

IEEE Standard for DC Power Transmission and Communication to DC Loads

IEEE Communications Society

Developed by the
Power Line Communications Standards Committee

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STANDARDS

IEEE Standard for DC Power Transmission and Communication to DC Loads

Developed by the

Power Line Communications Standards Committee
of the
IEEE Communications Society

Approved 9 November 2021

IEEE SA Standards Board

Abstract: Physical layer and data link layer specifications for power supply and communication over power lines from a dc power source to multiple dc loads are specified. Each receiver has its own physical address and is connected to the transmitter through a pair of power lines in a multi-drop bus or tree topology. The dc power is sent by the transmitter. This dc power, by electrically changing the voltage of the wires, corresponds to the communication packets, including the control command/data for controlling the dc loads and the target address. Power to the dc loads with the transmitted and voltage-flattened dc power is supplied by each receiver. The control command/data and addresses from electric signals on the power line is decoded by each receiver, to be used for the connected dc loads control if the addresses match. The standard is in compliance with known electromagnetic compatibility (EMC) regulations.

Keywords: DC, dc loads, dc power, dc power line communication, dc power transmission, differential signal, differential signal communication, high-power differential signal power line communication, IEEE 2847™, PLC, power line communication

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Introduction

This introduction is not part of IEEE Std 2847-2021, IEEE Standard for DC Power Transmission and Communication to DC Loads.

This standard defines physical layer and data link layer specifications for power supply and communication over power lines from a dc power source to multiple dc loads. Each receiver has its own physical address and is connected to the transmitter through a pair of power lines in a multi-drop bus or tree topology. The transmitter sends the dc power and the electric signals corresponding to the communication packets, including the control command/data for controlling the dc loads and the target address, through the power line by electrically changing the voltage of the wires. Each receiver supplies power to the dc loads with the transmitted and voltage-flattened dc power. Each receiver decodes the control command/data and address from electric signals on the power line and uses them for the connected dc load control if the address matches. The relationship between this standard and known electromagnetic compatibility (EMC) regulations is also addressed.

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IEEE Standard for DC Power Transmission and Communication to DC Loads

1. Overview

1.1 Scope

This standard defines physical layer and data link layer specifications of a new power supply and communication technology over a power line from a dc power source to multiple dc loads with the following conditions:

- Communication speed is 9600 bps or less.
- DC power source is 50 V or less.
- DC load consumes more than 10 W and less than 2 kW.
- The capacity of one power supply is more than 100 W.
- Each receiver has its own physical address (4 b or more).
- Each receiver is connected to the transmitter through a pair of power line wires of 1 km or less.
- Each receiver is connected to the power line in a multi-drop bus or tree topology.
- The transmitter transmits the dc power and the electric signals in the form of electrically changing voltage of the wires through the power line to the receivers and the signals are corresponding to the communication packets that include the control command/data for controlling the dc loads and the target address.
- Each receiver supplies the transmitted and voltage-flattened dc power to the dc loads.
- Each receiver decodes the control command/data and the address from electric signals on the power line and uses them for the connected dc loads if the address matches.

This standard is for dc power line communication technology given the name *high power differential signal power line communication (HPDS-PLC)*.

The relationship between this standard and known electromagnetic compatibility (EMC) regulations is also addressed.

1.2 Purpose

The purpose of this standard is to define how to supply power and transmit a control command or data through a power line to the dc loads in an economical and reliable way, such as:

- Light-emitting diode (LED) lighting
- DC motor
- DC actuator
- Battery control device
- DC home electronic appliances from dc power source, such as alternating current (ac) to dc power conversion device
- Battery
- Uninterruptible power supply (UPS)
- Energy storage system (ESS)
- Renewable dc power generation device, such as a solar panel

This standard provides the following advantages:

- It enables high noise margin and signal-to-noise (S/N) ratio as well as common mode noise rejection (to use the line dc voltage totally as signal range).
- Costs of communication solutions may be reduced or eliminated by adopting simple circuits.
- Cost of controlling LED lighting or dc loads may be reduced by eliminating electrolytic capacitors for ac to dc conversion that frequently cause failures and shorten the life span of the loads.
- It makes it possible to avoid efficiency problems due to the double conversions of dc→ac→dc in the power supply process from renewable energy generation.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{1, 2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 60227:2007, Polyvinyl chloride insulated cables of rated voltages up to and including 450/750V.³

IEC 60445:2017, Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals, conductor terminations and conductors.

