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Multimedia systems and equipment – Multimedia signal transmission – Dependable line code with error correction

Systèmes et équipements multimédias – Transmission de signaux multimédias – Code en ligne fiable avec capacité de correction d'erreurs

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MULTIMEDIA SYSTEMS AND EQUIPMENT – MULTIMEDIA SIGNAL TRANSMISSION – DEPENDABLE LINE CODE WITH ERROR CORRECTION

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The text of this International Standard is based on the following documents:

Draft	Report on voting
100/4289/FDIS	100/4318/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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INTRODUCTION

This document defines a line code with error correction to ensure dependable communication. Several complex machines, such as IoT devices, wearable devices, sensor networks, robotics, and spacecraft, have a growing demand for distributed processing. In addition, modernizing facilities such as factories, offices, schools, and homes creates a ubiquitous and multimedia computing environment. Unlike conventional PC applications for documentation and Internet applications that exchange texts without time constraints, these types of cooperative computing require reliable real-time responses to physical events occurring in the real world that can be noisy. For distributed nodes to cooperate in real-time, an interconnecting network realizes dependable real-time communication without re-transmission in noisy environments. As a dependable line code with error correction for such reliable real-time communications, the 4b/10b provides an embedded clock, DC (direct current) balance, error detection, and error correction capabilities at a time.

"Real-time" means that the exactness of the system, including computation and communication, depends not only on the result but also on the time taken to achieve the result. In a narrow sense, "real-time" means that the time constraints, including deadlines or periods, are met. A line code is the lowest-level communication protocol on a communication line. Most current line codes have typical functions, including the embedded clock, DC balance, and basic error detection. The 8b/10b line code [1][1] is a major example, which is used for USB 3.0 [2], Serial ATA [3], and PCI Express 2.0 [4]. However, no conventional line code has an error correction capability. In the case of the 8b/10b line code, when one bit of an encoded code (a 10b code) is inverted during communication, the multi bits of the decoded code (the 8b code) are inverted. In other words, when a single-bit error occurs in an encoded 10-bit code, the decoded 8-bit code (a byte) is completely corrupted.

When the decoder detects an error, the corrupted data is generally re-transmitted under an upper-level communication protocol. However, the re-transmission scheme is unsuitable for real-time communication because the WCRT cannot be obtained. Therefore, the forward error correction scheme against the bit error is required for real-time communication. However, even if a one-bit error occurs in the encoded line code, multiple bits of the decoded code are inverted at the receiver, so it is difficult to use a bit-error correction code, such as Hamming code or BCH code, as an error correction code.

To correct an error at the receiver side, it has been necessary to use a block-level error correction code such as RS (Reed-Solomon) code in a large block unit at the subsequent stage. In this scheme, error correction can only be performed if all packets are received, and latency becomes long. Therefore, this scheme is also unsuitable for real-time communication. The line code with error correction is desirable for reliable and low-latency real-time communication.

The 4b/10b line code is designed so that the following functions necessary for dependable real-time communication, which could not be performed at a time by conventional line codes, can be achieved by a single line code:

a) embedded clock,

b) DC balance,

c) error detection, and

d) error correction

[1] Numbers in square brackets refer to the Bibliography.

The 4b/10b line code is designed for highly reliable digital communications among sensor networks, wearable devices, robots, etc. Even in extremely noisy environments where communication cannot be performed by a conventional line code, such as the 8b/10b line code, communication can be performed using the 4b/10b line code. Since communication errors can be corrected per hop by hop using the 4b/10b line code and error correction latency becomes short, the 4b/10b line code is suitable for reliable real-time communications.

Moreover, the 4b/10b line code is designed to have high affinity with the 8b/10b line code, which is one of the most popular line codes. All 10b codes of the 4b/10b line code are fully included in the 10b codes of the 8b/10b line code. For example, more reliable communication can be achieved by changing the line code from 8b/10b to 4b/10b.

Sensor networks and wearable device communications are typical target applications, as shown in Figure 1, since the 4b/10b line code is specially designed for reliable real-time communications in noisy environments. Many sensors, actuators, and IoT devices are connected via sensor networks, whose cables are inexpensive and affected by external noises. Error-free real-time communications are required to realize these distributed real-time systems. Although the 4b/10b line code has error detection and error correction functions, it can be implemented by small-scale hardware. Since re-transmission at the upper communication layer is unnecessary, communication latency becomes short, which is especially suitable for wearable devices and sensor networks.

