecture (AP or CP), and in the case of a CP implementation, it will also depend on the type of transmission: direct transmission, triggered transmission or transport protocol. These design specific dependencies are not part of the protocol specification.

1.3.2 Dependencies to other standards and norms

[1] *IEC 7498-1 The Basic Model, IEC Norm, 1994*

[2] *National Institute of Standards and Technology (NIST): FIPS-180-4, Secure Hash Standard (SHS), March 2012, available electronically at <http://csrc.nist.gov/publications/fips/fips180-4/fips-180-4.pdf>*

[3] *FIPS Pub 197: Advanced Encryption Standard (AES), U.S. Department of Commerce, Information Technology Laboratory (ITL), National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA, Federal Information Processing Standards Publication, 2001, electronically available at <http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf>*

1.3.3 Dependencies to the Application Layer

The `SecOC` protocol does not have dependencies to typical Automotive application. However, it relies on the existence of a software component that provides a freshness information. In addition, there could also be specialized applications that trigger a modification in `SecOC` behavior (e.g. for development purpose) or applications that monitor the verification results.

2 Use Cases

<i>ID</i>	<i>Name</i>	<i>Description</i>
UC_001	SecOC SOME/IP	Secure communication between AP and CP using SOME/IP
UC_002	SecOC SignalBased	Secure communication between AP and CP using signal-based communication and SignalToService translation

3 Protocol Requirements

3.1 Requirements Traceability

Requirement	Description	Satisfied by
[RS_Main_00510]	Secure Onboard Communication	[PRS_SecOc_00101] [PRS_SecOc_00102] [PRS_SecOc_00103] [PRS_SecOc_00104] [PRS_SecOc_00105] [PRS_SecOc_00200] [PRS_SecOc_00206] [PRS_SecOc_00208] [PRS_SecOc_00210] [PRS_SecOc_00211] [PRS_SecOc_00213] [PRS_SecOc_00215] [PRS_SecOc_00216] [PRS_SecOc_00220] [PRS_SecOc_00221] [PRS_SecOc_00223] [PRS_SecOc_00300] [PRS_SecOc_00306] [PRS_SecOc_00309] [PRS_SecOc_00313] [PRS_SecOc_00314] [PRS_SecOc_00315] [PRS_SecOc_00316] [PRS_SecOc_00317] [PRS_SecOc_00320] [PRS_SecOc_00341] [PRS_SecOc_00342] [PRS_SecOc_00600] [PRS_SecOc_00610] [PRS_SecOc_00620] [PRS_SecOc_00630]
[SRS_BSW_00337]	Classification of development errors	[PRS_SecOc_00500]
[SRS_BSW_00350]	All AUTOSAR Basic Software Modules shall allow the enabling/disabling of detection and reporting of development errors.	[PRS_SecOc_00500]
[SRS_BSW_00385]	List possible error notifications	[PRS_SecOc_00330] [PRS_SecOc_00340] [PRS_SecOc_00341] [PRS_SecOc_00500]
[SRS_BSW_00450]	A Main function of a un-initialized module shall return immediately	[PRS_SecOc_00500]

Table 3.1: Requirements Tracing

4 Definition of terms and acronyms

4.1 Acronyms and abbreviations

Abbreviation / Acronym:	Description:
SecOC	Secure Onboard Communication
MAC	Message Authentication Code
FV	Freshness Value
FM	Freshness Manager

4.2 Definition of terms

Terms:	Description:
Authentic I-PDU	An Authentic I-PDU is an arbitrary AUTOSAR I-PDU the content of which is secured during network transmission by means of the Secured I-PDU. The secured content comprises the complete I-PDU or a part of the I-PDU.
Authentication	Authentication is a service related to identification. This function applies to both entities and information itself. Two parties entering into a communication should identify each other. Information delivered over a channel should be authenticated as to origin, date of origin, data content, time sent, etc. For these reasons, this aspect of cryptography is usually subdivided into two major classes: entity authentication and data origin authentication. Data origin authentication implicitly provides data integrity (for if a message is modified, the source has changed).
Authentication Information	The Authentication Information consists of a Freshness Value (or a part thereof) and an Authenticator (or a part thereof). Authentication Information are the additional pieces of information that are added by SecOC to realize the Secured I-PDU.
Authenticator	Authenticator is data that is used to provide message authentication. In general, the term Message Authentication Code (MAC) is used for symmetric approaches while the term Signature or Digital Signature refers to asymmetric approaches having different properties and constraints.
Data integrity	Data integrity is the property whereby data has not been altered in an unauthorized manner since the time it was created, transmitted, or stored by an authorized source. To assure data integrity, one should have the ability to detect data manipulation by unauthorized parties. Data manipulation includes such things as insertion, deletion, and substitution.
Data origin authentication	Data origin authentication is a type of authentication whereby a party is corroborated as the (original) source of specified data created at some (typically unspecified) time in the past. By definition, data origin authentication includes data integrity.