Modbus Protocol Specification V1.1b3, Modbus Organization, 26 Apr. 2012.⁴

TIA-485-A-1998, Electrical characteristics of generators and receivers for use in balanced digital multipoint systems.⁵

UM10204, I2C-bus specification and user manual, Rev. 6, NXP Semiconductors N.V., 4 Apr. 2014.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁶

0–10V: An electronic lighting control signaling system using dc voltage that varies between zero and 10 V as a control signal.

active rectifier: A device for improving the efficiency of rectification by replacing diodes with actively controlled switches, such as power metal oxide silicon field effect transistors (MOSFETs) or insulated gate bipolar transistors (IGBTs).

big-endian: The order or sequence of bytes of a word of digital data in computer memory in a way that the most significant byte of a word at the smallest memory address and the least significant byte at the largest.

Buck converter: A dc/dc power converter that steps down voltage (while stepping up current) from its input (supply) to its output (load). *Syn:* step-down converter

busbar: A metallic strip or bar, typically housed inside switchgears, panel boards, or busway enclosures for local high-current power distribution.

charge-pumping circuit: A kind of dc/dc converter circuit that uses capacitors for energetic charge storage to raise or lower voltage.

Colpitts oscillator circuit: A circuit for LC oscillators, electronic oscillators that use a combination of one inductor (L) and two capacitors (C) to produce an oscillation at a certain frequency.

³IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

⁴Modbus documents available: <https://modbus.org>.

⁵TIA publications are available from the Telecommunications Industry Association (<https://www.tiaonline.org/>).

⁶*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

common mode noise: The same external noise applied to both adjacent wires for signal transmitting and never reflected at the signal when the signal uses the difference of voltages between the two wires.

constant current circuit: A circuit that produces a constant value of current regardless of source voltage or load resistance.

contact resistance: The contribution amount to the total resistance of a system that can be attributed to the contacting interfaces of electrical leads and connections as opposed to the intrinsic resistance.

dc/dc step-down circuit: A dc/dc power converter that steps down voltage (while stepping up current) from its dc input (supply) to its dc output (load).

duplex communication: A point-to-point communication system composed of two or more connected parties or devices that can communicate with one another in both directions.

energy storage system (ESS): A device composed of batteries for storing several kilowatts or more power and modules that manage the batteries.

full-wave rectifier: A device or circuit that converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to pulsating direct current (dc), and yields a higher average output voltage.

gateway: A device or apparatus of a communication network composed of hardware and software that can interconnect with other communication networks using protocols, and equipment that can access other systems.

H-bridge: An electronic circuit that switches the polarity of a voltage applied to a load usually used to control dc motors to run forward or backward.

half-duplex communication (HDX): A communication manner that provides communication in both directions, but only one direction at a time, not simultaneously in both directions.

Hall effect: The production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current.

high-power differential signal power line communication (HPDS-PLC): A new power line communication technology with the following characteristics: The differential value of the voltages of the two-stranded wires of a power line that transmits dc power has two cases, $+V$ or $-V$, which are classified into two polarities, $(+)$ and $(-)$, respectively. When information is mapped to the switching pattern of this differential voltage value and transmitted remotely, the polarity pattern becomes a communication signal called a *differential signal*. The remote receiver decodes the transmission information from the differential signal, and the electricity of the polarity that is switched is converted into a flat dc through a rectifier circuit and is used as a power source for the load on the receiver side.

impedance termination: The practice of ending a transmission line with a device that matches the characteristic impedance of the line for preventing high-speed signals from reflecting off the end of the transmission line.

inrush current: The maximal instantaneous input current drawn by an electrical device when first turned on.

leakage current: The current that causes the gradual transfer of electrical energy across a boundary normally viewed as insulating, such as the spontaneous discharge of a charged capacitor, magnetic coupling of a transformer with other components, or flow of current across a transistor in the “off” state or a reverse-polarized diode.

