Space engineering

Adoption Notice of CCSDS 231.0-B-4, TC Synchronization and Channel Coding

Foreword

This Adoption Notice is one document of the series of ECSS Standards intended to be applied together for the management, engineering, product assurance and sustainability in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards. Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This Adoption Notice has been prepared by the ECSS Space Communications Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Change log

ECSS-E-AS-50-24C 1 March 2021	First issue NOTE: This document, together with ECSS-E-AS-50-25C and ECSS-E-AS-50-26C, replace ECSS-E-ST-50-04C.

ECSS-E-AS-50-24C Rev.1
 	
13 January 2023
	First issue, Revision 1
	
	Changes with respect to ECSS-E-AS-50-24C (1 March 2021) are:
	
	Update of the ECSS Adoption Notice with respect to the new version of CCSDS Standard.
	
	Alignment with CCSDS 231.0-B-4, for including the use of TC Space Data link protocol USLP, as follows:
	
	• Replacement of references to CCSDS 231.0-B-3 with CCSDS 231.0-B-4
	
	• Section 3, USLP abbreviation added
	
	• Table 4-1, modified text for:
	
	   o Note 2 to Transfer Frame definition in 1.6.1.2'
	
	   o Section 6.1, in replacement of former modified text in Section 6.1.2 and 6.1.3 (no longer existing)
	
	   o Annex A.3
	
	• Added section A.2.6 "USLP Transfer Frame".
	
	• Addition in Table 4-1 of modified text for informative notes that were reporting the TC randomiser as optional for BCH, instead of mandatory.

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Tables

1
Scope

This document identifies the clauses and requirements modified with respect to the standard CCSDS 231.0-B-4, *TC Synchronization and Channel Coding*, Issue 4, July 2021 for application in ECSS.

2
Context information

In the standard CCSDS 231.0-B-4, *TC Synchronization and Channel Coding*, CCSDS specifies synchronization and channel coding schemes, and the Physical Layer Operations Procedures, for use with CCSDS 231.0-B-4, *TC Space Data Link Protocol*, adopted by ECSS with ECSS-E-AS-50-25C.

With this Adoption Notice ECSS is adopting and applying CCSDS 231.0-B-4 with a minimum set of modifications, identified in the present document, to allow for reference and for a consistent integration in the ECSS system of standards.

CCSDS 231.0-B-4 is similar to clauses 8 (Synchronization and coding sublayer) and 9 (Physical layer) of the ECSS-E-ST-50-04 *Space data links – Telecommand protocols synchronization and channel coding* (31 July 2008), that is superseded by this Adoption Notice together with the following two Adoption Notices: ECSS-E-AS-50-25 and ECSS-E-AS-50-26 (latest versions).

Differences between this Adoption Notice and the relevant part of ECSS-E-ST-50-04 that are not covered by the normative modifications in clause 4 are described in the informative Annex A.

Mapping of superseded ECSS-E-50-xx Standards w.r.t. ECSS Adoption Notice versus CCSDS Standards.

Superseded ECSS	ECSS Adopted Notice	Based on CCSDS
ECSS-E-ST-50-01C 31 July 2008	ECSS-E-AS-50-21	CCSDS 131.0-B-x
ECSS-E-ST-50-03C 31 July 2008	ECSS-E-AS-50-22	CCSDS 132.0-B-x
	ECSS-E-AS-50-23	CCSDS 732.0-B-x
ECSS-E-ST-50-04C 31 July 2008	ECSS-E-AS-50-24	CCSDS 231.0-B-x
	ECSS-E-AS-50-25	CCSDS 232.0-B-x
	ECSS-E-AS-50-26	CCSDS 232.1-B-x
NOTE: The applicable CCSDS Standard referred to by the ECSS Adoption Notice is stated per latest version of the ECSS Adoption Notice.		

3
Abbreviated terms

Abbreviation	Meaning
BCH	Bose-Chaudhuri-Hocquenghem
CLTU	Communications Link Transmission Unit
LDPC	Low-density Parity-check
PLOP	Physical Layer Operations Procedure
SEC	Single Error Correction
USLP	Unified Space Data Link Protocol

4
Application requirements

ECSS-E-AS-50-24_1550001

CCSDS 231.0-B-4, TC Synchronization and Channel Coding, Issue 4, July 2021 shall apply with the following modifications listed in Table 4-1.

ECSS-E-AS-50-24_1550002

Table 4-1: Applicability table for CCSDS 231.0-B-4

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
Note 2 to Transfer Frame definition in 1.6.1.3	Modified	The service data unit of the Coding & Synchronization sublayer consists of <u>one TC Transfer Frame</u> or a single USLP Transfer Frame.	CCSDS requirement modified: only one TC Transfer Frame in a CLTU	The service data unit of the Coding & Synchronization sublayer consists of ~~either~~ one ~~or more~~ TC Transfer Frame~~s~~ or a single USLP Transfer Frame.