Terms:	Description:
Distinction unilateral / bilateral authentication	In unilateral authentication, one side proves identity. The requesting side is not even authenticated to the extent of proving that it is allowed to request authentication. In bilateral authentication, the requester is also authenticated at least (see below) to prove the privilege of requesting. There is an efficient and more secure way to authenticate both endpoints, based on the bilateral authentication described above. Along with the authentication (in the second message) requested initially by the receiver (in the first message), the sender also requests an authentication. The receiver sends a third message providing the authentication requested by the sender. This is only three messages (in contrast to four with two unilateral messages).
Entity authentication	<p>Entity authentication is the process whereby one party is assured (through acquisition of corroborative evidence) of the identity of a second party involved in a protocol, and that the second has actually participated (i.e., is active at, or immediately prior to, the time the evidence is acquired).</p> <p>Note: Entity authentication means to prove presence and operational readiness of a communication endpoint. This is for example often done by proving access to a cryptographic key and knowledge of a secret. It is necessary to do this without disclosing either key or secret. Entity authentication can be used to prevent record-and-replay attacks. Freshness of messages only complicates them by the need to record a lifetime and corrupt either senders or receivers (real-time) clock. Entity authentication is triggered by the receiver, i.e. the one to be convinced, while the sender has to react by convincing.</p> <p>Record and replay attacks on entity authentication are usually prevented by allowing the receiver some control over the authentication process. In order to prevent the receiver from using this control for steering the sender to malicious purposes or from determining a key or a secret ("oracle attack"), the sender can add more randomness. If not only access to a key (implying membership to a privileged group) but also individuality is to be proven, the sender additionally adds and authenticates its unique identification.</p>
Message authentication	Message authentication is a term used analogously with data origin authentication. It provides data origin authentication with respect to the original message source (and data integrity, but no uniqueness and timeliness guarantees).
Secured I-PDU	A Secured I-PDU is an AUTOSAR I-PDU that contains Payload of an Authentic I-PDU supplemented by additional Authentication Information.
Transaction authentication	Transaction authentication denotes message authentication augmented to additionally provide uniqueness and timeliness guarantees on data (thus preventing undetectable message replay).

5 Protocol specification

5.1 Specification of the security solution

The *SecOC* protocol as described in this document provides a mechanism to verify the authenticity and freshness of PDU based communication between ECUs within the vehicle architecture. The approach requires both the sending ECU and the receiving ECU to implement a *SecOC* module.

To provide message freshness, the *SecOC* module on the sending and receiving side get freshness from an external Freshness Manager for each uniquely identifiable *Secured I-PDU*, i.e. for each secured communication link.

On the sender side, the *SecOC* module creates a *Secured I-PDU* by adding *Authentication Information* to the outgoing *Authentic I-PDU*. The *Authentication Information* comprises of an *Authenticator* (e.g. Message Authentication Code) and optionally a Freshness Value. Regardless if the Freshness Value is or is not included in the Secure I-PDU payload, the Freshness Value is considered during generation of the *Authenticator*. When using a Freshness Counter instead of a Timestamp, the Freshness Counter should be incremented by the Freshness Manager prior to providing the *Authentication Information* to the receiver side.

On the receiver side, the *SecOC* module checks the freshness and authenticity of the *Authentic I-PDU* by verifying the *Authentication Information* that has been appended by the sending side *SecOC* module. To verify the authenticity and freshness of an *Authentic I-PDU*, the *Secured I-PDU* provided to the receiving side *SecOC* should be the same *Secured I-PDU* provided by the sending side *SecOC* and the receiving side *SecOC* should have knowledge of the Freshness Value used by the sending side *SecOC* during creation of the *Authenticator*.

5.1.1 Basic entities of the security solution

The term *Authentic I-PDU* refers to an AUTOSAR I-PDU that requires protection against unauthorized manipulation and replay attacks.

The payload of a *Secured I-PDU* consists of the *Authentic I-PDU* and an *Authenticator* (e.g. Message Authentication Code). The payload of a *Secured I-PDU* may optionally include the Freshness Value used to create the *Authenticator* (e.g. MAC). The order in which the contents are structured in the *Secured I-PDU* is compliant with [Figure 5.1](#).

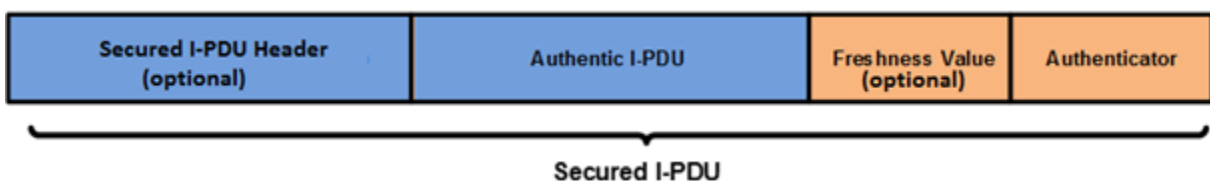


Figure 5.1: *Secured I-PDU* contents

The length of the **Authentic I-PDU**, the Freshness Value and the **Authenticator** within a **Secured I-PDU** may vary from one uniquely indefinable **Secured I-PDU** to another.

The **Authenticator** (e.g. **MAC**) refers to a unique authentication data string generated using a Key, Data Identifier of the **Secured I-PDU**, Authentic Payload, and Freshness Value. The **Authenticator** provides a high level of confidence that the data in an **Authentic I-PDU** is generated by a legitimate source and is provided to the receiving ECU at the time in which it is intended for.

Depending on the authentication algorithm used to generate the **Authenticator**, it may be possible to truncate the resulting **Authenticator** (e.g. in case of a **MAC**) generated by the authentication algorithm. Truncation may be desired when the message payload is limited in length and does not have sufficient space to include the full **Authenticator**.