Manchester encoding: A line coding method in which the encoding of each data bit is either low then high, or high then low, for equal time.

microgrid: A decentralized group of electricity sources and loads that normally operate connected to, and synchronous with, the traditional wide area synchronous grid (macrogrid), but can also disconnect to “island mode.”

Modbus: A data communications protocol originally published by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs).

multi-drop bus (MDB): A computer bus in which all components are connected to the electrical circuit and a process of arbitration determines which device sends information at any point and the other devices listen for the data they are intended to receive.

negative feedback: When some function of the output of a system, process, or mechanism is fed back in a manner that tends to reduce the fluctuations in the output, whether caused by changes in the input or by other disturbances.

node: A redistribution point or a communication endpoint. The definition of a node depends on the referred network and protocol layer.

non-volatile random-access memory (NVRAM): Memory that retains data without applied power.

output impedance: The impedance of an electrical network measured to the current flow (impedance), both static (resistance) and dynamic (reactance), into the load network being connected that is internal to the electrical source.

payload: The part of transmitted data that is the actual intended message. Headers and metadata are sent only to enable payload delivery.

polarity: The voltages A and B of the wires of power line are in one of the two cases: $A > B$ or $A < B$. The former is (+) polarity and the latter is classified as (–) polarity.

polyswitch: A resettable fuse or polymeric positive temperature coefficient device (PPTC) that is a passive electronic component used to protect against overcurrent faults in electronic circuits. The device is also known as a *multifuse* or *polyfuse*.

R_{ds}: The resistance between the drain and the source of metal oxide silicon field effect transistor (MOSFET).

rectifier: An electrical device that converts alternating current (ac), which periodically reverses direction, to direct current (dc), which flows in only one direction.

sensor network: A network that is composed of spatially distributed devices communicating through wireless radio and cooperatively sensing physical or environmental conditions.

slew rate: The change of voltage or current, or any other electrical quantity, per unit of time.

solder mask: A thin lacquer-like layer of polymer that is usually applied to the copper traces of a printed circuit board (PCB) for protection against oxidation and prevention of solder bridges from forming between closely spaced solder pads.

switching pattern of polarity: A changing pattern of the polarity of two wires in promised patterns over time according to the digital bit 0 or 1 of the data to be transmitted.

tree topology: A hybrid network topology in which star networks are interconnected via a bus network.

V_{ce}: Voltage between the collector and the emitter of bipolar transistor.

V_{ds}: Voltage between the drain and the source metal oxide silicon field effect transistor (MOSFET).

V_f: The forward bias voltage of diode.

V_{gs}: Voltage between the gate and the source metal oxide silicon field effect transistor (MOSFET).

voltage drop: The decrease of electrical potential along the path of a current flowing in an electrical circuit.

3.2 Acronyms and abbreviations

ac	alternating current
ac/dc	alternating current/direct current
ACK	acknowledge
AMI	advanced metering infrastructure
ARM	advanced reduced instruction set computer (RISC) machine
bps	bits per second
CAN	controller area network
CEMF	counter-electromotive force
CoAP	Constrained Application Protocol
CRC	cyclic redundancy check
dc	direct current
dc/dc	direct current/direct current
DIP	dual in-line package
DLLF	data link layer frame
DPDH	dual pole dual through
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMS	electromagnetic susceptibility
ESD	electrostatic discharge
ESS	energy storage system
HPDS	high-power differential signal
HTTP	Hypertext Transfer Protocol
HVDC	high-voltage direct current
I/O	input/output
I ² C	inter-integrated circuit
IC	integrated circuit

