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Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 5: Emissions-related diagnostic services

Véhicules routiers — Communications entre un véhicule et un équipement externe pour le diagnostic relatif aux émissions —

Partie 5: Services de diagnostic relatif aux émissions

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15031-5 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronical equipment*.

ISO 15031 consists of the following parts, under the general title *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics*:

— *Part 1: General information*

— *Part 2: Terms, definitions, abbreviations and acronyms*

— *Part 3: Diagnostic connector and related electrical circuits, specification and use*

— *Part 4: External test equipment*

— *Part 5: Emissions-related diagnostic services*

— *Part 6: Diagnostic trouble code definitions*

— *Part 7: Data link security*

Introduction

ISO 15031 consists of a number of parts which, taken together, provide a coherent self-consistent set of specifications to facilitate emissions-related diagnostics. Parts 2 through 7 are based on SAE recommended practices. This part is based on SAE J1979 SEP97 (E/E Diagnostic Test Modes).

ISO 15031-1 provides an introduction to the series of International Standards.

This part of ISO 15031 is based on the Open Systems Interconnection (OSI) Basic Reference Model in accordance with ISO/IEC 7498 and ISO/IEC 10731, which structures communication systems into seven layers as shown in the table below.

Table 1 — Applicability and relationship between documents

Applicability	OSI 7 layer	Emissions-related diagnostics			
Seven layer according to ISO/IEC 7498 and ISO/IEC 10731	Physical (layer 1)	ISO 9141-2	ISO 14230-1	SAE J1850	ISO 11898, ISO 15765-4
	Data link (layer 2)	ISO 9141-2	ISO 14230-2	SAE J1850	ISO 11898, ISO 15765-4
	Network (layer 3)	—	—	—	ISO 15765-2, ISO 15765-4
	Transport (layer 4)	—	—	—	—
	Session (layer 5)	—	—	—	ISO 15765-4
	Presentation (layer 6)	—	—	—	—
	Application (layer 7)	ISO 15031-5	ISO 15031-5	ISO 15031-5	ISO 15031-5

Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics —

Part 5: Emissions-related diagnostic services

1 Scope

This part of ISO 15031 specifies diagnostic services and functionally addressed request/response messages required to be supported by motor vehicles and external test equipment for diagnostic purposes which pertain to motor vehicle emission-related data. Any external test equipment meeting the requirements of ISO 15031-4 use these messages to retrieve emissions-related information from the vehicle.

Each section of this part of ISO 15031, which specifies additional detail to existing sections of ISO 9141-2, ISO 14230-4, SAE J1850, and ISO 15765-4 supersede those specifications.

NOTE This part of ISO 15031 provides the mechanism to satisfy the requirements included in the country-specific regulations and not all capabilities included in this document are required by the country-specific regulations. This part of ISO 15031 also is not considered a final authority for interpretation of the regulations, so readers should determine the applicability of capabilities defined in this document for their specific needs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9141-2, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information*

ISO 9141-2/Amendment 1, *Road vehicles — Diagnostic systems — Part 2: CARB requirements for interchange of digital information*

ISO 14230-4, *Road vehicles — Diagnostic systems — Keyword Protocol 2000 — Part 4: Requirements for emission-related systems*

ISO 15031-1, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 1: General information*

ISO/TS 15031-2, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 2: Terms, definitions, abbreviations and acronyms*

ISO 15031-3, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 3: Diagnostic connector and related electrical circuits, specification and use*

ISO 15031-4, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 4: External test equipment*

ISO 15031-6, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 6: Diagnostic trouble code definitions*

ISO 15765-2, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 2: Network layer services*

ISO 15765-4, *Road vehicles — Diagnostics on Controller Area Networks (CAN) — Part 4: Requirements for emissions-related systems*

SAE J1850: *MAY2001,Class B Data Communications Network Interface*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15031-2 and the following apply.

3.1
absolute throttle position sensor
value intended to represent the throttle opening

NOTE For systems where the output is proportional to the input voltage, this value is the percent of maximum input signal. For systems where the output is inversely proportional to the input voltage, this value is 100 % minus the percent of maximum input signal. Throttle position at idle usually indicates greater than 0 %, and throttle position at wide open throttle usually indicates less than 100 %.

3.2
bank
specific group of cylinders sharing a common control sensor, bank 1 always containing cylinder number 1, bank 2 the opposite bank

NOTE If there is only one bank, bank #1 DTCs is used, and the word bank may be omitted. With a single “bank” system utilising multiple sensors, bank #1 DTCs is used identifying the sensors as #1, #2, #3 in order as they move further away from the cylinder(s).