The **Authenticator** length contained in a **Secured I-PDU** (parameter **SecOCAuthInfoTruncLength**) is specific to a uniquely identifiable **Secured I-PDU**. This allows provision of flexibility across the system (i.e. two independent unique **Secured I-PDU**s may have different **Authenticator** lengths included in the payload of the **Secured I-PDU**) by providing fine grain configuration of the **MAC** truncation length for each **Secured I-PDU**.

If truncation is possible, the **Authenticator** should only be truncated down to the most significant bits of the resulting **Authenticator** generated by the authentication algorithm. **Figure 5.2** shows an example of the truncation of the **Authenticator** and the Freshness Values respecting the parameter **SecOCFreshnessValueTruncLength** and **SecOCAuthInfoTruncLength**.

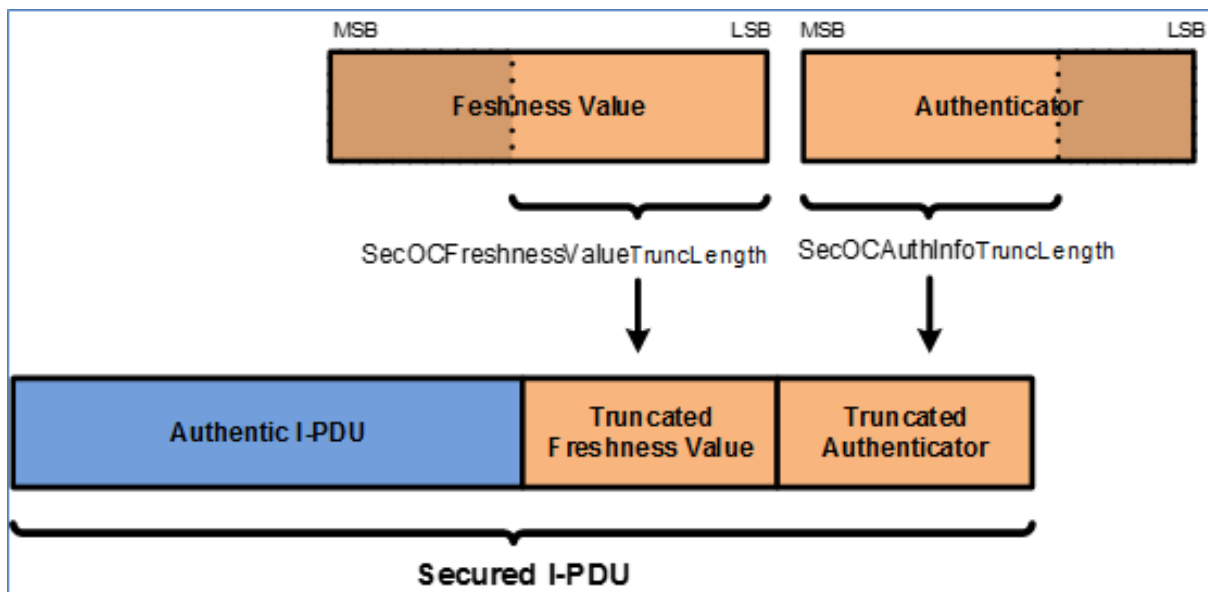


Figure 5.2: An example of **Secured I-PDU** contents with truncated **Freshness Counter** and truncated **Authenticator** (without **Secured I-PDU** Header)

Note: For the resource constraint embedded use case with static participants, we propose using Message Authentication Codes (MACs) as a basis for authentication (e.g. a CMAC [4] based on AES [3] with an adequate key length).

Note: In case a MAC is used, it is possible to transmit and compare only parts of the MAC. This is known as MAC truncation. However, this results in a lower security level at least for forgery of single MACs. While we propose to always use a key length of at least 128 bits, a MAC truncation can be beneficial. Of course, the actual length of the MAC for each use case has to be chosen carefully. For some guidance, we refer to appendix A of [4]. In general, MAC sizes of 64 bit and above are considered to provide sufficient protection against guessing attacks by NIST. Depending on the use case, different MAC sizes can be appropriate, but this requires careful judgment by a security expert.

[PRS_SecOc_00101] [All SecOC data (e.g. Freshness Value, Authenticator, Data Identifier, SecOC message link data,...) that is directly or indirectly transmitted to the other side of a communication link shall be encoded in Big Endian byte order so that each SecOC module interprets the data in the same way.] (RS_Main_00510)

[PRS_SecOc_00102] [The Secured I-PDU Header shall indicate the length of the Authentic I-PDU in bytes. The length of the Header shall be configurable by the parameter SecOCAuthPduHeaderLength.] (RS_Main_00510)

Each Secured I-PDU is configured with at least one Freshness Value. The Freshness Value refers to a monotonic counter that is used to ensure freshness of the Secured I-PDU. Such a monotonic counter could be realized by means of individual message counters, called Freshness Counter, or by a time stamp value called Freshness Timestamp. Freshness Values are to be derived from a Freshness Manager.

[PRS_SecOc_00103] [If the parameter SecOCFreshnessValueTruncLength is configured to a smaller length than the actual freshness value, SecOC shall include only the least significant bits of the freshness value up to SecOCFreshnessValueTruncLength within the Secured I-PDU.

