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Information technology — Telecommunications and information exchange between systems — Powerline communication (PLC) — High speed PLC medium access control (MAC) and physical layer (PHY) —

Part 1: General requirements

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Courants porteurs en ligne (PLC) — Contrôle d'accès au support (MAC) et couche physique (PHY) par PLC à grande vitesse —

Partie 1: Exigences générales

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Foreword

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

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ISO/IEC 12139-1 was prepared by Korean Agency for Technology and Standards (as KS X 4600-1) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by the national bodies of ISO and IEC.

ISO/IEC 12139 consists of the following parts, under the general title *Information technology — Telecommunications and information exchange between systems — Powerline communication (PLC) — High speed PLC medium access control (MAC) and physical layer (PHY)*:

— *Part 1: General requirements*

Advanced MAC and PHY requirements will form the subject of a future Part 2.

Part 1 covers MAC and PHY technology for In-home/Access data networks via powerline communications (PLC), the system of which is operating below 30MHz. The coexistence schemes will be considered in developing Part 2, which will apply to data and high quality multimedia networks requiring advanced MAC and PHY technology. The used or forbidden band of this standard will be subject to national regulations.

Information technology — Telecommunications and information exchange between systems — Powerline communication (PLC) — High speed PLC medium access control (MAC) and physical layer (PHY) —

Part 1:
General requirements

1 Scope

The scope of this standard is a physical and medium access control layer specification with respect to the connectivity for 'In-home' and 'Access' network high speed powerline communication stations.

This standard provides functional requirements and specification of the physical and medium access control layer for high speed powerline communication devices, and does not include specific implementation methods.

2 Normative References

The following referenced documents are indispensable for the application 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 8802-11:2005, Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications

ITU-T G.992.1: Asymmetric Digital Subscriber Line (ADSL) Transceivers

ITU-T G.994.1: Handshake Procedure for Digital Subscriber Line (DSL) Transceivers

IEEE Std 802.3:2000, Information technology — Local and metropolitan area networks — Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications

FCC Rules, 47 CFR (10-1-98 Edition), Part 15: Radio Frequency Devices

Federal Information Processing Standards: Publication 46-3 Data Encryption Standard (DES)

T1E1.4 Trial-Use Standard: Very-High-Bit-Rate Digital Subscriber Lines (VDSL) Metallic Interface Part 1: Functional Requirements and Common Specification

T1E1.4 Trial-Use Standard: Very-High-Bit-Rate Digital Subscriber Lines (VDSL) Metallic Interface Part 3: Technical Specification for a Multi-Carrier Modulation (MCM) Transceiver

3 Terms and Definitions

3.1 Ad-hoc network
A network consisting of only stations within the boundary of communication through powerlines
The ad-hoc network is typically generated in a voluntary manner.

3.2 Backbone
A facility or a collection of facilities for connecting LAN to WAN

3.3 Backoff Period
A period during which stations contend for the medium access

3.4 Backoff Procedure
A procedure to disperse the times at which stations with queued frames attempt transmission

3.5 Backoff Value
The number of time slots that a station shall wait for initiating a transaction

3.6 Bit
The basic unit of the binary system
In binary system, every number is expressed in '0' or '1', each of which is a bit.

3.7 Byte
A unit comprised of a set of bits, the basic unit of data representing '0' or '1'
8 bits constitute 1 byte.

3.8 Carrier Sense
A station's standard for determining whether the medium is currently occupied

3.9 Cell
A synonym for logical network

3.10 Cell Bridge (CB)
A station connecting two different cells
Cell Bridge provides the repeater functionality.

3.11 Ciphertext
Encrypted data

3.12 Cleartext
Unencrypted data

3.13 Collision
An event of two or more frames colliding in the medium, caused by simultaneous transmission of the frames

3.14 Contention Window
A slotted range in which each station can select a time slot to initiate a transaction

3.15 Delimiter
A combination of preamble and control frame

3.16 Differential Modulation
A modulation that encodes information by the 'phase difference' between two consecutive symbols

3.17 Discrete Multi-Tone (DMT)
A modulation technique in which a channel with a certain bandwidth is divided into subchannels (or tones) of narrower bandwidths
Each subchannel is modulated by a different subcarrier.

