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Space engineering – Ranging and Doppler tracking; English version FprEN 16603-50-02:2013

Ingénierie spatiale – Mesure de distance et suivi Doppler; Version anglaise FprEN 16603-50-02:2013

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Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

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Nationales Vorwort

Dieses Dokument (FprEN 16603-50-02:2013) wurde vom Technischen Komitee CEN/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Dieses Dokument ist derzeit zum einstufigen Annahmeverfahren vorgelegt.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, die denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

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Nationaler Anhang A
(informativ)

Begriffe

3 Begriffe, Symbole und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieses Dokumentes gelten die Begriffe der ECSS-S-ST-00-01 und ECSS-E-ST-50.

3.2 Für diese Norm spezifische Begriffe

3.2.1
Kategorie A
Kategorie der Raumflugkörper, die sich in einer Höhe von weniger als 2×10^6 km oberhalb der Erdoberfläche bewegen

3.2.2
Kategorie B
Kategorie der Raumflugkörper, die sich in einer Höhe gleich oder größer als 2×10^6 km oberhalb der Erdoberfläche bewegen

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4 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen der ECSS-S-ST-00-01:

Abkürzung	Bedeutung
AGC	automatische Amplitudenregelung (en: automatic gain control)
AU	astronomische Einheit (en: astronomical unit)
$2B_L$	Rauschbandbreite einer beidseitig phasensynchronisierten Schleife (en: double-sided phase locked loop noise bandwidth)
BPSK (siehe PSK)	binäre Phasenumtastung (en: binary phase shift keying)
CCSDS	etwa: Beratender Ausschuss für Raumfahrtdaten-Systeme (en: Consultative Committee for Space Data Systems)
CLCW	Steuerbefehl für Kommandoverbindung (en: command link control word)
C/N	Träger-Rausch-Abstand (en: carrier to noise ratio)
dB	Dezibel
dBc	Dezibel in Bezug auf den unmodulierten Träger (en: dB with respect to the unmodulated carrier)
DRVID	Spezielles Frequenzverfahren, das Range und Doppler unterstützt (en: differenced range versus integrated Doppler)
IF	Zwischenfrequenz (en: intermediate frequency)
LO	Festfrequenzoszillator (en: local oscillator)
NRZ	Non-Return-to-Zero (en: non-return to zero)
NRZ-L	Non-Return-to-Zero-Level (en: NRZ-level)
PCM	Pulscode-Modulation (en: pulse code modulation)
PLL	Phasenregelkreis (en: phase-locked loop)
PM	Phasenmodulation (en: phase modulation)
PSK	Phasenumtastung (en: phase shift keying)
Pp	Spitze-Spitze (en: peak to peak)
RF	Hochfrequenz, Funkfrequenz (en: radio frequency)
r.m.s.	Effektivwert (en: root-mean-square)
SNR	Signal-Rausch-Abstand (en: signal-to-noise ratio)
SPE	Fehler der statischen Phase (en: static phase error)
SP-L	geteilter Phasenpegel (en: split phase-level)
TC	Fernsteuern (en: telecommand)
TM	Telemetrie (en: telemetry)
TR	Nachführung (en: tracking)
UTC	Koordinierte Weltzeit, koordinierte Universalzeit (en: Coordinated Universal Time)

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English version

Space engineering - Ranging and Doppler tracking

Ingénierie spatiale - Mesure de distance et suivi Doppler

Raumfahrttechnik - Entfernungsbestimmung und Dopplerverfolgung

This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/CLC/TC 5.

If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN and CENELEC in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Table of contents

Foreword **4**

Introduction **5**

1 Scope **6**

2 Normative references **7**

3 Terms, definitions and abbreviated terms **8**

3.1 Terms from other standards 8

3.2 Terms specific to the present standard 8

3.3 Abbreviated terms 8

4 Requirements **10**

4.1 Functional 10

4.1.1 Functional breakdown 10

4.1.2 Earth-to-Space link function 12

4.1.3 Transponder function 12

4.1.4 Space-to-Earth link function 13

4.1.5 Link control function 14

4.1.6 Data acquisition function 14

4.2 Frequency assignment, modulation and spectral sharing 15

4.2.1 Frequency assignment 15

4.2.2 Modulation 16

4.2.3 Spectral sharing 18

4.3 Carrier frequency stability 22

4.4 Earth station 24

4.4.1 Earth-to-Space link 24

4.4.2 Space-to-Earth link 25

4.5 Spacecraft transponder 27

4.5.1 General 27

4.5.2 Range and range rate operations 27

4.5.3 Range only operations 28

4.5.4 Group delay 28

Documents
Document Sharing Hub

Full document details: E DIN EN 16603-50-02:2014-02

4.5.5 Telemetered monitoring 29
4.5.6 Amplitude response 29
4.5.7 Phase modulation 30
4.5.8 Baseband automatic gain control (AGC) 30
4.5.9 Modulation index 30
4.5.10 Ranging technological loss 30
4.6 Performance 31
4.6.1 Overview 31
4.6.2 Integrated Doppler performance 31
4.6.3 Ranging performance 32
4.6.4 Ancillary measurements 33

5 Compatibility testing 35
5.1 General 35
5.2 Tests 35

Annex A (informative) Compatibility with other ground stations networks 37

Annex B (informative) Transponder ranging technological loss 39

Annex C (informative) Integrated Doppler measurement 40

Bibliography 42

Figures

Figure 4-1: Ranging and Doppler tracking: functional block diagram 11
Figure 4-2: Ranging signal spectrum for code length = 2^0 18
Figure 4-3: Ranging signal spectrum for code length = 2^2 19
Figure 4-4: Ranging signal spectrum for code length = 2^4 19
Figure 4-5: Ranging signal spectrum for code length = 2^{12} 20
Figure 4-6: Carrier frequency stability requirements 23
Figure C-1 :Integrated Doppler measurement 41

Documents
Document Sharing Hub
Full document details: E DIN EN 16603-50-02:2014-02

Foreword

This document (FprEN 16603-50-02:2013) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN (Germany).

