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**Performance requirements & testing approaches of
commercial vehicle communication system (V2X) terminal**

营运车辆车路/车车通信（V2X）终端性能要求和检测方法

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Performance requirements & testing approaches of commercial vehicle communication system (V2X) terminal

1 Scope

This document specifies the composition and application, performance requirements, positioning performance, communication performance test methods of vehicle-to-road/vehicle-to-vehicle communication (V2X) terminals for commercial vehicles.

This document applies to vehicle-to-road/vehicle-to-vehicle communication (V2X) terminals for commercial vehicles, as well as the communication performance and positioning performance test of such terminal equipment in direct communication of the Internet of Vehicles (intelligent connected vehicles).

2 Normative references

The contents of the following documents constitute essential clauses of this document through normative references in the text. Among them, for dated references, only the version corresponding to that date applies to this document; for undated references, the latest version (including all amendments) applies to this document.

GB/T 6113.104-2021 Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Antennas and test sites for radiated disturbance measurements

JT/T 1253-2019 GNSS for operating vehicles-Test methods of on-board unit

YD/T 3848-2021 LTE-based vehicle access wireless communication technology direct connection communication terminal equipment test support

SJ/T 11420-2010 General specification for GPS navigation receiver

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

Commercial vehicle

Vehicles that have obtained road transport licenses and are engaged in commercial

4 Symbols and abbreviations

4.1 Symbols

The following symbols apply to this document.

$V_{\max}$ - Maximum test speed of the vehicle

4.2 Abbreviations

The following abbreviations apply to this document.

AWGN: Additive White Gaussian Noise

GNSS: Global Navigation Satellite System

PDCCP: Packet Data Convergence Protocol

QPSK: Quadrature Phase Shift Keying

RB: Resource Block

SDU: Service Data Unit

V2I: Vehicle to Infrastructure

V2V: Vehicle to Vehicle

V2X: Vehicle to Everything

5 Composition and application of on board unit

5.1 Composition

The on board unit shall include at least the following functional units:

- a) Radio communication unit: Receiving and sending signals; one or more radio communication subsystems can be installed in an on-board device;
- b) Positioning unit: This unit usually contains a global navigation satellite system receiver to provide information such as the vehicle's location, direction, speed, time;
- c) Signal processing unit: Run specific programs to process the signals to be sent and received;
- d) Antenna: Used to receive and send RF signals.

The positioning reacquisition time shall be less than 5 s.

6.1.5 Sensitivity

The sensitivity shall meet the following requirements:

- a) The acquisition sensitivity is not less than -140 dBm;
- b) The tracking sensitivity is not less than -150 dBm.

6.2 Communication performance requirements

6.2.1 Working frequency band

The working frequency band of the on-board unit's direct link communication shall meet the following requirements:

- a) Support working frequency range: 5905 MHz ~ 5925 MHz;
- b) Support channel bandwidth: 20 MHz.

6.2.2 Maximum output power

The maximum output power of the on-board unit's direct link is 23 dBm, which has a tolerance of ± 2 dB.

6.2.3 Receiver sensitivity

The working frequency is between 5905 MHz and 5925 MHz; the channel bandwidth is 20 MHz; it occupies 96 RB; the transmission block size is 6968 bits; it uses single transmission; the modulation mode is QPSK. Under the AWGN channel conditions, when the receiving power is -87.5 dBm, the throughput of the on-board unit is not less than 95% of the maximum throughput of the reference measurement channel.

6.2.4 Reliability

The communication reliability of the on-board unit shall meet the following requirements:

- a) The packet error rate within the safe communication distance shall not exceed 10%;
- b) The time delay within the safe communication distance shall not exceed 100 ms.

7 On-board unit positioning performance test

7.1 Test conditions

The RF conditions of the test site meet the RF requirements of the test site specified in GB/T 6113.104-2021.

7.2 Static positioning accuracy

The test method of static positioning accuracy shall comply with the provisions of 5.4.1.1 of SJ/T 11420-2010.

7.3 Dynamic positioning accuracy

The test method of dynamic positioning accuracy shall comply with the provisions of 7.3.3 of JT/T 1253-2019.

7.4 First positioning time

7.4.1 Cold start time to first fix

The test method for cold start time to first fix is as follows:

- a) Clear the short-term ephemeris and the latitude and longitude of the last positioning temporarily stored in the terminal to be tested; turn off the terminal to be tested;
- b) Determine a set of satellite simulator ephemeris samples;
- c) Load the ephemeris samples; adjust the output power of the satellite positioning simulator to -130 dBm;
- d) Cold start the terminal to be tested; start timekeeping, until the terminal is correctly positioned; record the timing time;
- e) It should repeat the above steps for no less than 5 times; take the average value of the time recorded in step d) as the test result. When selecting the ephemeris sample in step b), it shall be ensured that the time interval with the previous ephemeris scene exceeds 4 hours.

