IEC TR 61375-2-7

Edition 1.0 2014-04

TECHNICAL REPORT

colour inside

Electronic railway equipment – Train communication network (TCN) – Part 2-7: Wireless Train Backbone (WLTB)

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ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

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FOREWORD

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IEC TR 61375-2-7, which is a technical report, has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
9/1768/DTR	9/1797A/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 61375 series, under the general title *Electronic railway equipment – Train Communication Network (TCN)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

IEC TR 61375-2-7 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways, in the frame of the IEC 61375 series.

Considering that:

a) inauguration is not automatic;

b) some parameters are configured manually in the guided traction vehicle;

c) the parameters required in the leading traction vehicle depend on the application;

d) inauguration verification is manual and based on checking pressure in the train pipe;

IEC technical committee 9 decided to consider the result of the preparation work not suitable for being an international standard within the IEC 61375 series, nevertheless decided to publish the result of the work as a technical report which can offer to the reader the status of the technology used for the implementation of a radio based train communication network.

ELECTRONIC RAILWAY EQUIPMENT – TRAIN COMMUNICATION NETWORK (TCN) –

Part 2-7: Wireless Train Backbone (WLTB)

1 Scope

This part of IEC 61375 describes the protocols stack of a radio based Wireless Train Backbone which is used in distributed power freight trains. This part provides information on the physical layer, the data link layer, the application layer and distributed power application.

The automatic inauguration of the radio based Wireless Train Backbone is not considered in this technical report.

2 Terms, definitions and abbreviations

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

2.1 Terms and definitions

2.1.1
application layer
upper layer in the OSI model, interfacing directly to the application

2.1.2
application process
element within a real open system which performs the information processing for a particular application

2.1.3
broadcast
nearly simultaneous transmission of the same information to several destinations

2.1.4
bus
communication medium which broadcasts the same information to all attached participants at nearly the same time, allowing all devices to obtain the same sight of its state, at least for the purpose of arbitration

2.1.5
communication devices
devices connected to consist network or train backbone with the ability to source and sink data.

2.1.6
composition
number and characteristics of the vehicles forming a train

2.1.7
configuration
definition of the topology of a network, the devices connected to it, their capabilities and the traffic they produce; by extension, the operation of loading the devices with the configuration information before going to regular operation

2.1.8
consist
single vehicle or a group of vehicles which are not separated during normal operation

Note 1 to entry: A consist contains no, one or several consist networks.

2.1.9
consist network
communication network interconnecting communication devices in one consist

2.1.10
function
application process which exchanges messages with another application process

2.1.11
gateway
connection between different communication technologies

2.1.12
inauguration
operation executed in case of composition change, which gives all nodes of the train backbone their train backbone address, their orientation and information about all named nodes on the same backbone

2.1.13
leading traction vehicle
the traction vehicle at the extremity towards the operation direction

2.1.14
medium
physical carrier of the signal: electrical wires, optical fibre, wireless, etc.

2.1.15
medium access control
sub-layer of the data link layer, which controls the access to the medium

2.1.16
message
data item transmitted in one or several packets

2.1.17
multi-hop relay communication
communication with each other through the relay function of the other devices for the devices not able to communicate directly

2.1.18
network address
address which identifies a communication device on network layer

2.1.19
network layer
layer in the OSI model responsible for routing between different busses

2.1.20
node
device on the train backbone, which may act as a gateway between train backbone and consist network

2.1.21
operation direction
travelling direction for a train along railway line from one station to another station, normally designated as two directions, i.e. up and down

2.1.22
operator
enterprise or organization which is operating trains

2.1.23
packet
unit of a message (information, acknowledgement or control) transmitted by protocols on network or transport layer

2.1.24
guided traction vehicle
the traction vehicles except the leading traction vehicle of the train

2.1.25
train communication network
data communication network for connecting programmable electronic equipment on-board rail vehicles

2.1.26
transport layer
layer of the OSI model responsible for end-to-end flow control and error recovery

2.1.27
wireless train backbone
a wireless train communication network for connecting the vehicles of a train

2.1.28
wireless train backbone node
device connected to the wireless train backbone for connecting end devices or consist networks to the wireless train backbone

2.2 Abbreviations

CAN	Control Area Network
CN	Consist Network
ECN	Ethernet Consist Network
ETB	Ethernet Train Backbone
GTV	Guided Traction Vehicle
ISO	International Standardization Organization
LTV	Leading Traction Vehicle
MAC	Medium Access Control
MVB	Multi-function Vehicle Bus
OSI	Open System Interconnect
PD	Process Data
PDU	Protocol Data Unit
TCP/IP	Transport Control Protocol /Internet Protocol
UDP	User Datagram Protocol
VCU	Vehicle Control Unit

VSWR Voltage Standing Wave Ratio
WLTB Wireless Train Backbone
WLTBN Wireless Train Backbone Node
WNG Wireless train backbone Node of Guided traction vehicle
WNL Wireless train backbone Node of Leading traction vehicle
WTB Wire Train Bus

3 Architecture

3.1 Framework of the train communication backbones

The radio based WLTB is one of the several train backbones of the IEC 61375 series. WLTB is used for coupling the traction vehicles of a distributed power freight train. Figure 1 describes the framework of the train communication backbones within the IEC 61375 series.

