INTERNATIONAL STANDARD

ISO 18423

Second edition
2015-08-15

Space data and information transfer systems — Pseudo-Noise (PN) Ranging Systems

Systèmes de transfert des informations et données spatiales — Systèmes de mesure du pseudo-bruit

Reference number
ISO 18423:2015(E)

© ISO 2015



COPYRIGHT PROTECTED DOCUMENT

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18423 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 414.1-B-2, February 2014) and was adopted (without modifications except those stated in clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

© ISO 2015 – All rights reserved

The Consultative Committee for Space Data Systems

Recommendation for Space Data System Standards

PSEUDO-NOISE (PN) RANGING SYSTEMS

RECOMMENDED STANDARD

CCSDS 414.1-B-2

BLUE BOOK

February 2014

AUTHORITY

Issue:	Recommended Standard, Issue 2
Date:	February 2014
Location:	Washington, DC, USA

This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS documents is detailed in *Organization and Processes for the Consultative Committee for Space Data Systems* (CCSDS A02.1-Y-3), and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This document is published and maintained by:

CCSDS Secretariat
Space Communications and Navigation Office, 7L70
Space Operations Mission Directorate
NASA Headquarters
Washington, DC 20546-0001, USA

© ISO 2015 – All rights reserved

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- Whenever a member establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommended Standard**. Establishing such a **standard** does not preclude other provisions which a member may develop.
- Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members with the following information:
  - -- The **standard** itself.
  - -- The anticipated date of initial operational capability.
  - -- The anticipated duration of operational service.
- Specific service arrangements shall be made via memoranda of agreement. Neither this **Recommended Standard** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than three years from its date of issuance, this **Recommended Standard** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or (3) be retired or canceled.

In those instances when a new version of a **Recommended Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.

© ISO 2015 – All rights reserved

FOREWORD

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CCSDS shall not be held responsible for identifying any or all such patent rights.

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommended Standard is therefore subject to CCSDS document management and change control procedures, which are defined in *Organization and Processes for the Consultative Committee for Space Data Systems* (CCSDS A02.1-Y-3). Current versions of CCSDS documents are maintained at the CCSDS Web site:

http://www.ccsds.org/

Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

© ISO 2015 – All rights reserved

At time of publication, the active Member and Observer Agencies of the CCSDS were:

Member Agencies

- Agenzia Spaziale Italiana (ASI)/Italy.
- Canadian Space Agency (CSA)/Canada.
- Centre National d'Etudes Spatiales (CNES)/France.
- China National Space Administration (CNSA)/People's Republic of China.
- Deutsches Zentrum für Luft- und Raumfahrt (DLR)/Germany.
- European Space Agency (ESA)/Europe.
- Federal Space Agency (FSA)/Russian Federation.
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- Japan Aerospace Exploration Agency (JAXA)/Japan.
- National Aeronautics and Space Administration (NASA)/USA.
- UK Space Agency/United Kingdom.

Observer Agencies

- Austrian Space Agency (ASA)/Austria.
- Belgian Federal Science Policy Office (BFSPO)/Belgium.
- Central Research Institute of Machine Building (TsNIIMash)/Russian Federation.
- China Satellite Launch and Tracking Control General, Beijing Institute of Tracking and Telecommunications Technology (CLTC/BITTT)/China.
- Chinese Academy of Sciences (CAS)/China.
- Chinese Academy of Space Technology (CAST)/China.
- Commonwealth Scientific and Industrial Research Organization (CSIRO)/Australia.
- Danish National Space Center (DNSC)/Denmark.
- Departamento de Ciência e Tecnologia Aeroespacial (DCTA)/Brazil.
- European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)/Europe.
- European Telecommunications Satellite Organization (EUTELSAT)/Europe.
- Geo-Informatics and Space Technology Development Agency (GISTDA)/Thailand.
- Hellenic National Space Committee (HNSC)/Greece.
- Indian Space Research Organization (ISRO)/India.
- Institute of Space Research (IKI)/Russian Federation.
- KFKI Research Institute for Particle & Nuclear Physics (KFKI)/Hungary.
- Korea Aerospace Research Institute (KARI)/Korea.
- Ministry of Communications (MOC)/Israel.
- National Institute of Information and Communications Technology (NICT)/Japan.
- National Oceanic and Atmospheric Administration (NOAA)/USA.
- National Space Agency of the Republic of Kazakhstan (NSARK)/Kazakhstan.
- National Space Organization (NSPO)/Chinese Taipei.
- Naval Center for Space Technology (NCST)/USA.
- Scientific and Technological Research Council of Turkey (TUBITAK)/Turkey.
- South African National Space Agency (SANSA)/Republic of South Africa.
- Space and Upper Atmosphere Research Commission (SUPARCO)/Pakistan.
- Swedish Space Corporation (SSC)/Sweden.
- Swiss Space Office (SSO)/Switzerland.
- United States Geological Survey (USGS)/USA.