This document (FprEN 16603-50-02:2013) originates from ECSS-E-ST-50-02C.

This document is currently submitted to the Unique Acceptance Procedure.

This document has been developed to cover specifically space systems and will therefore have precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

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Introduction

The purpose of this Standard is to:

- Ensure compatibility between space agencies' spacecraft transponders and the ranging and Doppler tracking facilities of the Earth stations for the Space Operation, Space Research and Earth Exploration Satellite services.
- Ensure, as far as possible, compatibility between space agencies' spacecraft transponders and other networks from which they request support.
- Ensure an adequate level of ranging and Doppler tracking accuracy for missions conforming to this standard.

Facilitate the early design of flight hardware and ensure that the resulting interfaces and system performances are compatible with given ranging and Doppler tracking configurations and specifications.

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1 Scope

This Standard is applicable to spacecraft that are supported for ranging or Doppler tracking by direct links to Earth stations and to all related Earth stations (therefore, this Standard is not applicable for spacecraft supported by data relay satellites) operating within the Space Operation, Space Research and Earth Exploration Satellite services (therefore, this Standard is not applicable to the Meteorological Satellite service) as defined in ECSS-E-ST-50-05 clause 1.

Other space telecommunication services are not covered in this issue.

This Standard applies to projects with unprocessed ranging accuracies of 2,5ns to 30 ns (for conventional projects with tracking accuracies less stringent than these, CCSDS 401.0-B recommendations may be sufficient) and Doppler tracking accuracies of 0,1 mm/s to 1 mm/s. The analysis of compatibility between systems compliant with this standard and with the CCSDS recommendations is given in Annexes A.2 and A.3.

This document:

- Defines the requirements concerning spacecraft transponder and Earth station equipment for the purposes of ranging and Doppler tracking.
- Provides criteria by which the extent to which the accuracy of the measurements is influenced by equipment effects can be determined. This accuracy is different to the accuracy of the overall orbit determination process, which is also influenced by effects outside the scope of the standards, i.e. modelling of gravitational and non-gravitational forces, modelling of propagation effects, pre-processing and screening of data.

This standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

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2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-50	ECSS-E-ST-50	Space engineering – Communications
EN 16603-50-05	ECSS-E-ST-50-05	Space engineering – Radio frequency and modulation

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3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-E-ST-50 apply.

3.2 Terms specific to the present standard

3.2.1 category A

category of those spacecraft having an altitude above the Earth's surface of less than 2×10^6 km

3.2.2 category B

category of those spacecraft having an altitude above the Earth's surface equal to, or greater than, 2×10^6 km

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 apply:

Abbreviation	Meaning
AGC	automatic gain control
AU	astronomical unit
$2B_L$	double-sided phase locked loop noise bandwidth
BPSK	binary phase shift keying (see PSK)
CCSDS	Consultative Committee for Space Data Systems
CLCW	command link control word
C/N	carrier to noise ratio
dB	decibel
dBc	dB with respect to the unmodulated carrier
DRVID	differenced range versus integrated Doppler

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IF	intermediate frequency
LO	local oscillator
NRZ	non-return to zero
NRZ-L	NRZ-level
PCM	pulse code modulation
PLL	phase-locked loop
PM	phase modulation
PSK	phase shift keying
Pp	peak to peak
RF	radio frequency
r.m.s.	root-mean-square
SNR	signal-to-noise ratio
SPE	static phase error
SP-L	split phase-level
TC	telecommand
TM	telemetry
TR	tracking
UTC	universal time (coordinated)

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4 Requirements

4.1 Functional

4.1.1 Functional breakdown

The ranging and Doppler tracking system is a spacecraft tracking system capable of providing information on the range and range rate between a spacecraft and an Earth station. It uses an active transponder on-board the spacecraft for the retransmission to the ground of an Earth-to-Space link signal: ranging signal generation and measurement are performed in the Earth station. As a baseline, it is assumed that the spacecraft transponder is used not only for ranging purposes, but also for receiving telecommand signals from Earth and for transmitting telemetry signals to Earth modulated on the same RF carriers. When a transponder is used exclusively for ranging, the requirements in this standard concerning sharing with telecommand and telemetry have no relevance.

A functional breakdown of the ranging and Doppler tracking system is presented in Figure 4-1. It depicts the five major functions of the system, broken down into functional blocks, as follows:

- The Earth-to-Space link function, employing ground communication, process control, ranging signal generation and Earth-to-Space communication.

  NOTE Ground communication between the Earth station and the Control Centre is not part of the present Standard.

- The transponder function, either spacecraft transponder or ground-calibration transponder depending on the application.
- The Space-to-Earth link function, employing Space-to-Earth communication, Doppler measurement, ranging replica generation, ranging correlation, process control and ground communication.
- The link-control function, resident partly in the Space-to-Earth and Earth-to-Space communication and partly in the process control.
- The data-acquisition function, concerned with collection, measurement, processing and transfer of data to the control centre, employing the process-control and the ground communication functions.

The requirements relevant to these five major functions are listed in clauses 4.1.2 to 4.1.6.

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