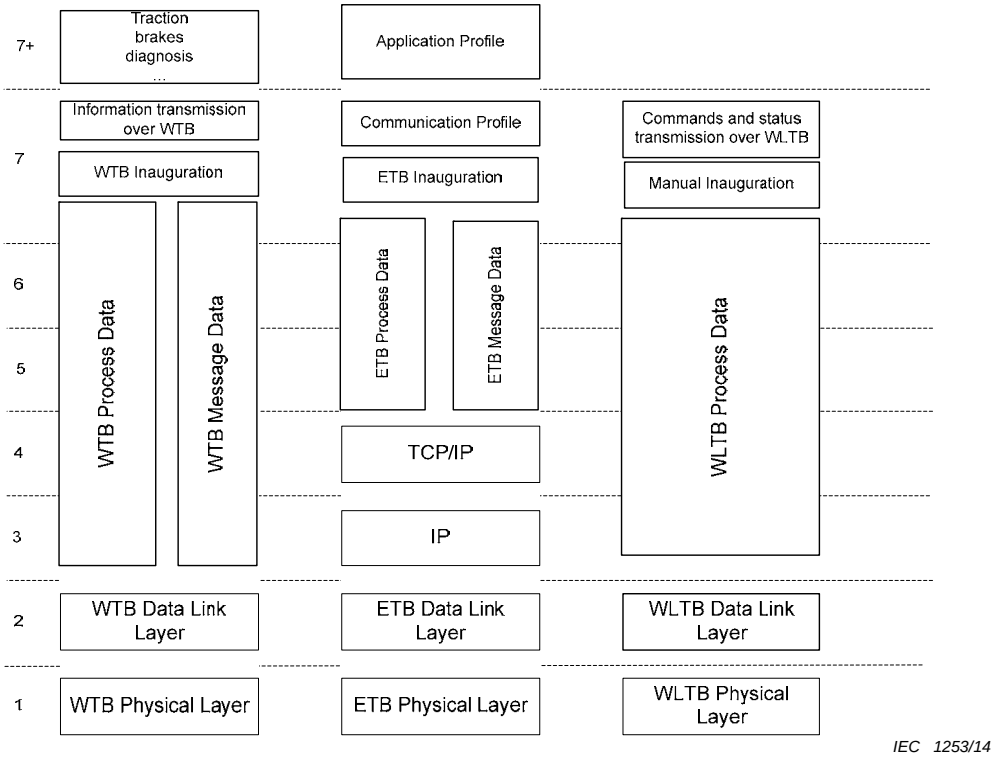

Figure 1 – Framework of the Train Communication Backbones

The WTB is a widely used train backbone. The communication protocols of the process data, message data and the WTB inauguration are specified by IEC 61375-2-1 and the information transmission over WTB is specified by UIC 556. The applications, in the field of traction, brakes, diagnosis, are specified by a series of the UIC documents, such as UIC 647, UIC 541 and UIC 557, respectively.

The ETB is a wide bandwidth train backbone. The physical layer to the application layer of the ETB, including the data link, IP, TCP, UDP and the ETB inauguration protocols are specified by future IEC 61375-2-5. The communication profile, including the train real-time data protocol, the universal recourse identity addressing and the safety communication are specified in future IEC 61375-2-3. The detailed data for the control and status of a specific device is specified by the application profile in future IEC 61375-2-4.

The following considerations apply:

- wiring along the freight cars is typically not available;
- retrofit of cables may be non-economic;
- total distance between the traction vehicles in the composition may exceed the maximum transmission length of the WTB/ETB.

WLTB, which is based on the wireless communication between the traction vehicles, is a proper solution for the transmission of the commands and status data is needed for the distributed power train.

The WLTB is a radio based backbone for trains with distributed power traction.

The protocols of the WLTB, including the physical layer, data link layer, the manual inauguration and the data transmission over the WLTB are described in this technical report.

3.2 Distributed power train compositions

The distributed power freight train is composed of at least 2 traction vehicles and a number of freight cars with the traction vehicles distributed among the train. The train pipe is connected through all the train and the communication between the different traction vehicles is used for managing the distributed power.

Figure 2 gives an example of the WLTB for a distributed power train composed of 3 traction vehicles.

Figure 2 – WLTB in a distributed power train composed of 3 traction vehicles

In the distributed power train, one traction vehicle in the train is selected as the LTV, others are GTVs. The driver in the LTV controls the traction and braking of the LTV by manipulating the control panel on the driver's desk. The GTVs receive commands from the LTV for traction and braking control and transmit their status to the LTV via the WLTB.

3.3 Communication protocols of the WLTB nodes

The OSI-ISO model and the communication protocols of the WLTB node are shown in Figure 3.

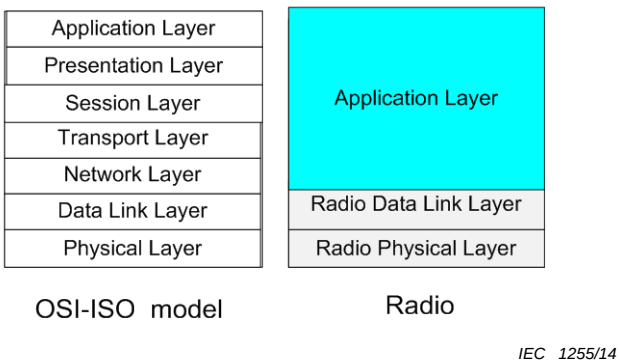

Figure 3 – OSI-ISO model and structure of WLTB communication protocols

Comparing with the OSI-ISO model, the WLTB protocol stack includes the radio physical layer, data link layer and application layer. The communication schedule, structure of PDUs, manual inauguration and related dataset, and the process data transmission are within the application layer.

4 Physical layer

4.1 General

The physical layer is based on the Chinese standard "*Technical specification of the end of the train with 800 MHz radio and the train safety pre-alarm system*", which specifies the management of the end of the train by radio communication.

4.2 Transmission power

The transmission power of the radio is dependent on the distributed power application requirement and the local regulations. According to the distance between the neighbour traction vehicles, the transmission power may be adjusted, providing that the values requested to obey the local regulations are not exceeded.

4.3 Frequency

In order to avoid interference between different trains along the railway lines, the WLTB nodes provide several alternative radio frequencies. Table 1 lists the 8 channels and frequencies used by WLTB. In case that the frequencies are conflicting with the regulations of the radio administration authority, the operator applies for alternative frequencies compliant with such regulations.

Table 1 – Channels and frequencies of the radio

Channel number	Frequency MHz
1	822,237 5
2	822,737 5
3	823,237 5
4	823,737 5
5	867,237 5
6	867,737 5
7	868,237 5
8	868,737 5

4.4 Modulation

The modulation of the radio is continuous-phase frequency shift keying.