If the parameter SecOCFreshnessValueTruncLength is configured to 0, the freshness value shall not be included in the Secured I-PDU.] (RS_Main_00510)

[PRS_SecOc_00104] [If SecOCUseAuthDataFreshness is set to TRUE, SecOC shall use a part of the Authentic I-PDU as freshness. In this case, SecOCAuthDataFreshnessStartPosition determines the start position in bits of the freshness inside the Authentic I-PDU and SecOCAuthDataFreshnessLen determines its length in bits.] (RS_Main_00510)

Note: This allows reusing existing freshness values from the payload which are guaranteed to be unique within the validity period of a Freshness Timestamp, e.g. a 4-bit E2E counter. In this case SecOC does not need to generate any additional counter values.

[PRS_SecOc_00105] [The Freshness Manager provides or receives freshness information in interface functions as byte arrays. The freshness is always aligned to the MSB of the first byte in the array. The 15th bit of the freshness is the MSB of the 2nd

byte and so on. Unused bits of the freshness array must be set to 0. The associated length information must be given in bits.] ([RS_Main_00510](#))

5.1.2 Authentication of I-PDUs

[PRS_SecOc_00200] [The creation of a [Secured I-PDU](#) consists of the following steps in this order:

1. Generate [Authenticator](#).
2. Construct [Secured I-PDU](#).
3. Increment [Freshness Counter](#).

It shall be ensured that the [Authenticator](#) is generated before the freshness counter is incremented.] ([RS_Main_00510](#))

[PRS_SecOc_00206] [If the [Freshness](#) value calculation or the authenticator calculation fails and a default [Pattern](#) is configured by parameter [SecOCDefaultAuthenticationInformationPattern](#), then [Secured I-PDU](#) shall use the default pattern for all the bytes of [Freshness Value](#) and [Authenticator](#).] ([RS_Main_00510](#))

[PRS_SecOc_00221] [If the [Freshness](#) value calculation or the authenticator calculation fails and a default [Pattern](#) is not configured by parameter [SecOCDefaultAuthenticationInformationPattern](#), then [Secured I-PDU](#) shall be dropped.] ([RS_Main_00510](#))

Note:

Example:

[SecOCFreshnessValueTxLength](#) = 4bits

[SecOCAuthInfoTxLength](#) = 20 bits

[SecOCDefaultAuthenticationInformationPattern](#) = 0xA5

The resulting default [Authentication Information](#) within the secured PDU would be 0x05 (Truncated [Freshness Value](#)) | 0xA5 0xA5 0xA0 (Truncated [Authenticator](#)). "|" denotes concatenation.

[PRS_SecOc_00222] [The [Data Identifier](#) of the [Secured I-PDU](#) ([SecOCDataId](#)) has a size of 16-bits.] ()

[PRS_SecOc_00208] [The data, on which the [Authenticator](#) is calculated, consists of [SecOCDataId](#), [Authentic I-PDU](#) data and [Complete Freshness Value](#) in the given order. These are concatenated together respectively to make up the bit array that is passed into the authentication algorithm for [Authenticator](#) generation/verification.

[DataToAuthenticator](#) = [Data Identifier](#) | secured part of the [Authentic I-PDU](#) | [Complete Freshness Value](#).] ([RS_Main_00510](#))

Note: "|" denotes concatenation

[PRS_SecOc_00210] [The [Authenticator](#) shall be truncated down to the number of bits specified by the parameter [SecOCAuthInfoTruncLength](#).] ([RS_Main_00510](#))

[PRS_SecOc_00211] [The [Secured I-PDU](#) shall be constructed by adding the [Secured I-PDU Header](#) (optional), the [Freshness Value](#) (optional) and the [Authenticator](#) to the [Authentic I-PDU](#).

The scheme for the [Secured I-PDU](#) (includes the order in which the contents are structured in the [Secured I-PDU](#)) shall be compliant with below:

SecuredPDU = SecuredIPDUHeader (optional) | AuthenticIPDU | FreshnessValue [SecOCFreshnessValueTruncLength] (optional) | [Authenticator](#) [SecOCAuthInfoTruncLength]] ([RS_Main_00510](#))

Note: The [Freshness Counter](#) and the [Authenticator](#) included as part of the [Secured I-PDU](#) may be truncated per configuration specific to the identifier of the [Secured I-PDU](#). Also, [Freshness Value](#) may be a part of [Authentic I-PDU](#).

Note: This means there is no dependency between the IF/TP configuration of Up versus Lower PDU interfaces.

[PRS_SecOc_00213] [If [SecOCTxSecuredPduCollection](#) is used, then [SecOC](#) shall transmit the [Secured I-PDU](#) as two messages: The original [Authentic I-PDU](#) and a separate [Cryptographic I-PDU](#). The [Cryptographic I-PDU](#) shall contain all [Authentication Information](#) of the [Secured I-PDU](#), so that the [Authentic I-PDU](#) and the [Cryptographic I-PDU](#) contain all information necessary to reconstruct the [Secured I-PDU](#).] ([RS_Main_00510](#))

[PRS_SecOc_00215] [If [SecOCTxSecuredPduCollection](#) is used then [SecOC](#) shall repeat a part of the [Authentic I-PDU](#) inside the [Cryptographic I-PDU](#) as [Message Linker](#) and the [Cryptographic I-PDU](#) shall be constructed as [Cryptographic I-PDU](#) = [Authentication Data](#) | [Message Linker](#)] ([RS_Main_00510](#))