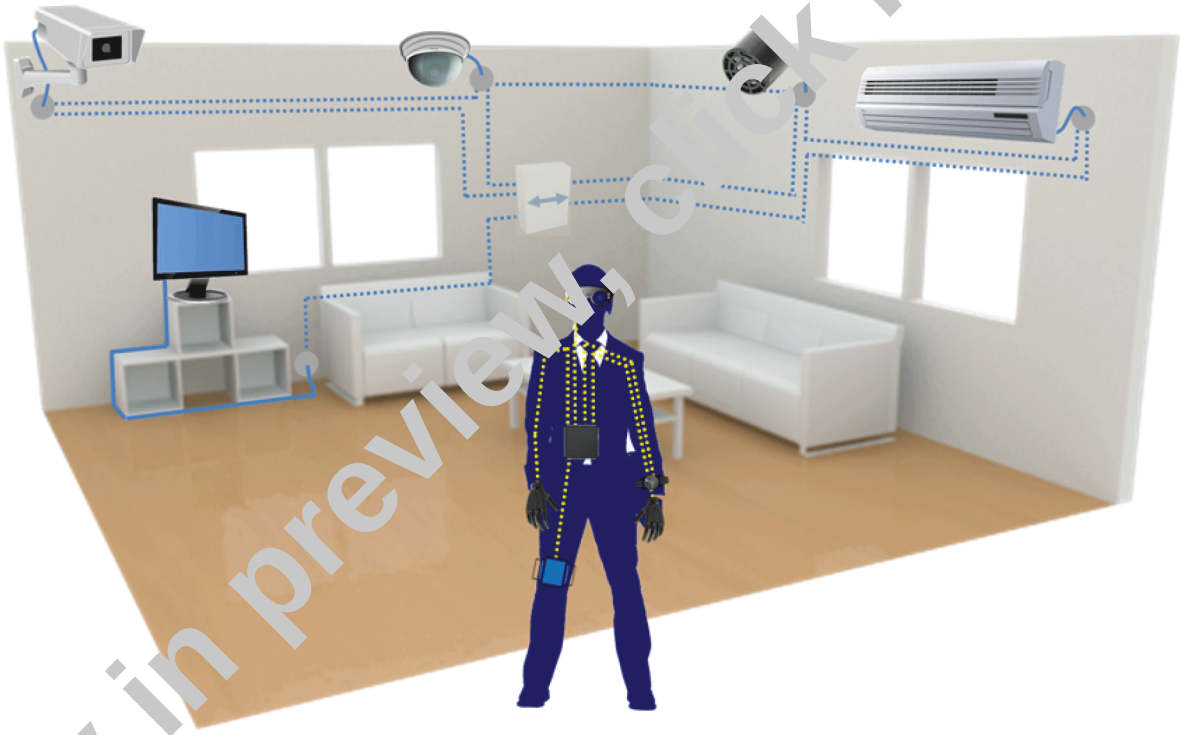

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Figure 1 – Communications among sensor networks and wearable devices

MULTIMEDIA SYSTEMS AND EQUIPMENT – MULTIMEDIA SIGNAL TRANSMISSION – DEPENDABLE LINE CODE WITH ERROR CORRECTION

1 Scope

This document specifies the 4b/10b line code with error correction for dependable multimedia data transmission, especially for real-time communications even in noisy environments, such as IoT devices, wearable devices, sensor networks, robotics, and spacecraft. This document corresponds to the functions specified in layer 1 to layer 2 of the OSI reference model (ISO/IEC 7498).

This document aims to facilitate the usage of the 4b/10b line code in complex systems by providing the 4b/10b line code protocol. This document defines the 4b/10b line code protocol for interconnections in complex systems, mainly distributed real-time systems such as embedded systems, control systems, IoT devices, wearable devices, sensor networks, amusement systems, robot systems, and spacecraft. Specifically, the 4b/10b line code is the line code that realizes embedded clock, DC balance, error detection, and error correction at the same time, whose functions are not satisfied by a conventional single line code so that the 4b/10b line code can achieve highly reliable digital communications. The most significant feature of the 4b/10b line code is that it is a line code with error correction capability. Therefore, there is no need for error correction in the upper layers, and communication can be performed using only the 4b/10b line code in noisy environments.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model – Part 1*

ISO/IEC 24740:2008, *Information technology – Responsive Link (RL)*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

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- IEC Electropedia: available at https://www.electropedia.org/
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3.1 Terms and definitions

3.1.1
byte
B
group of eight bits