7.4.2 Warm start time to first fix

The warm start time to first fix test method is as follows:

- a) Clear the short-term ephemeris and the latitude and longitude of the last positioning temporarily stored in the terminal to be tested;
- b) Determine at least 2 sets of satellite simulator ephemeris samples, to ensure that the time interval between ephemeris scenes exceeds 2 hours;
- c) Load the first set of ephemeris samples; adjust the output power of the satellite positioning simulator to -130 dBm;

- a) Load the satellite positioning simulator with a fixed ephemeris sample; adjust the output power to -165 dBm;
- b) Turn on the terminal to be tested;
- c) Increase the output power of the satellite positioning simulator by 1 dBm; then increase it again every 20 seconds, until the positioning is successful;
- d) Wait for 60 seconds after the terminal to be tested is successfully positioned;
- e) Record the simulator output power value, when the terminal to be tested is successfully positioned.

7.6.2 Tracking sensitivity

The test method of tracking sensitivity is as follows:

- a) Load the satellite positioning simulator with a fixed ephemeris sample; adjust the output power to -130 dBm;
- b) Turn on the terminal to be tested;
- c) Wait for 60 seconds, after the terminal to be tested is successfully positioned;
- d) Reduce the output power at 1 dBm intervals; then reduce it again every 20 seconds, until the positioning information is lost;
- e) Record the simulator output power value, when the terminal to be tested loses positioning.

7.7 Test data recording and analysis

For the data recording format of the on-board unit's positioning performance test, please refer to Table A.1.

8 Communication performance test of on-board unit

8.1 Road test conditions

The road test conditions for on-board unit performance shall meet the following requirements:

- a) The test is conducted on a dry, flat asphalt road or cement concrete road;
- b) The horizontal visibility is greater than 1 km;
- c) There is no rain, fog or snow during the test;

The preparation of the test method is as follows:

- a) The reference roadside terminal is deployed at a fixed position; the antenna is deployed at a height of 5 m; there is no obstruction around; it is connected to the data sending and receiving recording device 1 via wired Ethernet;
- b) The operating vehicle is equipped with the on-board unit to be tested; the on-board unit to be tested is connected to the data sending and receiving recording device 2 via wired Ethernet;
- c) The on-board unit to be tested and the reference roadside terminal are both configured to use a 20 MHz channel bandwidth of 5905 MHz ~ 5925 MHz. The terminal is started and can receive GNSS signals normally. The data sending and receiving recording device is started and can receive GNSS signals normally for clock synchronization and positioning.

8.4.1.2.2 Testing steps

The testing steps of the V2I test method are as follows:

- a) The reference roadside terminal is configured as a send-only mode; the on-board unit to be tested is configured as a receive-only mode;
- b) The sending period of the sender is fixed to 20 ms or 100 ms (i.e., 50 or 10 data packets per second); the data packet size is fixed to PDCP SDU = 300 Byte. The packet content includes: sending device number, serial number, sending time, current position coordinates at the sending time, current speed at the sending time. Among them, the sequence number is repeated from 0 to 65535; the accuracy of the sending time is not less than 1 ms; the accuracy of the current position coordinates at the sending time is not less than 1 m; the accuracy of the current speed at the sending time is not less than 5 km/h;
- c) For each received data packet submitted by the receiving end, the data packet content is recorded: receiving device number, received data packet content, receiving time, current position at the receiving time, current speed at the receiving time, communication distance of the received data packet. Among them, the accuracy of the receiving time is not less than 1 ms; the accuracy of the current position coordinates at the receiving time is not less than 1 m. The communication distance of each received data packet is calculated based on the sending position and receiving position in the data packet;
- d) The operating vehicle equipped with the on-board unit to be tested drives back and forth on the test path. The driving path is shown in Figure 2. It drives straight at a constant speed of $v_{\max}$ in the target test interval. Once it leaves this interval, it shall slow down and turn around to repeat the test;

8.4.2.2 Static test item of V2V communication reliability

8.4.2.2.1 Preparation

The preparation work for the V2V communication reliability static test item is as follows:

- a) The reference on-board unit is installed on the mobile test vehicle (small vehicle) and connected to the data sending and receiving recording device 1 via wired Ethernet. The antenna is arranged on the roof of the vehicle, with no obstructions around it at a height of 1.5 m;
- b) The commercial vehicle equipped with the on-board unit to be tested is parked stationary; the on-board unit to be tested is connected to the data sending and receiving recording device 2 via wired Ethernet;
- c) The on-board unit to be tested and the reference roadside terminal are both configured to use a 20 MHz channel bandwidth of 5905 MHz ~ 5925 MHz. The terminal is started and can receive GNSS signals normally. The data sending and receiving recording device is started and can receive GNSS signals normally, for clock synchronization and positioning.

Note: Static testing refers to the V2V communication testing when one party is stationary and the other party is in motion.