ID	identification
Id	drain current
IEC	International Electrotechnical Commission
IGBT	insulated gate bipolar transistor
IoT	Internet of things
IP	Internet Protocol
IR	infrared
LAN	local area network
LED	light-emitting diode
LPWAN	low-power wide-area network
MCU	microcontroller unit
MOSFET	metal oxide silicon field effect transistor
MQTT	message queuing telemetry transport
MSB	most significant bit
NPN	negative-positive-negative
NRZ	non-return-to-zero
NVRAM	non-volatile random-access memory
OPAMP	operational amplifier
PCB	printed circuit board
PHY	physical layer
PLC	power line communication
PNP	positive-negative-positive
PoC	power over coaxial
PoE	power over ethernet
PWM	pulse width modulation
R/C	radio/control
RAM	random access memory
RC	resistance capacitance
Rds	drain-source on-resistance
RF	radio frequency
RGB	red, green, and blue
RXD	receive data
RZ	return-to-zero
S/N ratio	signal-to-noise ratio
SCL	serial clock
SDA	serial data

SNR	signal-to-noise ration
SPI	serial peripheral interface
THD	total harmonic distortion
TTL	transistor-transistor logic
TVS	transient voltage suppressor
TXD	transmit data
UART	universal asynchronous receiver transmitter
UPS	uninterruptible power supply
USB	universal serial bus

4. General description

4.1 Background

The era of energy alternation has persisted since the electricity debate between Tesla and Edison in the 1880s. With the recent development of information and communication technology, most current devices are dc-powered devices, and the technical field of power transmission and distribution is rapidly changing into a dc power environment, such as high-voltage direct current (HVDC) transmission and distribution according to the development of power semiconductors. In addition, a paradigm shift is finally taking place from the era of ac electricity to the era of dc electricity due to the spread of new and renewable energy such as solar power, leading to peak power demand, the use of batteries and dc storage electricity, and the emergence of electric vehicles.

However, most devices that use dc power (such as information and communication devices and household electrical devices) also have a power supply that converts ac to dc in each electric device according to the environment of the existing ac power supply method, or a dc adaptor that converts ac to dc. In certain facilities and equipment, an ac to dc converter that converts alternating current into direct current is required, and light-emitting diode (LED) lighting incorporates this for each ceiling light.

The load electricity used by those devices is direct current. The method of transmitting electricity is also changing to direct current, a device that converts alternating current to direct current is commonly used, and electricity can be stored only in the form of direct current. As dc storage means, such as batteries, are spreading, a dc-friendly power environment is coming. Instead of supplying ac power with the existing indoor wiring and converting it to dc at the load, power can be supplied through the dc power line under a dc power environment, or through hybrid indoor wiring that can cover not only ac but also dc power. Automobiles, ships, and aircraft are powered by batteries, consequently, a new efficient power supply system should be put into consideration. (Ships use ac wiring for energy efficiency with very-high voltage. However, as HVDC can be introduced into ships, a new dc power supply system for ships could be a valid topic.) Such being the case, dc power line communication, which provides such dc power and simultaneously communicates through a dc power supply line, is necessary.

This standard deals with high-power differential signal power line communication (HPDS-PLC), a technology for supplying large-capacity dc power and performing power line communication easily with the power line. It is a power line communication that transmits dc power with high power, and the communication signal is different from that of the existing communications. In particular, it is a method that is different from the classical power line communication in which a high-frequency signal is loaded on the existing ac power line by a capacitor coupling method, or other dc power line communication, such as power over ethernet (PoE). As it is a new technology, it needs to be established as a standard.

HPDS-PLC deals with direct current power supply and communication through power lines. The power supply deals with the electrical specifications of the transmission power, and the communication sets the rules for address information, communication reliability, and signal generation. Before dealing with these detailed specifications, this clause provides a brief look at each element of the technology so that anyone can understand the technical concept of HPDS-PLC and some context, such as the environment under which HPDS-PLC could be implemented.

In general, communication includes a transmitter, a receiver, a signal, a transmission medium in which the contents of transmission are electrified as a signal, a means for designating an accurate receiver and transmitting information thereto, and a means for accurate transmission.