Note: "|" denotes concatenation

[PRS_SecOc_00216] [If [SecOCUseMessageLink](#) is used then [SecOC](#) shall use the value at bit position [SecOCMessageLinkPos](#) of length [SecOCMessageLinkLen](#) bits inside the [Authentic I-PDU](#) as the [Message Linker](#).] ([RS_Main_00510](#))

[PRS_SecOc_00220] [For a Tx [Secured I-PDU](#) with [SecOCAuthPduHeaderLength](#) > 0, the [SecOC](#) module shall add the [Secured I-PDU Header](#) to the [Secured I-PDU](#) with the length of the [Authentic I-PDU](#) within the [Secured I-PDU](#), to handle dynamic [Authentic I-PDU](#).] ([RS_Main_00510](#))

5.1.3 Verification of I-PDUs

[PRS_SecOc_00300] [The verification of a [Secured I-PDU](#) consists of the following 3 steps:

1. Calculate the expected [Freshness Value](#).

2. Construct Data for Authentication.
3. Verify Authentication Information.

](RS_Main_00510)

[PRS_SecOc_00306] [If the verification of the `Authenticator` could be successfully executed but the verification failed (e.g. the `MAC` verification has failed or the key was invalid), the authentication verify attempt counter shall be incremented, and the freshness value shall be updated to the next valid value.](RS_Main_00510)

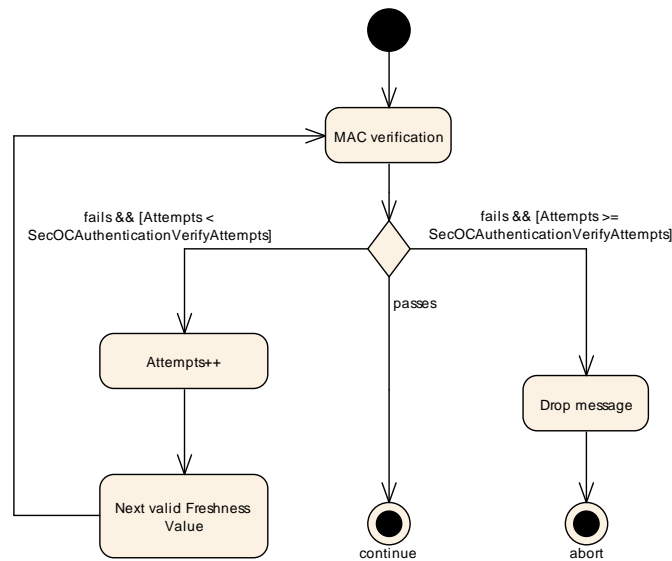


Figure 5.3: Verification of MAC

[PRS_SecOc_00309] [If the authentication verify attempt counter has reached the threshold of the `SecOCAuthenticationVerifyAttempts` on a failed verify attempt, then the received PDU shall be discarded.](RS_Main_00510)

[PRS_SecOc_00223] [If the parameter `SecOCEnableForcedPassOverride` is true, then the `SecOC` shall provide a mechanism to allow reception of the PDUs that failed in authentication.](RS_Main_00510)

[PRS_SecOc_00313] [If `SecOCRxSecuredPduCollection` is used, then `SecOC` shall not perform any verification until it has received both the `Authentic I-PDU` and `Cryptographic I-PDU` which make up the `Secured I-PDU`. Only after both have been received `SecOC` shall attempt to verify the resulting `Secured I-PDU`. If `SecOC_VerifyStatusOverride` is used, the verification result and I-PDU are handled according to `overrideStatus` value.](RS_Main_00510)

Note: This applies to all instances when a `Secured I-PDU` is received by `SecOC` from the lower layer, which happens in parts as described above when `SecOCRxSecuredPduCollection` is used. There is no further distinction made throughout this document to avoid duplication and clutter.

[PRS_SecOc_00314] [If `SecOCRxSecuredPduCollection` is used then `SecOC` shall not attempt to verify the `Secured I-PDU` until it has received and buffered an

[Authentic I-PDU](#) and [Cryptographic I-PDU](#) with matching [Message Linker](#) values. If [SecOC_VerifyStatusOverride](#) is used, the verification result and I-PDU are handled according to [overrideStatus](#) value.]([RS_Main_00510](#))

Note: If [SecOCUseMessageLink](#) has 0 multiplicity, it means If [SecOCMessageLinkLen](#) is 0 and that [Message Linker Values](#) are always matching.

[PRS_SecOc_00315] [Upon reception of a [Secured I-PDU](#), [SecOC](#) shall parse the [Authentic I-PDU](#), the [Freshness Value](#) and the [Authenticator](#) from it.]([RS_Main_00510](#))

[PRS_SecOc_00316] [The data that is used to calculate the [Authenticator](#) ([DataToAuthenticator](#)) on the receiver side shall be constructed. This data is comprised of [SecOCDataId](#) | [AuthenticIPDU](#) | [FreshnessVerifyValue](#).]([RS_Main_00510](#))

[PRS_SecOc_00317] [The [SecOC](#) module shall verify the [Authenticator](#) by passing [DataToAuthenticator](#), [length](#) of [DataToAuthenticator](#), the [Authenticator](#) parsed from [Secured I-PDU](#), and [SecOCAuthInfoTruncLength](#) into the authentication algorithm corresponding to configured cryptographic service. If [SecOC_VerifyStatusOverride](#) is used, the verification result and I-PDU are handled according to [overrideStatus](#) value.]([RS_Main_00510](#))

Note: If the [Freshness Manager](#) requires the status of a [Secured I-PDU](#) if it was verified successfully or not, e.g. to synchronize time or counter, then this status shall be taken from the [VerificationStatus](#) service provided by [SecOC](#).