3.18 Flip-flop
A circuit that has two stable states
It maintains its state until the input decides on one stable state and another input approves of it by deciding on the other state.
It can memorize a bit by corresponding two stable states to '1' and '0'.

3.19 Frame
A synonym for PSDU

3.20 Home Networking
Sharing digital data and constructing an environment with availability of broadband communication by forming a network between information devices at home

3.21 InterFrame Space
A time interval between frames on the medium

3.22 Link Timer
A value that increases at each symbol after the link between two stations is established

3.23 Logical Network

A network classified by Group Identifier (GID)
A single physical network can be divided into more than one logical network.
Logical Network is a synonym for cell.

3.24 MAC Management Information (MMI)

Management information for MAC generated by MAC Management Entity (MME)

3.25 MAC Protocol Data Unit (MPDU)
A frame unit that consists of frame header and frame body
Frame body contains either MSDU(s) or MMI(s), each in FBB format.

3.26 MAC Service Data Unit (MSDU)
A frame unit used in the MAC layer
It contains data from link layer.

3.27 Medium BUSY
A medium state indicating that a station has occupied the medium
To determine this state, Physical Carrier Sense (PCS) and Virtual Carrier Sense (VCS) are used.

3.28 Medium CONTENTION
A medium state indicating that stations are contending for the medium access
It starts after Short Contention InterFrame Space (SCIFS) or Long Contention InterFrame Space (LCIFS) from the end of the last previous transaction.

3.29 Medium IDLE
A medium state indicating that no station has occupied the medium
It starts after SCIFS or LCIFS plus maximum Contention Window Size (CWS) from the end of the last previous transaction.

3.30 MAC Interface (MI)
The logical interface between the upper link layer and the MAC layer of the station

3.31 Network
A collection of interconnected elements that provides connection services to users

3.32 PHY Interface (PI)
The physical interface between the station and powerline

3.33 Privacy
The service to prevent the content of messages from being read by others beside the intended recipients

3.34 Proxy Station
The representative of all stations within a logical network
It renders partial Automatic Repeat reQuest (ARQ) possible.

3.35 PHY Service Data Unit (PSDU)
A frame unit used in physical layer

3.36 Reassembly
The reverse process of segmentation

3.37 Repeater
A station that relays frames from one station to another station for which direct communication is impeded

3.38 Routing Table
A table that maps MAC addresses to Station Identifier (SID) and Tone Map Index (TMI)

3.39 Scrambler
A circuit that converts the input data into random signal series in order to repress the single frequency component by repeating regular data patterns among the successive input data

3.40 Segmentation
A process of partitioning a service block into multiple segments

3.41 Serial Interface
The interface in which all the data are transmitted through the same communication line, bit after bit

3.42 Service Block
A synonym for Frame Body Block (FBB)

3.43 Station
A synonym for PLC Transceiver Unit (PTU)

3.44 Sub-frame
A group of symbols existing in a frame
Sub-frame includes the control frame and the data frame.

3.45 Symbol
A bit or a defined sequence of bits

3.46 Symbol Block
A group of symbols processed as one unit in physical layer
Its length is always 16 symbols.

3.47 Time Slot
A time unit used in backoff procedure

3.48 Transaction
A minimal set of interactively transmitted/received frames between two stations

3.49 Transaction Combo
A combination of consecutive transactions
Except for the first transaction, all transactions in a transaction combo do not contend for the medium. The interframe space between two contiguous transactions in a transaction combo is always Short Response InterFrame Space (SRIFS).

3.50 Transmission Mode
Frame-based transmission scheme
Transmission mode is classified into Diversity (DV), Extended DV (EDV), and NORMAL modes.