The transmitter of HPDS-PLC includes a physical means that can switch the differential values of the voltages of two wires of a power line. The signal transmission medium is a power line capable of transmitting power large enough to supply load power with two or more wires. The signal is a switching pattern of the voltage difference between the two wires of a power line. The receiver is an object to which power and signals are transmitted by being electrically connected to two wires indiscriminately to the power line, which is a multi-drop bus. In order to select from a number of receivers and deliver the desired content to the correct receiver, the receiver has its own identification address. The transmitter attaches the address to the signal pattern and transmits it as a differential signal of the transmission medium power line. The receiver interprets the entire signal only when its own identification address is included, and decodes the content by analyzing the switching pattern of the transmitted, that is, the differential voltage value pattern (in other words, differential signal).

HPDS-PLC is a power line communication that also supplies power. When a signal is included, the transmitted power has the switching differential voltage value of the two wires, so its switching voltage levels shall be flattened and then supplied as load power.

4.2 General description of HPDS-PLC

4.2.1 Basic requirements of HPDS-PLC

4.2.1.1 Electrical and communication requirements specifications

HPDS-PLC is power line communication for power supply and communication at the speed of 9600 b/s (bps) or lower over power line from a direct current (dc) power source of 50 V or less to multiple dc loads (more than 10 W and less than 2 kW for each load and supply capacity more than 100 W of one power transmitter). Each receiver has its own physical address (1 B or 2 B) and is connected to the transmitter through a pair of power lines in a multi-drop bus or tree topology.

The transmitter sends the dc power and the electric signals corresponding to the communication packets, including the control command/data for controlling the dc loads and the target address, through the power line by electrically changing the voltage of the wires. Each receiver supplies the transmitted and voltage-flattened dc power to the dc load. Each receiver decodes the control command/data and address from electric signals on the power line and uses them for the connected dc load control if the address matches. HPDS-PLC considers compliance to electromagnetic compatibility (EMC) regulations.

4.2.1.2 Functional and economic requirements specifications

Functional and economic HPDS-PLC requirements include the following:

- It should enable an increased noise margin and signal-to-noise (S/N) ratio, and common mode noise rejection (to use the line dc voltage totally as signal range).
- It should make it possible to eliminate electrolytic capacitors in the installed devices on the ceiling, which are for ac to dc conversion, but cause frequent failures and shorten the life span of the loads.

- It should make it possible to avoid efficiency problems due to the double conversions of dc→ac→dc when it is in the power supply process from renewable energy generation system to end loads.

4.2.2 Determined HPDS-PLC conditions

The HPDS-PLC shall perform power transmission and communication in the form of a non-polar differential voltage applied to a two-wire power line.

In order to reduce the time when power is disconnected, communication should be performed only in one direction from the transmitter to the receiver.

The transmitter of power line communication shall have the capacity to supply more than 1 A current to the loads.

The transmitter of power line communication shall have the capacity to supply more than 100 W of power to the load side.

The communication speed of the transmitter and receiver shall match each other with a value of 9600 bps or less.

The transmitter shall maintain a low and stable output impedance of less than 1 Ω max.

In the case of transmitting a communication signal, the power cutoff time shall be less than 1% when the transmission time during the 1-bit signal time is considered as 100%.

The voltage drop occurring between the power input terminal and the output terminal of the transmitter shall be 1 V at most.

There are no specific listed conditions for electromagnetic interference (EMI), but in the process of implementing this standard, regulations of each country related to EMC, such as FCC Part 15 [B3] in the United States, CE [B4] in Europe, and KC [B11] in Korea, etc., shall be complied with.

4.2.3 Contents of HPDS-PLC

4.2.3.1 Power transmission and communication

HPDS-PLC is a power line communication that performs both high-power dc power supply and communication through the same power line. It is a power line communication that uses the differential voltage value pattern of the two wires of the power line as a signal and supplies the transmitted power to the loads. For a comparison to other communication technologies, see [Annex B](#).