5.1.3.1 Successful verification of I-PDUs

[PRS_SecOc_00320] [If the verification of a [Secured I-PDU](#) was successful or the status override was set accordingly, the [SecOC](#) module shall pass the [Authentic I-PDU](#) to the upper layer communication modules using the lower layer interfaces of the communication stack.]([RS_Main_00510](#))

5.1.3.2 Skipping Authentication for Secured I-PDUs at SecOC

[PRS_SecOc_00330] [For a Rx [Secured I-PDU](#), there should be a configuration option to skip the verification. In this case the [SecOC](#) module shall extract the [Authentic I-PDU](#) without Authentication.]([SRS_BSW_00385](#))

5.1.3.3 Error handling and discarding of reception

[PRS_SecOc_00340] [If the lower layer transport protocol module reports an error during reception of a [Secured I-PDU](#), the [SecOC](#) module shall drop the [Secured I-PDU](#) and free all corresponding buffers.]([SRS_BSW_00385](#))

[PRS_SecOc_00341] [If the Crypto module reports an error during verification (verification cannot be performed) of a *Secured I-PDU*, the *SecOC* module shall not provide the *Authentic I-PDU*. It shall keep the *Secured I-PDU* (if not overwritten by an incoming *Secured I-PDU* of the same type) and start the verification with the next call of the scheduled main function.] (*RS_Main_00510*, *SRS_BSW_00385*)

[PRS_SecOc_00342] [If *SecOC* has received both an *Authentic I-PDU* and a Cryptographic PDU and the verification of the resulting *Secured I-PDU* fails, both the *Authentic* and *Cryptographic I-PDU* shall remain buffered and verification shall be reattempted each time new data for any of them is received.] (*RS_Main_00510*)

Note: This and the above requirement ensure that even if either an *Authentic I-PDU* or a *Cryptographic I-PDU* is lost in transit, *SecOC* will still function as expected as soon as an *Authentic I-PDU* and its corresponding *Cryptographic I-PDU* are received in direct succession.

5.2 Error detection

[PRS_SecOc_00500] [The *SecOC* module shall be able to report errors in case the module is called before initialization, in case a freshness value cannot be provided or in case there is no cryptographic operation configured for the verification check.] (*SRS_BSW_00337*, *SRS_BSW_00350*, *SRS_BSW_00385*, *SRS_BSW_00450*)

5.3 Security Profiles

5.3.1 Overview of security profiles

Secure Onboard Communication protocol allows multiple cryptographic algorithms and modes for the *MAC* calculation and how the truncation of the *MAC* and freshness value (if applicable) shall be done. The security profiles provide a consistent set of values for a subset of configuration parameters that are relevant for the configuration of Secure Onboard Communication.

[PRS_SecOc_00600] [Each Security Profile shall provide the configuration values for the authentication algorithm (parameter *algorithmFamily*, *algorithmMode* and *algorithmSecondaryFamily* in *CryptoServicePrimitive*), length of freshness Value, if applicable (parameter *SecOCFreshnessValueLength*), length of truncated Freshness Value (parameter *SecOCFreshnessValueTruncLength*), length of truncated *MAC* (parameter *SecOCAuthInfoTruncLength*), and a description of the profile.] (*RS_Main_00510*)

5.3.2 SecOC Profile 1 (or 24Bit-CMAC-8Bit-FV)

[PRS_SecOc_00610] [Using the CMAC algorithm based on AES-128 according to NIST SP 800-38B to calculate the [MAC](#), use the eight least significant bit of the freshness value as truncated freshness value and use the 24 most significant bits of the [MAC](#) as truncated [MAC](#).] ([RS_Main_00510](#))

Parameter	Configuration value
The algorithm for the MAC (parameter algorithmFamily)	CRYPTO_ALGOFAM_AES
The algorithm mode for the MAC (parameter algorithmMode)	CRYPTO_ALGOMODE_CMAC
Additional algorithm family configuration (parameter algorithmSecondaryFamily , not used in this profile)	CRYPTO_ALGOFAM_NOT_SET
Length of Freshness Value (parameter SecOCFreshnessValueLength)	Not Specified
Length of truncated Freshness Value (parameter SecOCFreshnessValueTruncLength)	8 bits
Length of truncated MAC (parameter SecOCAuthInfoTruncLength)	24 bits

5.3.3 SecOC Profile 2 (or 24Bit-CMAC-No-FV)

[PRS_SecOc_00620] [Using the CMAC algorithm based on AES-128 according to NIST SP 800-38B to calculate the [MAC](#), don't use any freshness value at all and use the 24 most significant bits of the [MAC](#) as truncated [MAC](#). The profile shall only be used if no synchronized freshness value is established. There is no restriction to a special bus.] ([RS_Main_00510](#))