4.5 Antenna and feeder

In order to guarantee the communication performances, the specifications of the antenna and feeder are shown in Table 2.

Table 2 – Specifications of the antenna and feeder

Parameters	Value
Frequency	815 MHz to 875 MHz
Gain of antenna	>4 dB
Attenuation of the feeder	<1,5 dB
Impedance	50 Ω
VSWR	≤1,5
Polarize of antenna	Vertical
Maximum power	10 W

5 Data link layer

There is no MAC layer in the radio based WLTB nodes. The communication schedule is mandatory at the application layer in order to avoid the collision. The transmission rate of the radio is equal to or greater than 9 600 bps. The logical link control of the radio based WLTB is in accordance with the Chinese standard "*Technical Specification of the end of the train with 800 MHz radio and the train safety pre-alarm system"*.

6 Application layer

6.1 Communication schedule

6.1.1 General

The communication schedule is used to manage the timing of sending, relaying and responding of frames, carrying command and status data, among the WLTBNs. Since the distances between the WLTBNs may exceed the maximum transmission distance of the radio, the WLTBNs support the multi-hop relay communication mode. In the multi-hop relay communication mode, all the WLTBN, including the WNL and the WNGs, have knowledge of each other.

WNGs relay commands from the WNL and status of the GTVs in a sequence according to the WLTBN sequence number. As shown in Figure 4, in a train composed of 4 traction vehicles with 1 LTV and 3 GTVs, WNL sends the command, and WNG 1 relays the command immediately after receiving the command. WNG 2 will relay the command only after receiving the command relayed by the WNG 1.

WNG 3 will respond with the status data immediately after receiving the command relayed by WNG 2. WNG 2 will relay the status of GTV 3 and the status data of itself towards WNL. WNG 1 will relay the status data of GTV 3, GTV 2 and the status data of itself towards WNL.

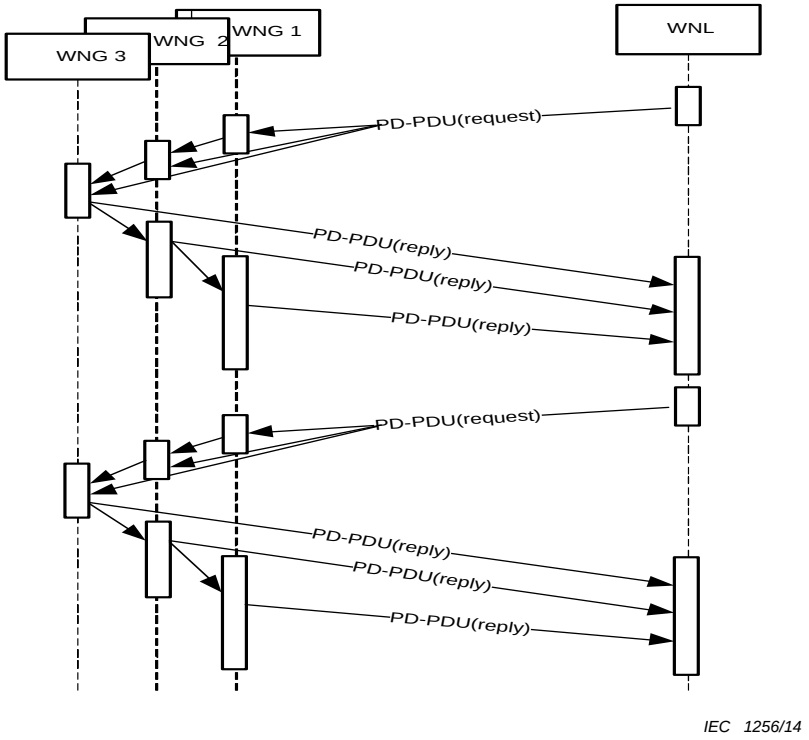

Figure 4 – Example of communication in a train composed of 4 traction vehicles

6.1.2 Flow chart of sending command by the WNL

WNL sends command data to WNGs and checks the status data replies from the WNGs. If the WNL receives the replies from all WNGs within the specified time T_{pc}, the procedure is finished. Otherwise, WNL sends the command data again. If WNL has not received the correct replies from all WNGs after sending the command data 3 times, WNL stops sending this command data. The flow chart of sending command data by WNL is shown in Figure 5.

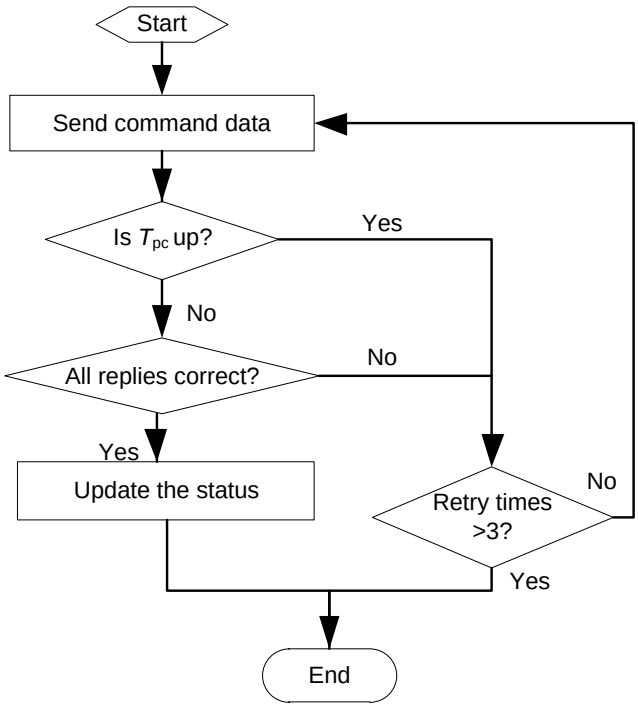

Figure 5 – Flow chart of sending command data by the WNL

6.1.3 Flow chart of receiving command data and status data by the WNGs

WNGs receive the command data from WNL. After receiving the command data from WNL or WNGs closer to the WNL that relayed the command data, WNG starts to process the command data. Meanwhile, WNG receives the status data of LTV and the other GTVs and relays the status data towards WNL. The flow chart of receiving command data and status data by WNGs is shown in Figure 6.