3.3
base fuel schedule
the fuel calibration schedule programmed into the Powertrain Control Module or PROM when manufactured or when updated by some off-board source, prior to any learned on-board correction

3.4
Calculated Load Value
for spark ignition engines, typically an indication of the current airflow divided by peak airflow at wide open throttle as a function of rpm, where airflow is corrected for altitude and ambient temperature

NOTE 1 This definition provides a unit-less number, and provides the service technician with an indication of the percent engine capacity that is being used.

NOTE 2 For diesel applications, the calculated load value shall be determined by substituting fuelflow in place of airflow in the calculation.

3.5
client
function that is part of the tester and that makes use of the diagnostic services

NOTE A tester normally makes use of other functions such as data base management, specific interpretation, man-machine interface.

3.6
continuous monitoring
sampling at a rate no less than two samples per second

3.7
convention
Cvt
column integrated in each message table which marks each parameter included

NOTE The following conventions are used: C = Conditional: the parameter marked “C” in a request/response message is present only under a condition specified in the bottom row of the message table. M = Mandatory: the parameter marked “M” in a request/response message table is always present. U = User optional: the parameter marked “U” in a request/response message table is or is not supplied, depending on dynamic usage by the manufacturer. The convention recommends a mnemonic, which might be used for implementation. In no case is the specified mnemonic a mandatory requirement for any implementation.

3.8
Electronic Control Unit
ECU
generic term for any electronic control unit

3.9
Fuel Trim
FT
feedback adjustments to the base fuel schedule

NOTE Short-term fuel trim refers to dynamic or instantaneous adjustments. Long-term fuel trim refers to much more gradual adjustments to the fuel calibration schedule than short-term trim adjustments. These long-term adjustments compensate for vehicle differences and gradual changes that occur over time.

3.10
negative numbers
signed binary, the most significant bit (MSB) of the binary number used to indicate positive (0) / negative (1)

NOTE 1 2s complement: negative numbers are represented by complementing the binary number and then adding 1.

EXAMPLE – 0,99 = 8001 hex = 1000 0000 0000 0001 binary

0 = 0000 hex = 0000 0000 0000 0000 binary

+ 0,99 = 7FFF hex = 0111 1111 1111 1111 binary

NOTE 2 (– 0,99) + (+ 0,99) = 0.

3.11
number
expressed by this symbol “#”

3.12
P2, P3 timing parameter
application timing parameters for the ECU(s) and the external test equipment

3.13
server
function that is part of an electronic control unit that provides the diagnostic services

NOTE This part of ISO 15031 differentiates between the server (i.e. the function) and the electronic control unit so that this document remains independent from the implementation.

3.14
service
information exchange initiated by a client (external test equipment) in order to require diagnostic information from a server (ECU) and/or to modify its behaviour for diagnostic purpose

NOTE This is also the equivalent of test mode or mode.

4 Symbols and abbreviated terms

CVN	Calibration Verification Number
ECM	Engine Control Module
ISR	Interrupt Service Routine
LSB	Least Significant Bit
MSB	Most Significant Bit
NRC	Negative Response Code
PCM	Powertrain Control Module
SI	International System of Units
TCM	Transmission Control Module

5 Technical requirements

5.1 General requirements

The requirements specified in this clause are necessary to ensure proper operation of both the external test equipment and the vehicle during diagnostic procedures. External test equipment, when using messages specified, shall not affect normal operation of the emission control system.

5.2 Diagnostic service requirements

5.2.1 Multiple responses to a single data request

The request messages are functional messages, which means the external test equipment will request data without knowledge of which ECU(s) on the vehicle will respond. In some vehicles, multiple ECUs may respond with the information requested. Any external test equipment requesting information shall therefore have provisions for receiving multiple responses.

IMPORTANT — All emissions-related OBD ECUs which at least support one of the services defined in this part of ISO 15031 shall support service $01 and PID $00. Service $01 with PID $00 is defined as the universal "initialization/keep alive/ping" message for all emissions-related OBD ECUs.

5.2.2 Application timing parameter definition

5.2.2.1 Overview

The definition of P2 and P3 is included in this clause. A subscript is added to each timing parameter to identify the protocol:

— $P2_{K\text{-}line}$, $P3_{K\text{-}line}$: P2, P3 for ISO 9141-2 and ISO 14230-4 protocols

— $P2_{J1850}$: P2 for SAE J1850 protocol

— $P2_{CAN}$: P2 for ISO 15765-4 protocol

IMPORTANT — It is the vehicle manufacturer's responsibility to specify a shorter P2 timing window than specified in this part of ISO 15031 for each emission-related server/ECU in the vehicle to make sure that network topology delays of the vehicle architecture are considered.