3.51 VLAN Tag
The field within the layer-2 frame header defined in 802.1Q

4 Acronyms and Abbreviations

ACK	ACKnowledgement
AES	Advanced Encryption Standard
AG	AGC Gain
AGC	Automatic Gain Control
ARQ	Automatic Repeat reQuest
A/V	Audio/Video
BF	Broadcast Flag
BPS	Bits Per Symbol
BPSK	Binary Phase Shift Keying
CB	Cell Bridge
CE	Channel Estimation
CF	Control Frame
CFCS	Control Frame Check Sequence
CP	Cyclic Prefix
CRC	Cyclic Redundancy Check
CRD	Collision Recovery Duration
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
CTS	Clear To Send
CWS	Contention Window Size
D8PSK	Differential 8-ary Phase Shift Keying
DBPSK	Differential Binary Phase Shift Keying
DES	Data Encryption Standard
DF	Data Frame
DFCS	Data Frame Check Sequence

DMT	Discrete Multi-Tone
DQPSK	Differential Quadrature Phase Shift Keying
DSID	Destination Station ID
DT	Delimiter Type
DV	DiVersity
DVF	DiVersity Flag
EDV	Extended DiVersity
FBB	Frame Body Block
FBBL	Frame Body Block Length
FBBP	Frame Body Block Payload
FBBPAD	Frame Body Block PADding
FBBSSID	Frame Body Block Source Station ID
FBBT	Frame Body Block Type
FBBTTL	Frame Body Block Time To Live
FBBV	Frame Body Block Version
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FPV	Frame Protocol Version
GF	Galois Field
GID	Group ID
ID	IDentifier
IFFT	Inverse Fast Fourier Transform
IFS	InterFrame Space
ITR	Inverse TRaining
LCIFS	Long Contention InterFrame Space
LRIFS	Long Response InterFrame Space
LSB	Least Significant Bit
LSF	Last Segment Flag
MAC	Medium Access Control
MII	Media Independent Interface
MME	MAC Management Entity
MMI	MAC Management Information
MPDU	MAC Protocol Data Unit
MSB	Most Significant Bit
MSDU	MAC Service Data Unit
MTMI	My Tone Map Index

N/A	Not Applicable
NFBB	Number of Frame Body Block
NSB	Number of Symbol Block
NMS	Network Management System
PCS	Physical Carrier Sense
PHY	PHYsical (layer)
PLC	PowerLine Communication
PRS	Pseudo-Random Sequence
PSDU	PHY Service Data Unit
PSK	Phase Shift Keying
PTMI	Partner's Tone Map Index
PUNCI	PUNCturing Indicator
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RET	REsponse Type
RF	Response Flag
RS	Reed-Solomon
RT	Routing Table
RTS	Request To Send
SB	Service Block
SC	Segment Count
SCIFS	Short Contention InterFrame Space
SEG	SEGmentation
SID	Station ID
SN	Sequence Number
SNR	Signal-to-Noise Ratio
SRB	Slot Reservation Bit
SRIFS	Short Response InterFrame Space
SSID	Source Station ID
STA	STAtion
TM	Tone Map
TMI	Tone Map Index
TR	TRaining
TS	Training Sequence
TSD	Time Slot Duration
TSF	Training Sequence Flag

TSR	Training Sequence Request
UART	Universal Asynchronous Receiver Transmitter
VC	Version Control
VCS	Virtual Carrier Sense
VF	Variant Field
VLAN	Virtual Local Area Network

5 Reference Models

High speed PLC refers to interactive communication between more than two PLC devices in in-home or access network by using low and medium voltage powerline. Each PLC device can communicate with other PLC devices with the same group identifier as itself, and can communicate in various manners by forming a single logical network with them.

5.1 PLC Reference Model

Reference model of a high speed PLC system is constituted as in Fig. 1.

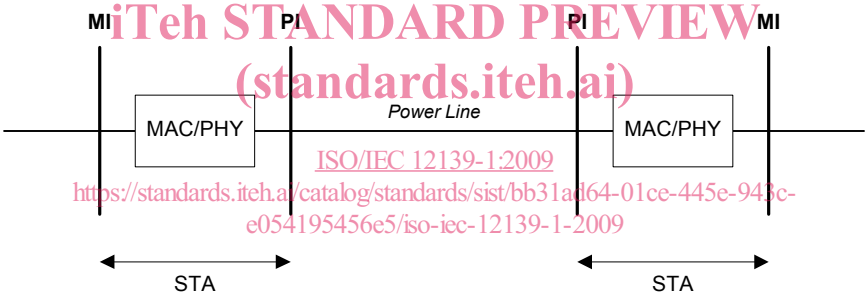

Fig. 1 - PLC Reference Model

PHY Interface (PI) is the physical interface between STA and the powerline. MAC Interface (MI) is the logical interface defining the relationship between the upper link layer and MAC layer of STA. The device including MAC and PHY, which are defined in this standard, is referred to as STA.