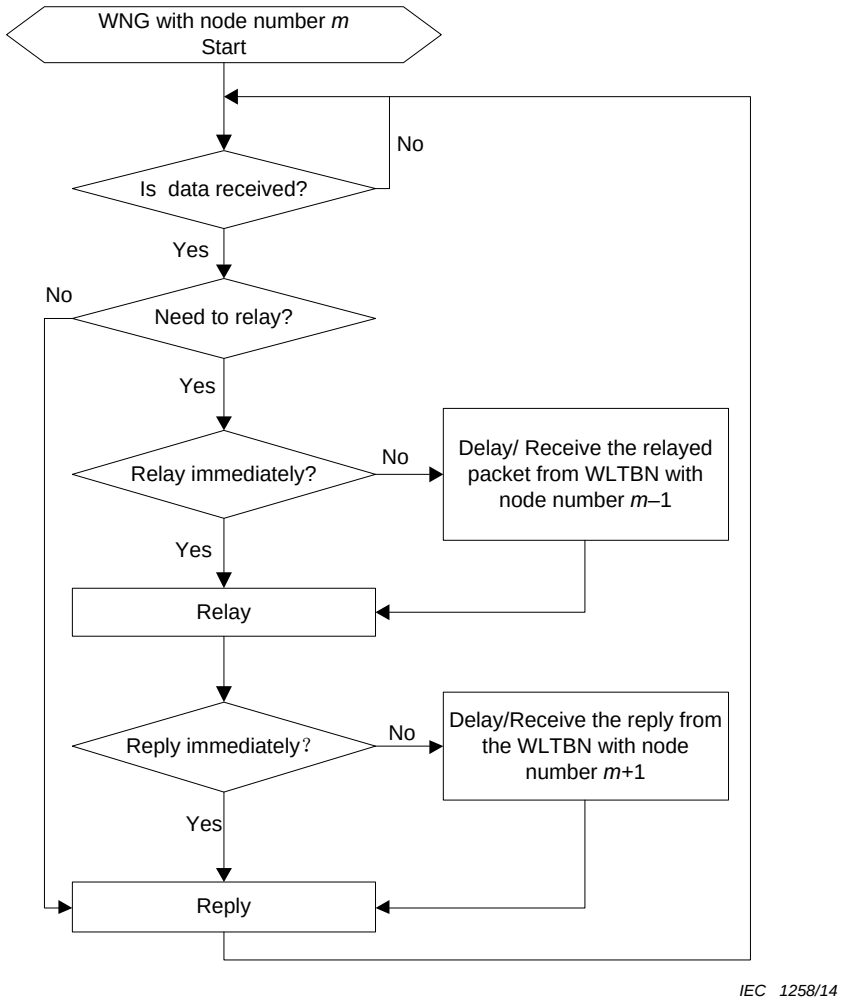

Figure 6 – Flow chart of the GTV

6.1.4 Addressing

The purpose of WLTB node address is to identify the destination of PDUs. The address is composed of the following 2 segments as shown in Table 3.

Table 3 – Segments of the address for the WLTB node

Segments	Size	Description
1	1 Byte	Nation code
2	3 Bytes	Serial number of the traction vehicle

NOTE For the nation code, refer to Annex A.

The WLTB node address of the LTV is also the train address of the distributed power freight trains.

6.2 PDU

The structure of a PDU is defined in Figure 7, the parameters description is reported in Table 4.

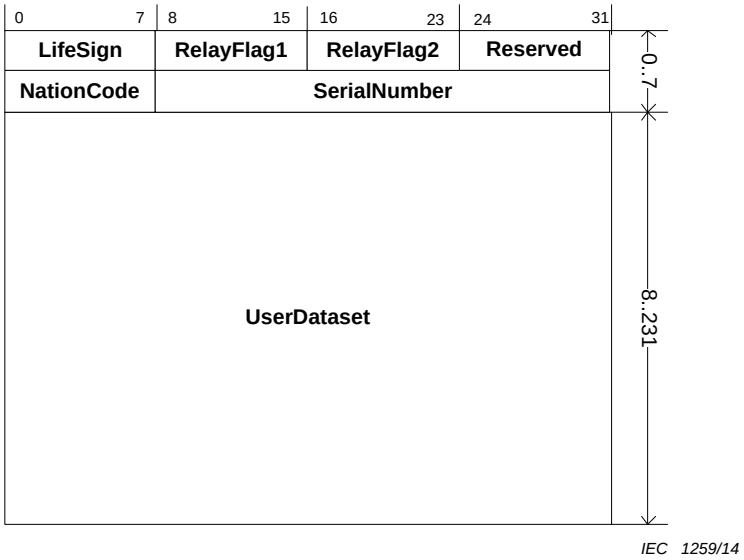

Figure 7 – Structure of PDU

Table 4 – PDU for the inauguration

Offset	Parameter	Description	Size (Byte)
0	LifeSign	From 0 to 255 cyclically	1
1	RelayFlag1	Relay flag byte 1 for relaying PDUs from LTV towards GTVs. Bit 0 relaying from GTV 1, Bit 1 relaying from GTV 2…Bit 6 relaying from GTV 7, bit 7 reserved.	1
2	RelayFlag2	Relay flag byte 2 for relaying PDUs from GTVs towards LTV. Bit 0 relaying from GTV 1, Bit 1 relaying from GTV 2…Bit 6 relaying from GTV 7, bit 7 reserved.	1
3	Reserved	-	1
4	NationCode	Nation code of traction vehicle, combined with serial number to form the universal unique traction vehicle number, refer to Annex A.	1
5	SerialNumber	Serial number for the traction vehicle designated by the manufacture, combined with nation code to form the universal unique traction vehicle number	3
6	UserDataset	User data. The length of the user data set is variable. The length for one traction vehicle is 32 bytes. In the case of a train composed of an LTV and *m* (*m* is from 1 to 7) GTVs, the WNG with sequence number *n* (*n* is from 1 to *m*) replies status with the length of the user data set 32 + (*m*–*n*) × 32 bytes.	224

6.3 Network security

The security mechanism for the radio based WLTB is based on the dynamic key management method.