© ISO 2015 – All rights reserved

DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 414.1-B-1	Pseudo-Noise (PN) Ranging Systems, Recommended Standard, Issue 1	March 2009	Original issue, superseded
CCSDS 414.1-B-2	Pseudo-Noise (PN) Ranging Systems, Recommended Standard, Issue 2	February 2014	Current issue

© ISO 2015 – All rights reserved

CONTENTS

Section Page

1 INTRODUCTION 1-1

1.1 PURPOSE 1-1
1.2 SCOPE 1-1
1.3 APPLICABILITY 1-1
1.4 RATIONALE 1-1
1.5 CONVENTIONS AND DEFINITIONS 1-2
1.6 REFERENCES 1-3

2 OVERVIEW 2-1

3 REGENERATIVE PSEUDO-NOISE RANGING 3-1

3.1 OVERVIEW 3-1
3.2 PN CODE STRUCTURE 3-1
3.3 GROUND STATION UPLINK PROCESSING 3-2
3.4 ON-BOARD PROCESSING 3-4
3.5 GROUND STATION DOWNLINK PROCESSING 3-8

4 TRANSPARENT PSEUDO-NOISE RANGING 4-1

4.1 OVERVIEW 4-1
4.2 PN CODE STRUCTURE 4-1
4.3 GROUND STATION UPLINK PROCESSING 4-1
4.4 ON-BOARD TRANSPARENT PROCESSING 4-3
4.5 GROUND STATION DOWNLINK PROCESSING 4-4

5 SECURITY 5-1

5.1 INTRODUCTION 5-1
5.2 SECURITY CONCERNS WITH RESPECT TO THE CCSDS DOCUMENT 5-1
5.3 POTENTIAL THREATS AND ATTACK SCENARIOS 5-1
5.4 CONSEQUENCES OF NOT APPLYING SECURITY TO THE TECHNOLOGY 5-2

ANNEX A SPECIFICATIONS FOR PN RANGING (NORMATIVE) A-1
ANNEX B EXAMPLE OF AVAILABLE CHIP RATES (INFORMATIVE) B-1
ANNEX C INFORMATIVE REFERENCES (INFORMATIVE) C-1
ANNEX D ABBREVIATIONS AND ACRONYMS (INFORMATIVE) D-1

© ISO 2015 – All rights reserved

CONTENTS (continued)

Figure Page

3-1 Regenerative T4B PN Code Generation 3-1
3-2 Regenerative T2B PN Code Generation 3-2
4-1 Transparent T2B PN Code Generation 4-1

Table

3-1 Uplink Chip Rates 3-4
3-2 Theoretical Ranging Code Phase Acquisition Time for the On-Board Receiver 3-6
3-3 Theoretical (One-Way) Ranging Jitter for the On-Board Receiver 3-7
3-4 Theoretical Ranging Code Phase Acquisition Time for the Station Receiver 3-9
3-5 Theoretical (One-Way) Ranging Jitter for the Station Receiver 3-10
4-1 Theoretical Ranging Code Phase Acquisition Time for the Station Receiver (Transparent Ranging) 4-5
4-2 Theoretical (One-Way) Ranging Jitter for the Station Receiver (Transparent Ranging) 4-6
A-1 Key Specifications for On-Board PN Regenerative Ranging A-1
A-2 Key Specifications for PN Ranging and On-Board Transparent Channel A-2
B-1 Example of Available Chip Rates B-1

© ISO 2015 – All rights reserved

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide a Recommendation for Space Data System Standards in the area of transparent[1] and regenerative Pseudo-Noise (PN) ranging systems. The PN ranging system is used to measure the round-trip light time between a ground station and a spacecraft. Regenerative ranging is primarily relevant for low Signal-to-Noise Ratio (SNR) cases like those seen in deep space missions; transparent ranging is more suitable for high SNR cases or when high accuracy ranging is not required.

1.2 SCOPE

This Recommended Standard defines both transparent and regenerative PN ranging systems for non–data relay satellite users. The specification for PN code components and generation, on-board spacecraft regenerative/transparent processing, ground station processing, and uplink and downlink signal modulation are defined in this document. This Recommended Standard does not specify a) individual implementations or products, b) implementation of service interfaces within real systems, or c) the management activities required to configure and control the protocol.

1.3 APPLICABILITY

The Recommended Standard specified in this document is to be invoked through the normal standards programs of each CCSDS Agency and is applicable to those missions for which cross support based on capabilities described in this Recommended Standard is anticipated. Where mandatory capabilities are clearly indicated in sections of the Recommended Standard, they must be implemented when this document is used as a basis for cross support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross support agreements between the Agencies involved.

1.4 RATIONALE

The CCSDS believes it is important to document the rationale underlying the recommendations chosen, so that future evaluations of proposed changes or improvements will not lose sight of previous decisions. Concept and rationale behind the decisions that formed the basis for this Recommended Standard are found in the CCSDS Pseudo-Noise Ranging Systems Green Book (reference [C1]).

[1] The term *'transparent ranging'* is used in this standard to mean non-regenerative ranging or turn-around ranging.

© ISO 2015 – All rights reserved

1.5 CONVENTIONS AND DEFINITIONS

1.5.1 DEFINITIONS

The following definitions apply throughout this Recommended Standard:

chip rate: rate at which the PN code bits (or 'chips') are transmitted.

coherent transponder: transponder for which the downlink carrier is phase-coherent with the received uplink carrier.

component sequences: family of shorter-length PN sequences used to form the ranging PN code using logic operations.

range clock: PN component code with the highest frequency (i.e., shortest period); determines the range resolution.

regenerative ranging: type of ranging where the spacecraft demodulates and acquires the ranging code by correlation with a local code replica from the uplink ranging signal, and regenerates the ranging code on the downlink.

transparent ranging: type of ranging where the spacecraft frequency-translates the uplink ranging signal to the downlink without code acquisition (i.e., non-regenerative ranging or turn-around ranging).

one-way jitter: ranging jitter in meters resulting from measuring the round-trip light time and halving the measurement to compute the distance.

1.5.2 NOMENCLATURE

The following conventions apply through this Recommended Standard:

- the words 'shall' and 'must' imply a binding and verifiable specification;
- the word 'should' implies an optional, but desirable, specification;
- the word 'may' implies an optional specification;
- the words 'is', 'are', and 'will' imply statements of fact.

1.5.3 CONVENTIONS

In this document, the following convention is used:

- A '+1' ranging chip corresponds to a binary 0 value;
- A '−1' ranging chip corresponds to a binary 1 value.

© ISO 2015 – All rights reserved