5.2 Interface Protocol Reference Model

Interface protocol reference model, illustrated in Fig. 2, is another expression of reference model and emphasizing the layer structure. The "upper layer" in this standard refers to the link layer above MI.

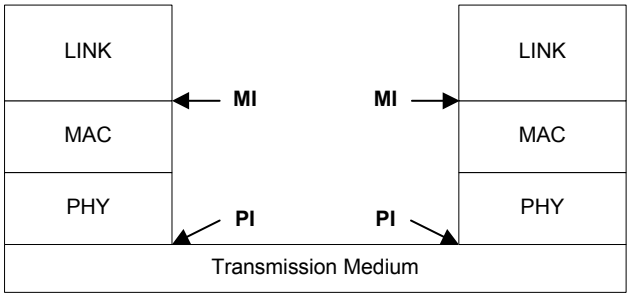

Fig. 2 - PLC Protocol Reference Model

5.3 PLC Network Topology

5.3.1 Home Networking

Fig. 3 illustrates the network topology in case of STA being applied to in-home for home networking only. STAs of each home shall form a cell (logical network) through GID. Each cell co-exists on the same physical network, but they shall be logically separated. Privacy shall be guaranteed by encoding data using different encryption keys. STAs of each cell render ad-hoc network and access network services possible through one-to-many communication.

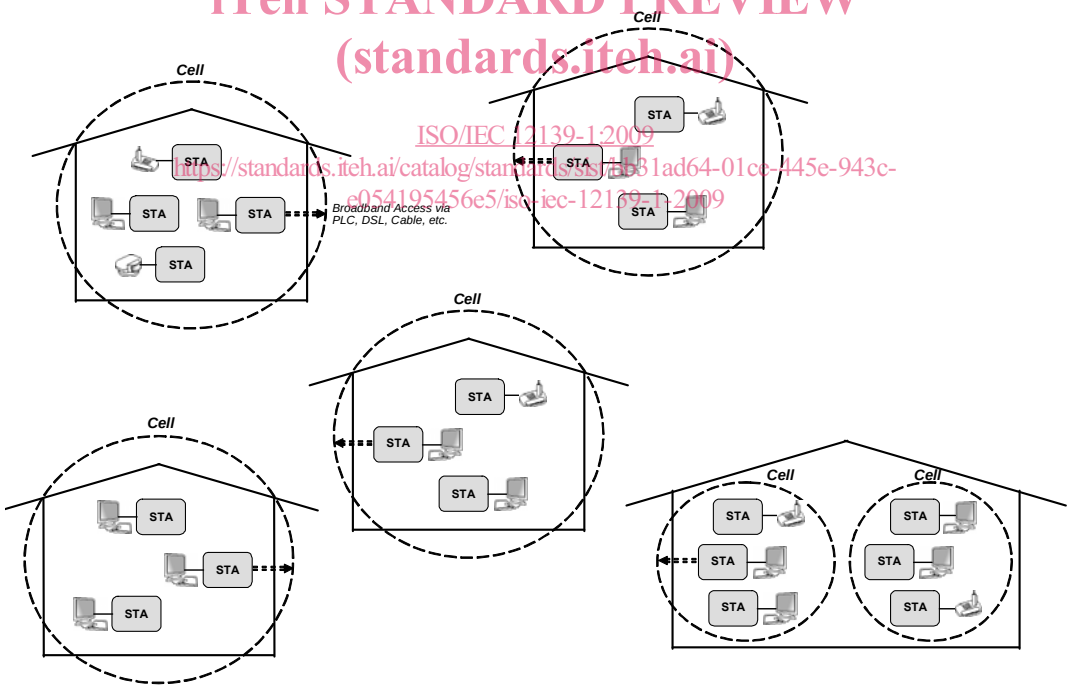

Fig. 3 - PLC Network Topology for Home Networking

5.3.2 Access Network

Fig. 4 illustrates the network topology in case of STA being applied to the access network. The entire PLC network is roughly divided into in-home network and access network.