7 WLTB inauguration

7.1 General

Unlike ETB, WLTB is unable to perform the automatic identification of the neighbouring nodes; consequently WLTB needs to be inaugurated manually.

The parameters required for the inauguration are manually inputted into all the WLTB nodes, installed in the traction vehicles of the train. The procedure of inauguration info check, including data exchange and verification among the LTV and GTVs, is started by the driver in the LTV. The train pipe pressure is tested and the inauguration is verified during the inauguration test and completion procedures.

7.2 Parameters

The following parameters are inputted into the WNGs:

- Nation code of the traction vehicle;
- Serial number of the traction vehicle;
- Flag of the selection as WNG;
- Distance(in m) between GTV and the nearest traction vehicle towards LTV;
- Sequence number of the WNG;
- Total number of the traction vehicles in the distributed power train;
- Operation direction of the train, in order to select the radio channel and frequency;
- Nation code of LTV;
- Serial number of LTV.

The following parameters are inputted into WNL:

- Nation code of LTV;
- Serial number of LTV;
- Flag of the selection as WNL;
- Distances (in m) between neighbouring traction vehicles of the train;
- Sequence number of each WNG;
- Total number of the traction vehicles of the train;
- Train operation direction (up or down);
- Nation code of each GTV;
- Serial number of each GTV.

7.3 Procedure

Figure 8 shows the procedure of inauguration of the WLTB.

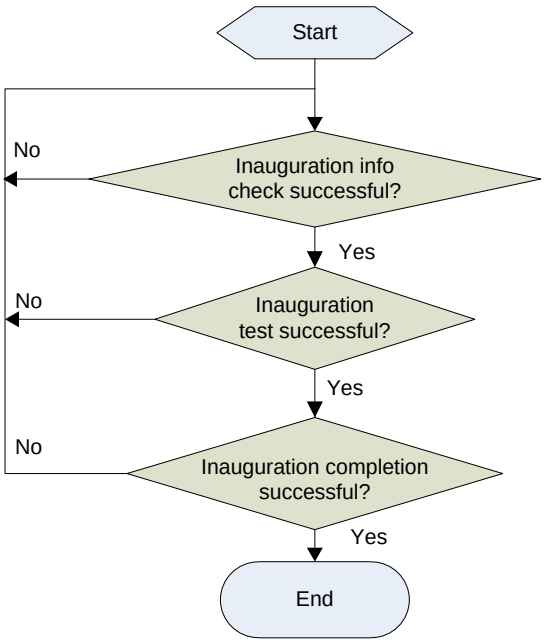

Figure 8 – Procedure of inauguration

The driver of the LTV starts the inauguration after the parameters are inputted. The procedure of the inauguration includes the following 3 steps:

a) **Inauguration info check.** WNL sends the inauguration info check request PDU to all WNGs. WNGs respond sending an inauguration info check reply PDU to WNL. The detailed user dataset in the PDU within this procedure are specified in Table 5, Table 6 and Table 7.

b) **Inauguration info test.** WNL sends the inauguration info test request PDU to all WNGs after the success of the inauguration info checking procedure. WNGs respond sending an inauguration info test reply PDU to WNL. The user dataset in PDU within this procedure are specified in Table 8 and Table 9.

c) **Inauguration completion.** The WNL sends the inauguration completion request PDU to all WNGs after the success of the inauguration info test procedure. WNGs respond sending an inauguration completion reply PDU to WNL. The user dataset in PDU within this procedure are specified in Table 10 and Table 11.

When the above procedures are successfully completed, the inauguration is finished and GTVs are controlled by LTV.

7.4 User Dataset

7.4.1 InaugInfoCheckRequest1

InaugInfoCheckRequest1 user dataset is shown in Table 5.

Table 5 – InaugInfoCheckRequest1 user dataset

Index	Parameter	Description	Size (Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x01: Inauguration info check 1	1
2	TVNumber	Number of traction vehicles in the train	1
3	TVSerial	Serial number of this traction vehile	1
4	NationCodeofTV1	Nation code of traction vehicle 1	1
5	SerialNumberOfTV1	Serial number of traction vehicle 1	3
6	NationCodeofTV2	Nation code of traction vehicle 2	1
7	SerialNumberOfTV2	Serial number of the traction vehicle 2	3
8	DistanceofTV2	Distance from traction vehicle 2 to traction vehicle 1	2
9	NationCodeofTV3	Nation code of traction vehicle 3	1
10	SerialNumberOfTV3	Serial number of traction vehicle 3	3
11	DistanceofTV3	Distance form traction vehicle 3 to traction vehicle 2	2
12	NationCodeofTV4	Nation code of traction vehicle 4	1
13	SerialNumberOfTV4	Serial number of traction vehicle 4	3
14	DistanceofTV4	Distance from traction vehicle 4 to 3	2
15	Reserved	-	6

7.4.2 InaugInfoCheckRequest2

InaugInfoCheckRequest2 user dataset is shown in Table 6.