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
2.2.2	Modified (statement in informative section)	The modified BCH code specified in this Recommended Standard is decoded in an error-correcting mode.	CCSDS informative section modified: words "may be" replaced by words "is"; words "either in an error-detecting mode or" and "depending on mission requirements" are deleted.	The modified BCH code specified in this Recommended Standard ~~may be~~ decoded ~~either in an error-detecting mode or~~ in an error-correcting mode~~, depending on mission requirements~~.
2.2.2	Modified (statement in informative section)	The Frame Error Control Field (FECF) defined in reference [1] or [6] is used to reduce the probability of undetected errors.	CCSDS informative section modified: words "may be used" replaced by words "is used"; words "particularly when the modified BCH code is decoded in an error-correcting mode"deleted.	The Frame Error Control Field (FECF) defined in reference [1] or [6] ~~may be~~ used to reduce the probability of undetected errors~~, particularly when the modified BCH code is decoded in an error-correcting mode~~.
2.2.4	Modified (statement in informative section)	This Recommended Standard specifies a randomizer to improve bit transition density as an aid to bit synchronization.	Randomization is not optional both for BCH and for LDPC. Word "optional" deleted.	This Recommended Standard specifies ~~an optional~~ randomizer to improve bit transition density as an aid to bit synchronization.
3.4.3	Modified	The fill data mentioned above shall be added either before or after randomization.	Randomization is not optional both for BCH and for LDPC. Words "if randomization is used" deleted.	~~If randomization is used,~~ the fill data mentioned above shall be added either before or after randomization.

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
3.5	Modified	Codewords that have been encoded using the modified BCH code described in 3.3 <u>shall</u> be decoded in an error correcting mode (Single Error Correction, or SEC)<u>. In error-correcting mode, the code can correct one bit in error and can detect two bits in error.</u>	CCSDS requirement modified: SEC decoding not optional for BCH; Word "may" replaced by word "shall". Words "either in an error-detecting mode (Triple Error Detection, or TED) or" and words "depending on mission requirements" deleted. Sentence "When the error-detecting mode is chosen, one, two or three bits in error will be detected within the codeword (not counting the appended Filler Bit); when the error-correcting mode is chosen, one bit in error will be corrected and two bits in error will be detected" deleted. New sentence "In error-correcting mode, the code can correct one bit in error and can detect two bits in error" added.	Codewords that have been encoded using the modified BCH code described in 3.3 ~~may~~ be decoded ~~either in an error-detecting mode (Triple Error Detection, or TED) or~~ in an error correcting mode (Single Error Correction, or SEC)~~, depending on mission requirements. When the error-detecting mode is chosen, one, two or three bits in error will be detected within the codeword (not counting the appended Filler Bit); when the error-correcting mode is chosen, one bit in error will be corrected and two bits in error will be detected.~~
Note 2 in section 5.2.3	Modified	The Transfer Frames contained in the Encoded Data field are randomized <u>either if BCH or</u> LDPC coding is used.	Randomization not optional both for BCH and for LDPC.	The Transfer Frames contained in the Encoded Data field are randomized if LDPC coding is used~~; randomization is optional with BCH coding~~.

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
Table 5-1, in row S3 for State Definition bullet 1	Modified (Text in a Table 5-1)	Codewords, which are either free of error or which can be corrected, are received, decoded, and derandomized, and their contents are transferred to the sublayer above	CCSDS text in Table 5-1 modified: randomization not optional both for BCH and for LDPC. Words "if necessary" deleted.	Codewords, which are either free of error or which can be corrected, are received, decoded, and derandomized ~~(if necessary)~~, and their contents are transferred to the sublayer above.
Note 1 below Table 5-2	Modified (NOTE)	<u>When BCH code is used,</u> the search for the Start Sequence in State 2 <u>accepts a Start Sequence containing one error.</u>	CCSDS NOTE modified: SEC decoding not optional for BCH. Word "in" deleted and replaced by words "when BCH code is used". Words "no error in the Start Sequence is allowed if the modified BCH code is decoded in the error-detecting mode; one error in the Start Sequence is allowed if the modified BCH code is decoded in the error-correcting mode" deleted and replaced by words " accepts a Start Sequence containing one error"	~~In~~ the search for the Start Sequence in State 2~~, no error in the Start Sequence is allowed if the modified BCH code is decoded in the error-detecting mode; one error in the Start Sequence is allowed if the modified BCH code is decoded in the error-correcting mode.~~