Parameter	Configuration value
The algorithm for the MAC (parameter algorithmFamily)	CRYPTO_ALGOFAM_AES
The algorithm mode for the MAC (parameter algorithmMode)	CRYPTO_ALGOMODE_CMAC
Additional algorithm family configuration (parameter algorithmSecondaryFamily , not used in this profile)	CRYPTO_ALGOFAM_NOT_SET
Length of Freshness Value (parameter SecOCFreshnessValueLength)	0
Length of truncated Freshness Value (parameter SecOCFreshnessValueTruncLength)	0 bits
Length of truncated MAC (parameter SecOCAuthInfoTruncLength)	24 bits

5.3.4 SecOC Profile 3 (or JASPAR)

[PRS_SecOc_00630] [This profile depicts one configuration and usage of the JasPar counter base [FV](#) with Master-Slave Synchronization method. It uses the CMAC algorithm based on AES-128 according to NIST SP 800-38B Appendix-A to calculate the [MAC](#). Use the 4 least significant bits of the freshness value as truncated freshness value

and use the 28 most significant bits of the **MAC** as truncated **MAC**. Freshness Value provided to **SecOC** shall be constructed as described in the [UC_SecOC_00202]. The profile shall be used for CAN. (RS_Main_00510)

Parameter	Configuration value
The algorithm for the MAC (parameter <code>algorithmFamily</code>)	CRYPTO_ALGOFAM_AES
The algorithm mode for the MAC (parameter <code>algorithmMode</code>)	CRYPTO_ALGOMODE_CMAC
Additional algorithm family configuration (parameter <code>algorithmSecondaryFamily</code> , not used in this profile)	CRYPTO_ALGOFAM_NOT_SET
Length of Freshness Value (parameter <code>SecOCFreshnessValueLength</code>)	64 bits
Length of truncated Freshness Value (parameter <code>SecOCFreshnessValueTruncLength</code>)	4 bits
Length of truncated MAC (parameter <code>SecOCAuthInfoTruncLength</code>)	24 bits

6 Configuration parameters

The table below describes the configuration parameters for the protocol. For the communication between AP and CP using SOME/IP network binding or raw data streaming, the protocol has a reduced functionality, therefore some parameters are not available in AP or they are implementation specific. These are described in column "Applicability to AP SOME/IP network binding". As a consequence, the requirements referring these parameters are not applicable either. The parameters that are not available are because following features are not available:

- It is not possible to use part of the Authentic PDU to construct as freshness information
- It is not possible to separate the Secure PDU in two different PDUs: Authentic and Cryptographic PDUs
- Provision of Freshness value already truncated by FM (the truncation is always done by SecOC)

Parameter	Description	Applicability to AP SOME/IP network binding
SecOCAuthPduHeaderLength	This parameter indicates the length (in bytes) of the Secured I-PDU Header in the Secured I-PDU. The length of zero means there's no header in the PDU.	no
SecOCFreshnessValueTruncLength	This parameter defines the length in bits of the Freshness Value to be included in the payload of the Secured I-PDU. This length is specific to the least significant bits of the complete Freshness Counter. If the parameter is 0 no Freshness Value is included in the Secured I-PDU.	yes





SecOCUseAuthDataFreshness	A Boolean value that indicates if a part of the Authentic I-PDU shall be passed on to the SWC that verifies and generates the Freshness. If it is set to TRUE, the values SecOCAuthDataFreshnessStartPosition and SecOCAuthDataFreshnessLen must be set to specify the bit position and length within the Authentic I-PDU .	no
SecOCAuthDataFreshnessStartPosition	This value determines the start position in bits (uint16) of the Authentic PDU that shall be passed on to the Freshness SWC.	no
SecOCAuthDataFreshnessLen	This attribute defines the length in bits of the authentic PDU data that is passed to the SWC that verifies and generates the Freshness.	no
SecOCProvideTxTruncatedFreshnessValue	This parameter specifies if the Tx query freshness function provides the truncated freshness info instead of generating this by SecOC in this case, SecOC shall add this data to the Authentic PDU instead of truncating the freshness value.	no
SecOCAuthenticationBuildAttempts	Parameter specifies the number of authentication build attempts.	Implementation specific
SecOCDefaultAuthenticationInformationPattern	The parameter describes the behavior of SecOC when authentication build counter has reached the configuration value SecOCAuthenticationBuildAttempts , or the query of the freshness function returns non-recoverable error (example: a systematic failure due to freshness value configuration) or the calculation of the Authenticator has returned a non-recoverable error (example: a systematic failure due wrong crypto configuration or missing	Implementation specific



△

	<p style="text-align: center;">△</p> <p>key). If the configuration parameter is not present, <i>SecOC</i> module shall remove the <i>Authentic I-PDU</i> from its internal buffer and cancel the transmission request. If the configuration parameter is present, <i>SecOC</i> will use this value for each byte of Freshness Value and <i>Authenticator</i> when building the Authentication Information, and will not cancel the transmission request.</p>	
SecOCDataId	This parameter defines a unique numerical identifier for the <i>Secured I-PDU</i> .	yes
SecOCFreshnessValueID	This parameter defines the Id of the Freshness Value	yes
SecOCTxAuthServiceConfigRef	This reference is used to define which crypto service function is called for authentication	Implementation specific
SecOCAuthInfoTruncLength	This parameter defines the length in bits of the authentication code to be included in the payload of the <i>Secured I-PDU</i> .	yes
SecOC_VerifyStatusOverride	When this configuration option is set to TRUE then the functionality inside the function <i>SecOC_VerifyStatusOverride</i> to send I-PDUs to upper layer independent of the verification result is enabled.	Implementation specific
SecOCTxSecuredPduCollection	Two separate Pdus are transmitted to the lower layer: <i>Authentic I-PDU</i> and <i>Cryptographic I-PDU</i> .	no