Table 6 – InaugInfoCheckRequest2 user dataset

Index	Parameter	Description	Size (Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x02: Inauguration info check 2	1
2	TVNumber	Number of traction vehicles in the train.	1
3	TVSerial	Serail number of this traction vehicle	1
4	NationCodeofTV5	Nation code of traction vehicle 5	1
5	SerialNumberOfTV5	Serial number of traction vehicle 5	3
6	NationCodeofTV6	Nation code of traction vehicle 6	1
7	SerialNumberOfTV6	Serial number of the traction vehicle 6	3
8	DistanceofTV6	Distance from traction vehicle 6 to traction vehicle 5	2
9	NationCodeofTV7	Nation code of traction vehicle 7	1
10	SerialNumberOfTV7	Serial number of traction vehicle 7	3
11	DistanceofTV7	Distance form traction vehicle 7 to traction vehicle 6	2
12	NationCodeofTV8	Nation code of traction vehicle 8	1
13	SerialNumberOfTV8	Serial number of traction vehicle 8	3
14	DistanceofTV8	Distance from traction vehicle 8 to 7	2
15	Reserved	-	6

7.4.3 InaugInfoCheckResponse

InaugInfoCheckResponse user dataset of the GTV with sequence number n is shown in Table 7.

Table 7 – InaugInfoCheckResponse user dataset

Index	Parameter	Description	Size (Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset.	1
1	ControlCode	Control code 0x01/0x02: Inauguration info check response	1
2	TVNumber	Number of traction vehicles in the train	1
3	TVSerail	Serail number of this traction vehicle	1
4	NationCodeofLTV	Nation code of LTV	1
5	SerialNumberOfLTV	Serial number of LTV	3
6	NationCodeofGTV	Nation code of GTV *n*	1
7	SerialNumberOfGTV	Serial number of GTV *n*	3
8	DistanceofGTV	Distance from GTV *n* to GTV *n*–1 (*n*>1) Distance from GTV to LTV (*n*=1)	2
9	InaugInfoCheckStatus	Status of the inauguration info check 0x00 Info incorrect 0x01 Info correct	1
10	Reserved	-	17

7.4.4 InaugTestRequest

InaugTestRequest user dataset is shown in Table 8.

Table 8 – InaugTestRequest user dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x03: Inauguration test request	1
2	TrainPipePressureofLTV	Pressure of the train pipe of the LTV	2
3	reserved	-	28

7.4.5 InaugtestResponse

InaugTestResponse user dataset is shown in Table 9.

Table 9 – InaugTestResponse user dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x03: Inauguration test response	1
2	TrainPipePressureofGTV	Pressure of the train pipe of the GTV *n*	2
3	Resultsoftest	Test result of this GTV	1
4	Timetodecreasepressure	Time (ms) to decrease the pressure of train pipe to set value	4
5	reserved	-	23

7.4.6 InaugCompletionRequest

InaugCompletionRequest user dataset is shown in Table 10.

Table 10 – InaugCompletionRequest user dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x04: Inauguration completion request	1
2	reserved	-	30

7.4.7 InaugCompletionResponse

InaugCompletionResponse user dataset is shown in Table 11.

Table 11 – InaugCompletionResponse user dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x01: Inauguration dataset	1
1	ControlCode	Control code 0x04: Inauguration completion response	1
2	InaugurationCompletionFlag	Flag of the inauguration completion status 0x00: not successful 0x01: successful	1
3	reserved	-	29

8 Process data communication

8.1 General

The process data communication is used for transmitting LTV command data and GTV status data. The multi-hop relay communication mode is used for process data communication.

8.2 LTV process dataset

LTV process dataset is shown in Table 12.

Table 12 – LTV process dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x02: Process dataset	1
1	ControlCode	Control code 0x00: LTV process dataset	1
2	CommandofLTV	Command of LTV	12
3	StatusofLTV	Status of LTV	13
4	Reserved	-	5

8.3 GTV process dataset

GTV process dataset is shown in Table 13.

Table 13 – GTV process dataset

Index	Parameter	Description	Size(Byte)
0	UserdataType	User dataset type 0x02: Process dataset.	1
1	ControlCode	Control code 0x00: GTV process dataset	1
3	StatusofGTV	Status of GTV	24
4	Reserved	-	6

9 Distributed power operation application

9.1 Operating conditions

The conditions to allow the radio based distributed power application to work properly are:

a) The control system of the involved traction vehicles is active.
b) The inauguration of the WLTB is completed.

For the majority of the functions described hereinafter, LTV is present in the composition.

9.2 Function model

9.2.1 Remote control process

Signals that contain all the necessary information are defined for the WLTB. These signals are "translated" in each vehicle in order to work with the actual control equipment. This process of the radio based remote control is represented in Figure 9.

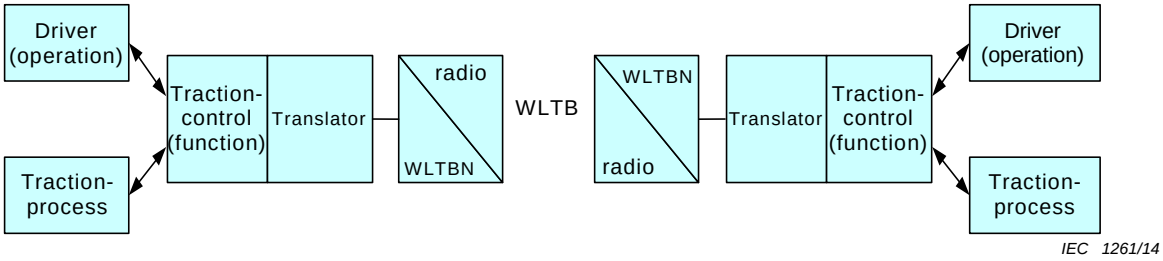

Figure 9 – Logic diagram of the remote control process

9.3 Function definition

9.3.1 General

In order to properly define the devices including traction, brakes, etc., the functional modules are listed below:

a) train composition,
b) operation direction,
c) primary energy,
d) air and pneumatics,
e) traction and dynamic brake,
f) equipment protection,
g) handing of communication loss,
h) data validation.

9.3.2 Train composition

Figure 10 gives several examples of the train composed of different numbers of traction vehicles and combinations.