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
6.1	Modified (statement in informative section)	Randomization is always applied either when BCH or LDPC coding is used. When BCH coding is used, the random sequence is applied to the Transfer Frame prior to encoding at the sending end and removed from the Transfer Frame after decoding at the receiving end.	CCSDS text modified randomization not optional for both BCH and LDPC.	~~When BCH coding is used, the Pseudo-Randomizer defined in this section is required unless the system designer verifies proper operation of the system if this Randomizer is not used.~~ ~~Its use is fixed for a Physical Channel and is managed (i.e., its presence or absence is not signaled but is known a priori by the receiver), per table 8-2.~~ Randomization is always applied when LDPC coding is used. When BCH coding is used, the random sequence is applied to the Transfer Frame**(s)** prior to encoding at the sending end and removed from the Transfer Frame(s) after decoding at the receiving end.
Note 2 in 6.3.1	Deleted		Randomization not optional for BCH	~~Randomization for BCH coding is optional and managed per table 8-2.~~

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
7.2.2	Modified	The Acquisition Sequence is a data structure forming a preamble which provides for initial symbol synchronization within the incoming stream of detected symbols. The length of the Acquisition Sequence shall be selected according to the communications link performance requirements of the mission. The minimum length <u>shall be</u> 16 octets. The length is not required to be an integral multiple of octets. The pattern of the Acquisition Sequence shall be alternating 'ones' and 'zeros', starting with either a 'one' or a 'zero'.	CCSDS requirement modified. Words "but", "preferred" and "is" deleted and replaced by word "shall"	The Acquisition Sequence is a data structure forming a preamble which provides for initial symbol synchronization within the incoming stream of detected symbols. The length of the Acquisition Sequence shall be selected according to the communications link performance requirements of the mission~~, but~~ the ~~preferred~~ minimum length ~~is~~ 16 octets. The length is not required to be an integral multiple of octets. The pattern of the Acquisition Sequence shall be alternating 'ones' and 'zeros', starting with either a 'one' or a 'zero'.
7.2.4	Modified	The Idle Sequence is the data structure which provides for maintenance of symbol synchronization in the absence of CLTUs. The bit pattern is a sequence of alternating 'ones' and 'zeros'. <u>The length of the Idle Sequence shall be at least 8 bits.</u> The <u>maximum</u> length of the Idle Sequence is an unconstrained number of bits<u>.</u>	CCSDS requirement modified to include minimum length of Idle Sequence . The sentence "The length of the Idle Sequence shall be at least 8 bits" added. The word "maximum" added.	The Idle Sequence is the data structure which provides for maintenance of symbol synchronization in the absence of CLTUs. The bit pattern is a sequence of alternating 'ones' and 'zeros'. The length of the Idle Sequence is an unconstrained number of bits.

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
7.5.2	Modified	When operating with PLOP-2, a minimum Idle Sequence of one octet <u>shall</u> be systematically inserted between each CLTU to eliminate the small but finite possibility of synchronization lockout. Such a lockout may occur if the start pattern of one CLTU is not detected (leaving the receiver in SEARCH state) and a start pattern exists over the last bits of the last BCH codeword of that CLTU and the first bits of its Tail Sequence. This creates an erroneous but temporary CLTU start (DECODE state), causing the true start of the following CLTU to be missed. The added Idle Sequence prevents this from happening. The CLTU transmission service specified in reference [5] includes a parameter to set the duration of the Idle Sequence following a CLTU.	CCSDS requirement modified. Words "should be noted that'' deleted. Words "it is recommended" deleted and replaced by word "shall".	~~It should be noted that~~ when operating with PLOP-2, ~~it is recommended that~~ a minimum Idle Sequence of one octet be systematically inserted between each CLTU to eliminate the small but finite possibility of synchronization lockout. Such a lockout may occur if the start pattern of one CLTU is not detected (leaving the receiver in SEARCH state) and a start pattern exists over the last bits of the last BCH codeword of that CLTU and the first bits of its Tail Sequence. This creates an erroneous but temporary CLTU start (DECODE state), causing the true start of the following CLTU to be missed. The added Idle Sequence prevents this from happening. The CLTU transmission service specified in reference [5] includes a parameter to set the duration of the Idle Sequence following a CLTU.
Table 8-2, in row *Decoding Mode*	Modified (Text in a Table 8-2)	Error-Correcting	CCSDS text in Table 8-2 modified: words "Error-Detecting" deleted. SEC decoding not optional	~~Error-Detecting,~~ Error-Correcting

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
Table 8-2, in row *Allowed Number of Errors in Start Sequence*	Modified (Text in a Table 8-2)	1	CCSDS text in Table-8-2 modified: number "0" deleted. SEC decoding not optional	0,1
Table 8-2, in row *Randomizer*	Modified (Text in a Table 8-2)	Used	CCSDS text in the Table 8-2 modified: words "not used" deleted, randomization not optional	Used, Not used