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SecOCFreshnessValueLength	This parameter defines the complete length in bits of the Freshness Value. As long as the key doesn't change the counter shall not overflow. The length of the counter shall be determined based on the expected lifetime of the corresponding key and frequency of usage of the counter.	yes
SecOCTxPduUnusedAreasDefault	The AUTOSAR <i>SecOC</i> module fills not used areas of a transmitted Secured Pdu with this byte pattern. This attribute is mandatory to avoid undefined behavior.	Implementation specific
SecOCUseMessageLink	<i>SecOC</i> links an <i>Authentic I-PDU</i> and Cryptographic I-PDU together by repeating a specific part (Message Linker) of the <i>Authentic I-PDU</i> in the Cryptographic I-PDU.	no
SecOCMessageLinkPos	The position of the Message Linker inside the <i>Authentic I-PDU</i> in bits. The bit counting is done according to 01068 and the bit ordering is done according to TPS_SYST_01069.	no
SecOCMessageLinkLen	Length of the Message Linker inside the <i>Authentic I-PDU</i> in bits.	no
SecOCSecuredRxPduVerification	This parameter defines whether the signature authentication or <i>MAC</i> verification shall be performed on this <i>Secured I-PDU</i> . If set to false, the <i>SecOC</i> module extracts the <i>Authentic I-PDU</i> from the <i>Secured I-PDU</i> without verification.	yes
SecOCUseTxConfirmation	A Boolean value that indicates if the function <i>SecOC_SPduTxConfirmation</i> shall be called for this PDU.	no



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SecOCVerificationStatusPropagationMode	This parameter is used to describe the propagation of the status of each verification attempt from the SecOC module to SWCs.	no
SecOCIgnoreVerificationResult	The result of the authentication process (e.g. MAC Verify) is ignored after the first try and the SecOC proceeds like the result was a success. The calculation of the authenticator is still done, only its result will be ignored. true: enabled (verification result is ignored). false: disabled (verification result is NOT ignored).	no
SecOCEnableForcedPassOverride	When this configuration option is set to TRUE then the functionality inside the function SecOC_VerifyStatusOverride to send I-PDUs to upper layer independent of the verification result is enabled.	no
SecOCPropagateOnlyFinalVerificationStatus	This parameter is used to specify if the verification status shall be reported only after the final determination of the verification status (TRUE) or on every verification attempt (FALSE).	no
SecOCAuthenticationVerifyAttempts	This parameter specifies the number of authentication verify attempts that are to be carried out when the verification of the authentication information failed for a given Secured I-PDU . If zero is set, then only one authentication verification attempt is done.	yes

7 Protocol usage and guidelines

This chapter has no content.

8 References

- [1] IEC:The Basic Model, IEC Norm
- [2] NIST:Secure Hash Standard (SHS)
<http://csrc.nist.gov/publications/fips/fips180-4/fips-180-4.pdf>
- [3] NIST:Announcing the Advanced Encryption Standard (AES)
<http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf>
- [4] NIST Special Publication 800-38B:Recommendation for Block Cipher Modes of Operation:The CMAC Mode for Authentication
http://csrc.nist.gov/publications/nistpubs/800-38B/SP_800-38B.pdf

A Change history of AUTOSAR traceable items

A.1 Change History of this document according to AUTOSAR Release R23-11

A.1.1 Added Specification Items in R23-11

[[PRS_SecOc_00221](#)] [[PRS_SecOc_00222](#)] [[PRS_SecOc_00223](#)]

A.1.2 Changed Specification Items in R23-11

[[PRS_SecOc_00200](#)] [[PRS_SecOc_00206](#)] [[PRS_SecOc_00208](#)] [[PRS_SecOc_00210](#)] [[PRS_SecOc_00211](#)] [[PRS_SecOc_00300](#)] [[PRS_SecOc_00306](#)] [[PRS_SecOc_00309](#)] [[PRS_SecOc_00316](#)]

A.1.3 Deleted Specification Items in R23-11

[[PRS_SecOc_00100](#)] [[PRS_SecOc_00201](#)] [[PRS_SecOc_00202](#)] [[PRS_SecOc_00203](#)] [[PRS_SecOc_00204](#)] [[PRS_SecOc_00205](#)] [[PRS_SecOc_00207](#)] [[PRS_SecOc_00209](#)] [[PRS_SecOc_00212](#)] [[PRS_SecOc_00214](#)] [[PRS_SecOc_00217](#)] [[PRS_SecOc_00218](#)] [[PRS_SecOc_00219](#)] [[PRS_SecOc_00301](#)] [[PRS_SecOc_00302](#)] [[PRS_SecOc_00303](#)] [[PRS_SecOc_00304](#)] [[PRS_SecOc_00305](#)] [[PRS_SecOc_00307](#)] [[PRS_SecOc_00308](#)] [[PRS_SecOc_00310](#)] [[PRS_SecOc_00311](#)] [[PRS_SecOc_00312](#)] [[PRS_SecOc_00318](#)]