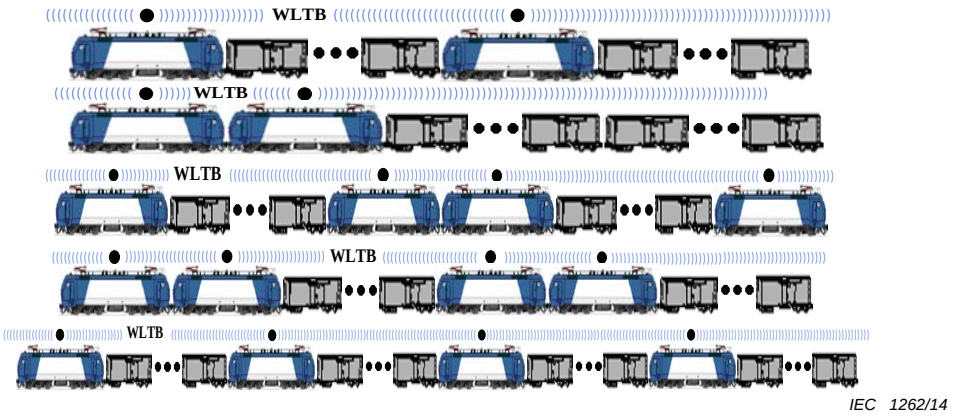

Figure 10 – Train composition cases

Before configuring GTVs, WNL is turned on and the electronic keys in GTVs are forbidden to be turned on to avoid any manually operation that may cause conflicts with LTV. Once WLTBN is detected to be turned on, the VCU of the traction vehicle knows which side is the one in charge of control.

Some important parameters are configured in GTVs manually, which are listed in 7.2.

When the parameters inputting is finished, GTVs come into the waiting state for inauguration. After the inauguration procedure is completed, GTVs come into the ready state.

When all GTVs come into ready state, LTV can be configured and some parameters are inputted as shown in 7.2.

When the parameters inputting for LTV is completed, LTV comes into waiting state for inauguration.

After the operations of GTVs and LTV, described here above, are completed, the driver in the LTV can start train inauguration procedure.

LTV broadcasts the inauguration request to all GTVs and waits for the responses from GTVs. When WNL receives and verifies all the responses from WNGs within the train, the wireless communication links have been set up and the train comes into operation state that is under the unique control of LTV.

When the train is in operation state, only LTV can be controlled by the driver. All GTVs will respond to the commands sent by LTV and control the traction vehicles according to the commands respectively. The drivers in GTV cannot control the traction vehicles and their duties are just to monitor the operation status of the traction vehicles. When something unexpected happens, the driver can switch WLTBN to off position and change the traction vehicle into single model. In this case, the main switch turns off and the pantograph is to be lowered, the traction vehicle comes into hauled state.

9.3.3 Operation direction

Operation direction is defined as the travelling direction of the train, or in another words, the up or down direction along the railway line. The motor rotating directions are controlled by the GTVs respectively (compared with the travelling direction).

9.3.4 Primary energy

The driver in the driver's cab of the LTV can control the pantographs of the train. When the driver needs to operate on the pantographs of the train, the operation commands can be sent to WNL via VCU of the LTV. WNL can send the commands to all GTVs of the train.

When WNGs receive the commands sent by WNL, WNGs will determine whether the commands can be sent to VCU according to the status of the traction vehicles. If the commands have been passed to the VCU, it is the duty of VCU to control pantographs according to the commands received.

9.3.5 Main switch

If the "main switch on" and "main switch off" commands are issued in LTV, the VCU sends the commands to WNL and then WNL passes the commands to all GTVs.

Once the GTVs receive the commands sent by LTV, WNGs determine whether pass the commands to VCUs according to the status of the traction vehicles. If the commands can be passed to VCU, it is the duty of VCU to control the operations on the main switch.

In the case that the LTV starts to pass the neutral section and sends the “main switch off” command to all GTVs, although GTVs have received the “main switch off” command from LTV, WNGs do not pass the command to VCUs and so GTVs will not perform the “main switch off” operation.

When something is wrong in GTV and the main switch cannot turn on, the driver who is in GTV driver’s cab can turn off WNG and cuts off the communication with WNL. Then, GTV will not respond to any commands sent from LTV and come into hauled state. When the problem has been solved and GTV can work again, the driver of GTV can turn WNG to “on” position and GTV can set up the communication with LTV again. WNG will pass all the commands sent from WNL to VCU and GTV can work with the LTV synchronically again.

9.3.6 Air and pneumatics

WLTBN communicates with the traction vehicle brake system via the consist network. The WNL does not participate in the brake operations of the GTV directly and only pass the brake commands and condition status via wireless communication. The train pipe is connected through the train. The driver in LTV can send the brake command to brake system of LTV directly and the braking can be applied. The LTV can pass the pneumatic braking commands to the WNGs that include the status of the train braking, the target value of automatic brake and the signal of independent brake handle. The commands can be sent to all the GTVs via wireless communication and then can be passed to the local brake system through the WNG. The brake system can apply the synchronous pneumatic braking operation according to the LTV’s commands.

All the GTVs can send the local air braking status back to the LTV respectively for monitoring purpose.

9.3.7 Traction and dynamic brake

The selection of traction and electronic braking can be controlled by the driver in the LTV. All the GTVs of the train keep in the same operation.

The VCU of LTV passes the set value of traction to the WNL, and then the WNL sends the set value to all the WNGs which passes the value to the VCU. The VCU controls the traction based on the set value from LTV.

When the LTV carries out passing neutral section operation, all the GTVs remain the previous operation and do not respond to new traction commands, only monitor the pneumatic braking command sent by LTV. In this process, if the WNL sends the braking command, all the GTVs respond to the command and apply the braking operation. When the LTV has finished passing neutral section operation, all the GTVs resume to respond to the traction commands sent by the LTV.

The GTVs carry out passing neutral section operation independently. When the GTV has passed the neutral section, it resumes to the same operation as the LTV.

There are two modes of passing neutral section: automatic mode and semi-automatic mode.