STA functioning as the connection point with the backbone network in the access network is located on neighborhood transformer and thereby renders it possible for STAs existing in the same physical network to form a high speed access network.

Cell Bridge (CB), which is STA connecting two separate cells (two logical networks), makes it possible for the STAs at home to access a high speed access network. CB also functions as the repeater extending the communication coverage.

STAs composing in-home network can access a high speed access network through home networking and CB.

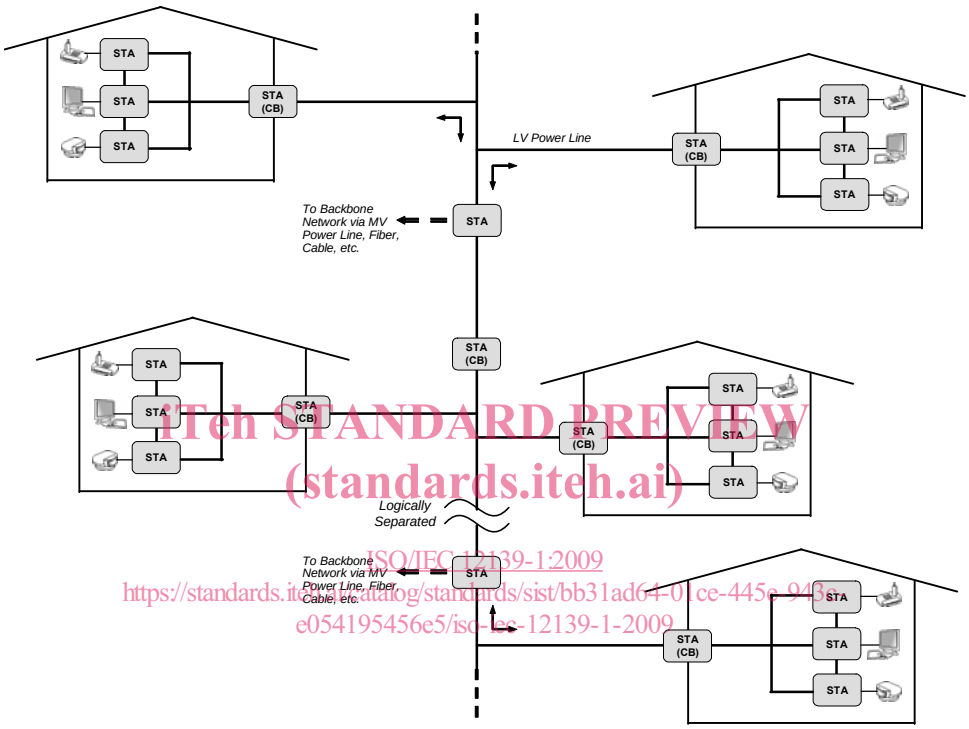

Fig. 4 - PLC Network Topology for Access Network

6 PHY Specification

The PHY specification presented in this chapter is for data network using high speed PLC.

6.1 Overview of PHY

The modulation-demodulation adopts DMT method. Table 1 shows the basic specification of PHY. Fig. 5 illustrates a DMT symbol to which cyclic prefix and pulse shaping are applied.

Table 1 - Specification of PHY

Item	Value
Bandwidth used	2.15 ~ 23.15 MHz
Forbidden band	*
Tone space (= 25MHz / 256)	97.65625 kHz
Sampling frequency	50 MHz
IFFT interval [Tfft]	512 sample
Cyclic prefix interval [Tcp]	128 sample

Rolloff interval [ßT]	16 sample
Symbol interval [Ts = Tfft + Tcp - ßT]	624 sample
Symbol rate	80.1282 kHz
Symbol period without CP	10.24 μs
Symbol period with CP	12.48 μs
Tone (or sub-channel) modulation	DBPSK, DQPSK, D8PSK
* This shall be subject to national regulations.	

