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| independent implementations for Optical On-Off-Keying Physical Layer |

CCSDS Record

CCSDS xxx.0-Y-1

Yellow Book

February 2021

FOREWORD

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|  |  |  |  |
| --- | --- | --- | --- |
| **Document** | **Title** | **Date** | **Status** |
| CCSDS xxx.0-Y-1 | Independent implementations for optical on-off-keying physical layer | February 2021 | Current issue |
|  |  |  |  |

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# INTRODUCTION

## Purpose

This document is a record of two independent implementations of the physical layer for the optical on-off-keying (O3K) update proposed in pink sheets [1] to CCSDS 141.0-B-1, “Optical Communications Physical Layer” [2]. In order to complete the standardization process, document CCSDS A02.1-Y-4, “Restructured Organization and Processes for the Consultative Committee for Space Data Systems” [3] requires that “at least two independent and interoperable prototypes or implementations must have been developed and demonstrated in an operationally relevant environment, either real or simulated …. The WG Chair is responsible for documenting the specific implementations that qualify the specification for CCSDS Recommended Standard status, along with reports relevant to their testing.” This document serves that purpose.

Document CCSDS A02.1-Y-2 also requires, “If patented or otherwise controlled technology is required for the separate implementations, they each must also have resulted from separate exercise of the licensing process.” No patents of concern have been identified (update this sentence if necessary). Implementers are cautioned that there are many patents filed on the general topics of optical communications.

## Scope

This document is not a part of any CCSDS Recommended Standard.

## Organization of this Report

This document is divided into three parts. Section 1 (this section) presents the purpose and organization. Section 2 documents two independent implementations of the optical communications coding and synchronization tests for interoperation. Section 3 contains a note about patented technology.

# independent implementations of the O3K physical layer standard

## overview

Pink sheets [1] to the 141.0-B-1 CCSDS standard [2] detail the physical layer characteristics of O3K communications systems used by space missions. The characteristics of telemetry, beacon, and optional data transmission accompanying the beacon transmissions are specified for O3K applications.

Implementations are listed in Section 2.2.

## Implementations

Implementations of the hardware for the proposed physical layer are listed below.

### O3K Telemetry signaling

Test results of O3K telemetry signaling at the physical layer (Section 5 of [1]) is shown in Table 2-1, where in each case, as least two independent manufacturers have demonstrated compliance, with either prototypes or commercially available products. [TBR] Implementation of the physical layer hardware for optical communications has been under development at <your space agency> internally as well as through various vendors in support of research and flight projects. <include further prose description of your efforts, as appropriate, that relate to the proposed standard.>

Describe vendors/manner in which entries in Table were filled.

**Table 2-1: Laser for O3K telemetry signaling**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **CCSDS Requirement** | **Prototypes Tested Value** | **Manufacturer** | **Compliance** |
| Center Frequencies | 193.1 + *n*x0.1 THz, $-18\leq n\leq 28$ |  |  | ✓ (include in each row) |
| Center Frequency Tolerance | +/- 10 GHz |  |  |  |
| Linewidth | < 10 GHz, FWHM over 100 ms |  |  |  |
| In-Band Emissions | 95% E within ±20 GHz |  |  |  |
| Modulation | OOK |  |  |  |
| Pulse shape/eye diagram | 5.6.2 |  |  |  |
| Timing Jitter | < 10% slot width, RMS |  |  |  |
| Extinction Ratio | $\geq 10$ dB |  |  |  |
| Slot Width | $$0.1×2^{k}, 0\leq k\leq 13$$ |  |  |  |
| Pulse Repetition Rates | To support slot widths and PPM order  |  |  |  |

### O3K Beacon and optional accompanying data transmission

Test results of beacon and optional accompanying data transmission at the physical layer (Section 6 of [1]) is shown in Table 2-2. [TBR] Implementation of the physical layer hardware for this proposed standard has been under development at <your space agency> internally as well as through various vendors in support of research and flight projects. <include further prose description of your efforts, as appropriate, that relate to the proposed standard.>

Describe vendors/manner in which entries in Table were filled.

**Table 2-2: Beacon Laser**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **CCSDS Requirement** | **Prototype Tested Value** | **Manufacturer** | **Compliance** |
| Center Frequencies | 188.350 to 188.750 THz;195.000 to 195.900 THz;281.543 to 281.807 THz;370.112 to 371.948 THz |  |  | ✓ |
| Center Frequency Tolerance | ±50 GHz for a), b);±132.3 GHz for c);±918 GHz for d) |  |  |  |
| Laser Linewidth | ±50 GHz for a), b); ±66 GHz for c), and ±50 to 300 GHz for d), FWHM over 100 ms |  |  |  |
| In-Band Emissions | 95% E within ±100 GHz for a), b); ±193 GHz for c); ±1218 GHz for d) |  |  |  |
| Modulation | OOK |  |  |  |
| Beacon Pulse Repetition Rate | 1 kHz to 10 MHz for a), b), c); 0 to 10 kHz for d) |  |  |  |
| Timing Jitter | < 10% slot width, RMS |  |  |  |
| Extinction Ratio | $\geq 10$ dB |  |  |  |

# Patent considerations

[ Disclose all relevant patents here, along with evidence that the patent will be offered on reasonable and non-discriminatory terms. If your space agency and your vendors have no patents, state: “<your space agency> has filed no patents relevant to the proposed O3K physical layer standard.”

Implementers are cautioned that there are many patents on the general topic of physical layer optical communications.

# References

1. Pink Sheets which incorporate O3K into reference [2], with filename 141x0p11\_final\_clean+RID-resolutions-v4 .doc, January 2021.
2. *Optical Communications Physical Layer*. CCSDS 141.0-R-1, Red Book, Washington, D.C., August 2019.
3. *Restructured Organization and Processes for the Consultative Committee for Space Data Systems*. CCSDS A02.1-Y-4. Yellow Book. Washington, D.C., April 2014.