- **Automatic mode:** If the track and traction vehicles are equipped with automatic pass neutral section equipments, the VCUs of all the GTVs can control the passing neutral section operation independently. Before VCU of LTV turns the main switch to “OFF” position, it informs the WNL the status of passing neutral section in advance so that other traction vehicles can get the status of LTV. The purpose is to make sure that the GTVs do not wrongly turn the main switch off at the time that the LTV starts to carry out passing neutral section operation.
- **Semi-automatic mode:** If the track and traction vehicles are not equipped with the automatic passing neutral section equipment and the traction vehicles have to pass the neutral section manually, the driver in the LTV informs the WNL the status of passing

neutral section by pushing the passing neutral section button on the driver's desk before the driver turns off the main switch. All the GTVs determine the time to carry out passing neutral section operation according to the time when the LTV starts to pass the neutral section and the distance between this GTV and LTV. After the VCU of a GTV turns off the main switch, it can determine when to turn on the main switch of this GTV by detecting the catenary voltage. When the GTV has passed the neutral section, it will control the traction vehicle according to the traction commands sent by the LTV.

9.3.8 Emergency brake

The emergency brake command is sent by any traction vehicle within the train. The other traction vehicles start emergency braking immediately as soon as they receive the command.

9.3.9 Equipment protection

Equipment protection function is carried out by VCU. When some equipment failures occur, VCU will carry out corresponding procedure and inform the LTV via WLTB.

9.3.10 Handling of communication loss

9.3.10.1 General

The following subclauses describe the handling of communication loss.

9.3.10.2 Transitory communication loss

If the communicaiton loss lasts within 30 s, all GTVs will remain in the same traction status as before and in the meanwhile they are monitoring the pressure of the train pipe for protection purposes. When the wireless communication resumes, GTVs carry out the synchronous traction according to the commands received from LTV.

9.3.10.3 Permanent communication loss

If the communication loss lasts more than 30 s, GTVs enter the coasting status.

9.3.11 Data verification

If the PDU cannot pass the verification, the PDU will be useless. When inputting the parameters, all the parameters will be checked to make sure that the input data is valid. If the input data is wrong or invalid, the configuration cannot be finished and the traction vehicle cannot enter the waiting for inauguration state.

Annex A
(informative)

Nation code specification

Table A.1 lists the nations in alphabetical order followed by their identification code.

Table A.1 – Nation identification code

Nation	Code	Nation	Code	Nation	Code	Nation	Code
Angola	1	Afghanistan	2	Albania	3	Algeria	4
Andorra	5	Anguilla	6	Antigua and Barbuda	7	Argentina	8
Armenia	9	Ascension	10	Australia	11	Austria	12
Azerbaijan	13	Bahamas	14	Bahrain	15	Bangladesh	16
Barbados	17	Belarus	18	Belgium	19	Belize	20
Benin	21	Bermuda Is	22	Bolivia	23	Botswana	24
Brazil	25	Brunei	26	Bulgaria	27	Burkina-faso	28
Burma	29	Burundi	30	Cameroon	31	Canada	32
Cayman Is.	33	Central African Republic	34	Chad	35	Chile	36
China	37	Colombia	38	Congo	39	Cook Is.	40
Costa Rica	41	Cuba	42	Cyprus	43	Czech Republic	44
Denmark	45	Djibouti	46	Dominica Rep.	47	Ecuador	48
Egypt	49	EI Salvador	50	Estonia	51	Ethiopia	52
Fiji	53	Finland	54	France	55	French Guiana	56
Gabon	57	Gambia	58	Georgia	59	Germany	60
Ghana	61	Gibraltar	62	Greece	63	Grenada	64
Guam	65	Guatemala	66	Guinea	67	Guyana	68
Haiti	69	Honduras	70	Hong Kong	71	Hungary	72
Iceland	73	India	74	Indonesia	75	Iran	76
Iraq	77	Ireland	78	Israel	79	Italy	80
Ivory Coast	81	Jamaica	82	Japan	83	Jordan	84
Kampuchea (Cambodia)	85	Kazakhstan	86	Kenya	87	Korea	88
Kuwait	89	Kyrgyzstan	90	Laos	91	Latvia	92
Lebanon	93	Lesotho	94	Liberia	95	Libya	96
Liechtenstein	97	Lithuania	98	Luxembourg	99	Macao	100
Madagascar	101	Malawi	102	Malaysia	103	Maldives	104
Mali	105	Malta	106	Mariana Is.	107	Martinique	108
Mauritius	109	Mexico	110	Moldova	111	Monaco	112
Mongolia	113	Montserrat Is	114	Morocco	115	Mozambique	116
Namibia	117	Nauru	118	Nepal	119	Netheriands Antilles	120
Netherlands	121	New Zealand	122	Nicaragua	123	Niger	124
Nigeria	125	North Korea	126	Norway	127	Oman	128

Nation	Code	Nation	Code	Nation	Code	Nation	Code
Pakistan	129	Panama	130	Papua New Guinea	131	Paraguay	132
Peru	133	Philippines	134	Poland	135	French Polynesia	136
Portugal	137	Puerto Rico	138	Qatar	139	Reunion	140
Romania	141	Russia	142	Saint Lueia	143	Saint Vincent	144
Samoa Eastern	145	Samoa Western	146	San Marino	147	Sao Tome and Principe	148
Saudi Arabia	149	Senegal	150	Seychelles	151	Sierra Leone	152
Singapore	153	Slovakia	154	Slovenia	155	Solomon Is	156
Somali	157	South Africa	158	Spain	159	Sri Lanka	160
St.Lucia	161	St.Vincent	162	Sudan	163	Suriname	164
Swaziland	165	Sweden	166	Switzerland	167	Syria	168
Taiwan	169	Tajikistan	170	Tanzania	171	Thailand	172
Togo	173	Tonga	174	Trinidad and Tobago	175	Tunisia	176
Turkey	177	Turkmenistan	178	Uganda	179	Ukraine	180
United Kiongdom	182	United States of America	183	Uruguay	184	Uzbekistan	185
United Arab Emirates	181	Venezuela	186	Vietnam	187	Yemen	188
Yugoslavia	189	Zimbabwe	190	Zaire	191	Zambia	192

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