4.2.3.2 DC power supply and consumption

HPDS-PLC is dc power line communication. Therefore, the supplied power is also dc power, and the differential signal is also based on the dc signal.

As the dc power source of HPDS-PLC, a dc power supply, called an *ac to dc converter*, or a battery shall be used. In the case of battery, the battery shall be a rechargeable secondary battery with separate charging means, and a built-in uninterruptible power supply (UPS) or energy storage system (ESS) can be used. The sum of the maximum driving power of each connected receiver load may exceed the maximum supply power of the battery or dc power supply, but the instantaneous driving power shall drive the loads so that the maximum supply power cannot be exceeded.

4.2.3.3 Transmitter and receiver

The transmitter sends power and communication, and the receiver receives them. The transmitter is connected to the dc power source and has interface to receive communication data from outside. Receivers are connected to loads that use the transmitted power. One transmitter and multiple receivers are connected via a power line.

4.2.3.4 Switching of voltage polarity for differential signal

When the voltages of two wires of a dc power line are called A and B for each, the potential difference of the two wires is positive when $A > B$ or negative when $A < B$. Two cases are possible, with the former as (+) polarity and the latter as (−) polarity, then we can define the voltage polarity of the power line. In other words, it is the same even if the polarity is defined as whether the voltage difference between the two wires is +V or −V. The polarities of the two states are controlled to switch to each other, and by mapping the binary values 0 and 1 to the switching pattern, this polarity can be used as the basis of the transmission signal.

The polarity can be switched to each other with a circuit including power semiconductor switching devices or relays. Such switching is usually performed by controlling the gate of the switching semiconductor device through the output port of the microcontroller. As an example of implementation, refer to [Annex A](#) for the use of an H-bridge circuit using four unidirectional switching devices to obtain high-power differential signal output. Differential mode output can be obtained by using relays with dual pole dual through (DPDH) contact, but the switching speed is too slow, therefore this is not practical. A driver integrated circuit (IC) for communication that produces differential mode output also uses a differential signal and it can supply electric power to the communication circuit of the receiver. However, it cannot transmit more than 1 A of high power and therefore cannot be used as a means for this standard.

4.2.3.5 Address and communication data

HPDS-PLC transmits communication data after selecting one of the multiple receivers (regarding the whole as one object in some cases, which is called *broadcasting*). Power is transmitted and supplied simultaneously to all loads of the entire receivers.

In order to control multiple loads independently, the selection of the target receiver shall be included in the signal, and each receiver has an identification address to be identified by the selection. Depending on whether to identify the receiver or the load connected to the receiver, it can be divided into a primary address for the receiver and a secondary address for the load, or the identification of the load can be handled in data separate from the address. The receiver needs a means to input and store its address.

Transmission data are the content of communication transmitted to each receiver. Transmission data are usually the content that controls the power usage of load that is connected to the receiver and is supplied with power through the HPDS-PLC. HPDS-PLC is not intended for transmission of enormous data such as multimedia streaming data, and does not cover large communication data because it is mainly used for controlling loads that use power.

4.2.3.6 Topology of connecting receivers to the system

In HPDS-PLC, communication and power supply are achieved by connecting one transmitter and multiple receivers in parallel to a power line consisting of two or more wires. Since multiple receivers shall be connected indiscriminately to the power line in the same way, the power line becomes a multi-drop bus, and the receiver shall be included in the communication network by connecting the receiver's input terminal with two wires of the power line at any position. This means that the power receiver is connected to the power line with the topology of a multi-drop bus. Since HPDS-PLC attempts to communicate at a low communication speed, impedance termination is unnecessary and is not used.

4.2.3.7 Rectifier

The dc power transmitted to the receiver is a differential voltage power signal with a pattern in which voltage polarity switches. In order to supply the power of the final dc load, a rectifier circuit that derives flat dc power shall be used. Usually, a full-wave rectifier circuit of four diodes is used, but an active rectifier circuit can also be used to increase power transmission efficiency. Refer to [Annex A](#) for an actual implementation example of the rectifier circuit.