8.4.2.2.2 Testing steps

The testing steps of the V2V communication reliability static testing items are as follows:

- a) The on-board unit to be tested is configured as a send-only mode; the reference on-board unit is configured as a receive-only mode;
- b) The sending period of the sender is fixed at 20 ms or 100 ms (i.e., 50 or 10 data packets per second); the data packet size is fixed at PDCP SDU = 300 Byte. The packet content includes: sending device number, serial number, sending time, current position coordinates at the time of sending, current speed at the time of sending. Among them, the serial number cycles from 0 to 65535; the accuracy of the sending time is not less than 1 ms; the accuracy of the current position coordinates at the time of sending is not less than 1 m; the accuracy of the current speed at the time of sending is not less than 5 km/h;
- c) For each received data packet submitted by the receiving end, the data packet content is recorded: receiving device number, received data packet content, receiving time, current position at the time of receiving, current speed at the time of receiving, communication distance of the received data packet. Among them, the accuracy of the receiving time is not less than 1 ms; the accuracy of the current

continuous driving time length t (in seconds) multiplied by the number of packets sent per second;

3) The total number of packet losses in each continuous driving time period is equal to the sum of the sequence number jump values;

4) The packet error rate is calculated according to formula (2):

$$A = \frac{s_1}{s_2} \times 100\% \quad \dots\dots\dots (2)$$

Where:

A - Static test packet error rate of V2V communication reliability;

s_1 - The sum of the total number of packet losses in each continuous driving time period of V2V communication reliability static test;

s_2 - The sum of the total number of packets sent in each continuous driving time period of V2V communication reliability static test.

b) Delay calculation:

1) Filter out the set of received data packets whose communication distance is within the above target test interval;

2) Calculate the maximum value of the difference between the delay receiving time and the sending time of each data packet within the statistical range.

c) Determination of performance test result:

1) If the packet error rate is not greater than 10%, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4a);

2) If the maximum delay is not greater than 100 ms, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4b).

8.4.2.3 Motion test items of V2V communication reliability

8.4.2.3.1 Preparations

The preparations for the motion test items of V2V communication reliability are as follows:

a) The reference on-board unit is installed on a mobile test vehicle (small vehicle) and connected to the data transmission and reception recording device 1 via wired Ethernet. The antenna is arranged on the roof of the vehicle, with no obstructions around it at a height of 1.5 m;

- b) The operating vehicle is equipped with the on-board unit to be tested; the on-board unit to be tested is connected to the data transmission device 2 via wired Ethernet;
- c) The on-board unit to be tested and the reference roadside terminal are both configured to use a 20 MHz channel bandwidth of 5905 MHz ~ 5925 MHz. The terminal is started and can receive GNSS signals normally. The data transmission and reception recording device is started and can receive GNSS signals normally for clock synchronization and positioning.

8.4.2.3.2 Testing steps

The testing steps for the test items of V2V communication reliability motion are as follows:

- a) The on-board unit to be tested is configured as a send-only mode, whilst the reference on-board unit is configured as a receive-only mode;
- b) The sending period of the transmitter is fixed to 20 ms or 100 ms (i.e., 50 or 10 data packets per second); the data packet size is fixed to PDCCP SDU = 300 Byte; The packet content includes: sending device number, serial number, sending time, current position coordinates at the sending time, current speed at the sending time. Among them, the sequence number is repeated from 0 to 65535; the accuracy of the sending time is not less than 1 ms; the accuracy of the current position coordinates at the sending time is not less than 1 m; the accuracy of the current speed at the sending time is not less than 5 km/h;
- c) For each received data packet submitted by the receiving end, the data packet content is recorded: receiving device number, received data packet content, receiving time, current position at the receiving time, current speed at the receiving time, communication distance of the received data packet. Among them, the accuracy of the receiving time is not less than 1 ms; the accuracy of the current position coordinates at the receiving time is not less than 1 m. The communication distance of each received data packet is calculated based on the sending position and receiving position in the data packet;
- d) The commercial vehicle and the mobile test vehicle drive in opposite directions according to the driving path shown in Figure 5. The two vehicles are required to drive in a straight line at a constant speed of $V_{\max}$ within the target test interval. Once they leave this interval, they shall slow down and turn around to conduct the opposite driving test;

Where:

A - Packet error rate of motion test for V2V communication reliability;

s_1 - The sum of the total number of packet error in each continuous driving time period of the V2V communication reliability motion test;

s_2 - The sum of the total number of packets sent in each continuous driving time period of the V2V communication reliability motion test.

b) Delay calculation:

- 1) Filter out the set of received data packets whose communication distance is within the above target test interval;
- 2) Calculate the maximum value of the difference between the delay receiving time and the sending time of each data packet within the statistical range.

c) Determination of performance test result:

- 1) If the packet error rate is not greater than 10%, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4a);
- 2) If the maximum delay is not greater than 100 ms, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4b).

8.4.3 Determination of test results of vehicle-to-road/vehicle-to-vehicle communication (V2X) reliability

After completing the V2I and V2V communication reliability tests, the packet error rate and delay are statistically summarized to make determination on performance test result:

- a) If the packet error rate of all test items is not greater than 10%, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4a);
- b) If the maximum delay of all test items is not greater than 100 ms, the transmission and reception of the on-board unit to be tested meets the requirements of 6.2.4b).

8.5 Recording and statistics of test data

For the recording table of communication performance test data, it can refer to Table A.2 and Table A.3.

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