Clause or requirement number	Applicability	Applicable text for ECSS (the new/added text is underlined)	Comments	Text as in the original CCSDS document (deleted text with strikethrough)
A3	Modified	The parameter Frames is the service data unit of this service and, at the sending end, shall consist of one TC Transfer <u>Frame</u> defined in reference [1] or a single USLP Transfer Frame defined in reference [6]. At the receiving end, however, the parameter Frames may contain an incomplete Frame or additional fill data, which are discarded by the applicable Space Data Link Protocol. If the optional Repetitions parameter is supported, then the parameter shall contain a positive integer value, greater than or equal to 1. If the value of the Repetitions parameter is greater than 1, then the Frames parameter should not contain any Type-BD frames defined in reference [1].	CCSDS requirement modified: only one frame in a CLTU	The parameter Frames is the service data unit of this service and, at the sending end, shall consist of one ~~or more~~ TC Transfer Frame~~s~~ defined in reference [1] or a single USLP Transfer Frame defined in reference [6]. At the receiving end, however, the parameter Frames may contain an incomplete Frame or additional fill data, which are discarded by the applicable Space Data Link Protocol. If the optional Repetitions parameter is supported, then the parameter shall contain a positive integer value, greater than or equal to 1. If the value of the Repetitions parameter is greater than 1, then the Frames parameter should not contain any Type-BD frames defined in reference [1].

Annex A (informative)
Differences from ECSS-E-ST-50-04C

A.1   General

Clause 4 of this document contains normative additions and modifications concerning some of the differences between CCSDS 231.0-B-4 and related parts of the ECSS standard ECSS-E-ST-50-04 (superseded by this Adoption Notice). This Annex describes some additional differences that are not covered by Clause 4.

This Annex lists the differences of technical content, but it is not the purpose of this Annex to provide complete details on each item in the list or to describe the consequences of each item in the list.

A.2   Differences

A.2.1   Coding methods

Section 4 of CCSDS 231.0-B-4 has a normative specification of Low-Density Parity-Check (LDPC) coding such that the Recommended Standard specifies two error-control coding methods: one uses a modified BCH code while the other uses LDPC codes. ECSS-E-ST-50-04 did not include any LDPC codes.

A.2.2   Managed parameters

Section 8 of CCSDS 231.0-B-4 has a normative specification of the managed parameters used by synchronization and channel coding including also managed parameters for LDPC codes. Annex E of ECSS-E-ST-50-04 had an informative specification, and referred to the parameters as mission configuration parameters and did not mention LDPC codes.

A.2.3   Specification of service interfaces

Annex A of CCSDS 231.0-B-4 provides a formal abstract specification of the service interfaces, including service primitives and parameters, provided by TC Synchronization and Channel Coding. There was no equivalent in ECSS-E-ST-50-04.

A.2.4   Addition of optional Repetitions parameter

Annex A of CCSDS 231.0-B-4 includes the optional Repetitions parameter, to specify the number of times the CLTU is transferred. ECSS-E-ST-50-04 did not include this option.

A.2.5   Application profiles

Annex D of ECSS-E-ST-50-04 provided information on performance issues for the frame rejection rate and the frame undetected error rate. There is no equivalent in CCSDS 231.0-B-4 but the CCSDS informational report, CCSDS 230.1-G-3, provides similar performance data.

A.2.6   USLP Transfer Frame

CSDS 231.0-B-4 has normative specifications that support two Space Data Link Protocols: the TC Space Data Link Protocol and the Unified Space Data Link Protocol. ECSS-E-ST-50-04 did not include the latter option.

Bibliography

ECSS-E-AS-50-21C Rev.1	Space engineering - Adoption Notice of CCSDS 131.0-B-4, TM Synchronization and Channel Coding
ECSS-E-AS-50-22C Rev.1	Space engineering - Adoption Notice of CCSDS 132.0-B-3, TM Space Data Link Protocol
ECSS-E-AS-50-23C Rev.1	Space engineering -Adoption Notice of CCSDS 732.0-B-4, AOS Space Data Link Protocol
ECSS-E-AS-50-24C Rev.1	Space engineering - Adoption Notice of CCSDS 231.0-B-4, TC Synchronization and Channel Coding
ECSS-E-AS-50-25C Rev.1	Space engineering - Adoption Notice of CCSDS 232.0-B-4, TC Space Data Link Protocol
ECSS-E-AS-50-26C	Space engineering - Adoption Notice of CCSDS 232.1-B-2, Communications Operation Procedure-1
ECSS-E-ST-50-01C 31 July 2008	Space engineering - Space data links - Telemetry synchronization and channel coding
ECSS-E-ST-50-03C 31 July 2008	Space engineering - Space data links - Telemetry transfer frame protocol
ECSS-E-ST-50-04C 31 July 2008	Space engineering - Space data links - Telecommand protocols synchronization and channel coding
CCSDS 230.1-G-3	TC Synchronization and Channel Coding - Summary of Concept and Rationale – Green Book, Issue 3, October 2021