4.2.3.8 DC power load

There is a wide variety of dc power loads connected to the receiver and supplied with power from HPDS-PLC: LED lighting, dc motors, dc actuators, household electric devices and appliances, and information and communication appliances. When the driving power of various sensors is supplied by wire instead of battery in the sensor network, the sensor network nodes also become dc power loads.

4.3 General description of HPDS-PLC environment

4.3.1 DC power source

4.3.1.1 DC power supply

HPDS-PLC is a dc power line communication, but the power environment of an existing home or building is an ac environment, and to apply HPDS-PLC to this, a dc power supply that converts ac power into real-time dc power is required. As for the dc power supply, an ac to dc converter using switching devices of power semiconductors is mainly used.

Since the dc power supply supplies power to the loads of multiple receivers connected to the transmitter, a failure of the dc power supply causes a problem to the function of the entire load that is connected. To avoid this, an abundant system that has two or more dc power supplies switch functions to the other when one fails, and function to indicate the failure should be configured. The power and voltage values shall be marked on the power output terminal of the dc power supply, and a dc power supply system with a capacity greater than the required maximum power shall be used.

4.3.1.2 DC power generation and energy storage system (ESS)

For instance, since solar cells that produce dc power do not always generate power depending on weather conditions, it is common to charge and use electric energy in a storage battery. At this time, the storage battery can be viewed as a kind of ESS. UPS equipment, which requires the use of another storage battery, has a power storage device even though it has different usages, so it can be used as a dc power source if necessary.

In addition to dc power supplies such as ac to dc converters, which convert commercial ac power into real-time dc, the HPDS-PLC can use this stored or on-generating dc power as a power source. There is no need to convert dc power to ac and then convert it back to dc at the load. Therefore, increasing energy efficiency and avoiding the cost of conversion equipment are the main advantages when HPDS-PLC is adopted to battery, ESS, or solar cell power generation.

The dc power load connected to the receiver of HPDS-PLC is mentioned in [5.8](#). In terms of the facility environment of HPDS-PLC, the dc power load shall be devices that meet the main purpose of use of HPDS-PLC. They are mainly, but not limited to, the end nodes of efficient load use such as smart grid, energy demand management, energy demand response, etc.

4.3.2 Interface to other service layer and other communication systems

4.3.2.1 Introduction

HPDS-PLC is a dc power line communication that is used to control the use of the load connected to the receiver. Communication is performed according to the signal of the terminal for user or management office, to the communication terminal from the remote location, or to the sensed value of the sensor network. Therefore, the intention to manipulate the external user or terminal shall be transmitted to the HPDS-PLC transmitter. Also, if it is from another type of communication means, there shall be a bridging function that interprets the meaning of the message.

4.3.2.2 Gateway

The content of input, such as user or management office terminal, is transmitted to HPDS-PLC through various external communications such as Internet, low-power wide-area network (LPWAN), or other wireless communications. The HPDS-PLC transmitter shall have means for interfacing with these external communications or upper layers. HPDS-PLC does not directly implement the external communication or reception of upper layers, but interfaces through the gateway of the corresponding communication system. Communication with these gateways is done by RS-485 wired communication, and details are described later in 6.4.5 (see TIA-485-A-1998).

RS-485 communication performs differential communication with universal asynchronous receiver transmitter (UART) signals. Because it is half-duplex communication that cannot perform transmission and reception through one differential line at the same time, communication between the gateway and the transmitter is achieved by dividing the transmission mode and reception mode.

4.4 Communication with adjacent devices in I²C method

In the case that the HPDS-PLC transmitter is a master and these external communication modules, sensors, or switch modules are slaves for one HPDS-PLC transmitter, I²C communication (UM10204) shall be selected because the microcontroller of HPDS-PLC transmitter usually has a I²C port.

4.5 General description of HPDS-PLC system function and architecture

4.5.1 Background

It is necessary to classify the detailed functions of HPDS-PLC and look at the architecture for each function. Its contents are shown in Figure 1.