DMT system presented in this standard shall adopt a bandwidth of 2.15~23.15MHz and each tone has a bandwidth of 97.65625kHZ (theoretical) with the exception of the bandwidth designated as the guard band in accordance with each national regulation. The cyclic prefix of 128 samples shall be used in order to remove interference between DMT symbols in powerline channels. In addition, in order to reduce the probability of a packet error caused by the noise generated in the powerline channel, Forward Error Correction (FEC) comprising the convolutional codes and Reed-Solomon codes shall be used. For the modulation method used in each tone, DBPSK, DQPSK and D8PSK shall be adopted according to the channel condition.

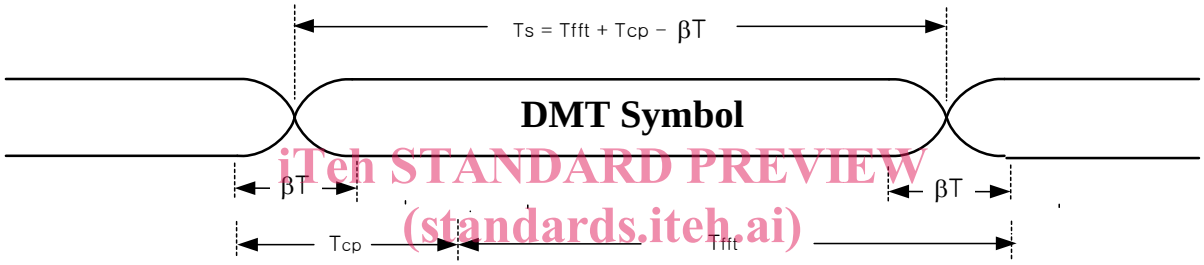

Fig. 5 - DMT Symbol

6.2 PSDU Format

The structure of PHY Service Data Unit (PSDU) used in this standard is shown in Fig. 6 and comprises delimiter and Data Frame (DF). The delimiter is composed of preamble and Control Frame (CF). DF may or may not exist according to the characteristics of the frame. The frame that has no DF is referred to as short PSDU and the frame that has DF is referred to as long PSDU. CF and DF are sub-frames existing in PSDU.

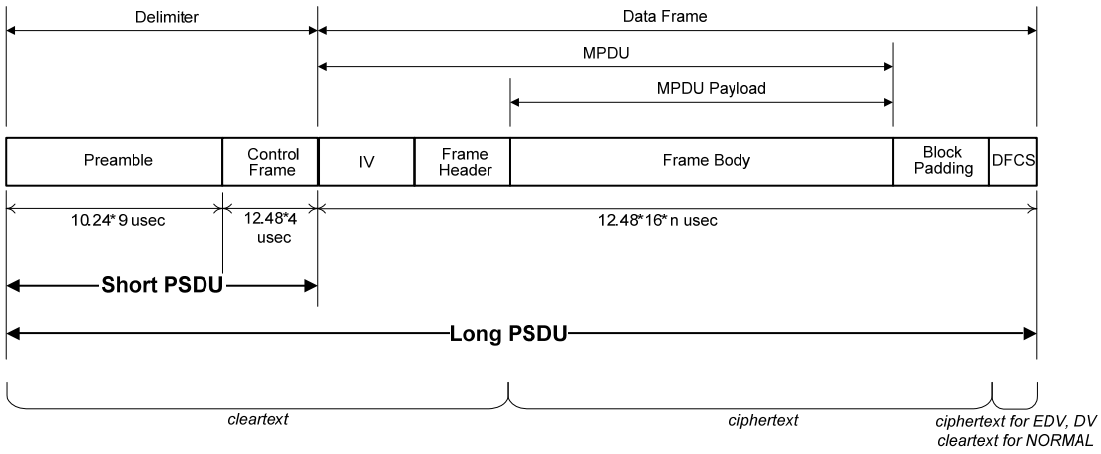

Fig. 6 - PSDU Format

6.2.1 Preamble

Preamble shall consist of 7 TRs followed by 2 ITRs without cyclic prefix. Using this, the reception end