5.2.2.2 Definition for ISO 9141-2

For ISO 9141-2 interfaces, Data Link Layer response time requirements (P1, P4) are specified in ISO 9141-2.

Table 2 specifies the application timing parameter values for P2 and P3.

Table 2 — Definition ISO 9141-2 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{K\text{-line}}$ Key Bytes: $08 $08	25	50	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall start sending its response message within $P2_{K\text{-line}}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-line}}$ of the previous response message for multiple message responses.
$P2_{K\text{-line}}$ Key Bytes: $94 $94	0	50	Time between external test equipment request message and the successful transmission of the ECU response message(s). The OBD ECU shall start sending its response message within $P2_{K\text{-line}}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-line}}$ of the previous response message for multiple message responses.
$P3_{K\text{-line}}$	55	5000	Time between the end of an ECU(s) successful transmission of response message(s) and start of new external test equipment request message. The external test equipment may send a new request message if all response messages related to the previously sent request message have been received and if $P3_{K\text{-line}}$ minimum time expired. ECU implementation guideline: TX (transmit) and RX (receive) line are connected. Each transmitted byte is read back by the receiver in the ECU. Upon the reception of a received byte, e.g. last byte of a request message (checksum) from the tester, the ECU shall reset the P3 timer value to zero. If the ECU supports the request message, it will start transmitting the response message within the P2 timing window. Each transmitted byte will cause the P3 timer value to be reset. If the ECU does not support the request and does not send a response message then in a single OBD ECU system the P3 is started with the last byte received of the request message. In a multiple OBD ECU system a response message by any one or more ECUs shall cause the P3 timer value to be reset in all ECUs including any ECU not supporting the request message.

5.2.2.3 Definition for ISO 14230-4

For ISO 14230-4 interfaces, Data Link Layer response time requirements are specified in ISO 14230-4.

Table 3 specifies the application timing parameter values for P2 and P3.

Table 3 — Definitions of ISO 14230-4 application timing parameter values

Parameter	**Minimum value** (ms)	**Maximum value** (ms)	**Description**
$P2_{K\text{-line}}$	25	50	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall start sending its response message within $P2_{K\text{-line}}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{K\text{-line}}$ of the previous response message for multiple message responses.
$P3_{K\text{-line}}$	55	5000	Time between the end of an ECU(s) successful transmission of response message(s) and start of new external test equipment request message. The external test equipment may send a new request message if all response messages related to the previously sent request message have been received and if $P3_{K\text{-line}}$ minimum time expired. ECU implementation guideline: TX (transmit) and RX (receive) line are connected. Each transmitted byte is read back by the receiver in the ECU. Upon the reception of a received byte, e.g. last byte of a request message (checksum) from the tester, the ECU shall reset the P3 timer value to zero. If the ECU supports the request message, it will start transmitting the response message within the P2 timing window. Each transmitted byte will cause the P3 timer value to be reset. If the ECU does not support the request and does not send a response message, then in a single OBD ECU system the P3 is started with the last byte received of the request message. In a multiple OBD ECU system, a response message by any one or more ECUs shall cause the P3 timer value to be reset in all ECUs including any ECU not supporting the request message.

5.2.2.4 Implementation guidance example for ISO 9141-2 and ISO 14230-4 protocols

This subclause provides an implementation example for client/external test equipment and server/ECU. It is assumed that the client (external test equipment) communicates to a vehicle with two (2) emission-related OBD servers (ECUs). The client requests a CVN, which is only supported by server #1 (ECU #1) with two (2) response messages. Server #2 (ECU #2) is not flash programmable. Figure 1 graphically depicts the timing handling in the client and two (2) servers for a functionally addressed request message. A description follows the figure that references the points marked in Figure 1.

From a server point of view, there is no difference in the timing handling compared to a physically addressed request message. The server shall reset the $P3_{K\text{-line}}$ timer value on each received byte regardless of whether the byte is part of a request message or a response message from any another server or an echo from its transmit line. There are several methods of how a server could implement the timing handling. The implementation of timing parameters is not part of this International Standard but an important system supplier responsibility. Some general server timing parameter implementation guidelines are described in this subclause. The server time stamps each receiver interrupt event and restarts/resets the $P3_{K\text{-line\_server}}$ timer or timing value, e.g. ISR time stamps received byte, and processing of the received information is performed outside the ISR. For simplification of the diagram, the Figure 1 only shows a $P3_{K\text{-line\_server}}$ restart after the reception of the first byte and last byte (checksum) of a received message. The $P3_{K\text{-line\_server}}$ restart is required on each received byte. The received message can be either a request message from the client or a response message from any other server connected and initialized by the 33 hex address. If the server has received a complete message, it compares the target address with the 33 hex address.

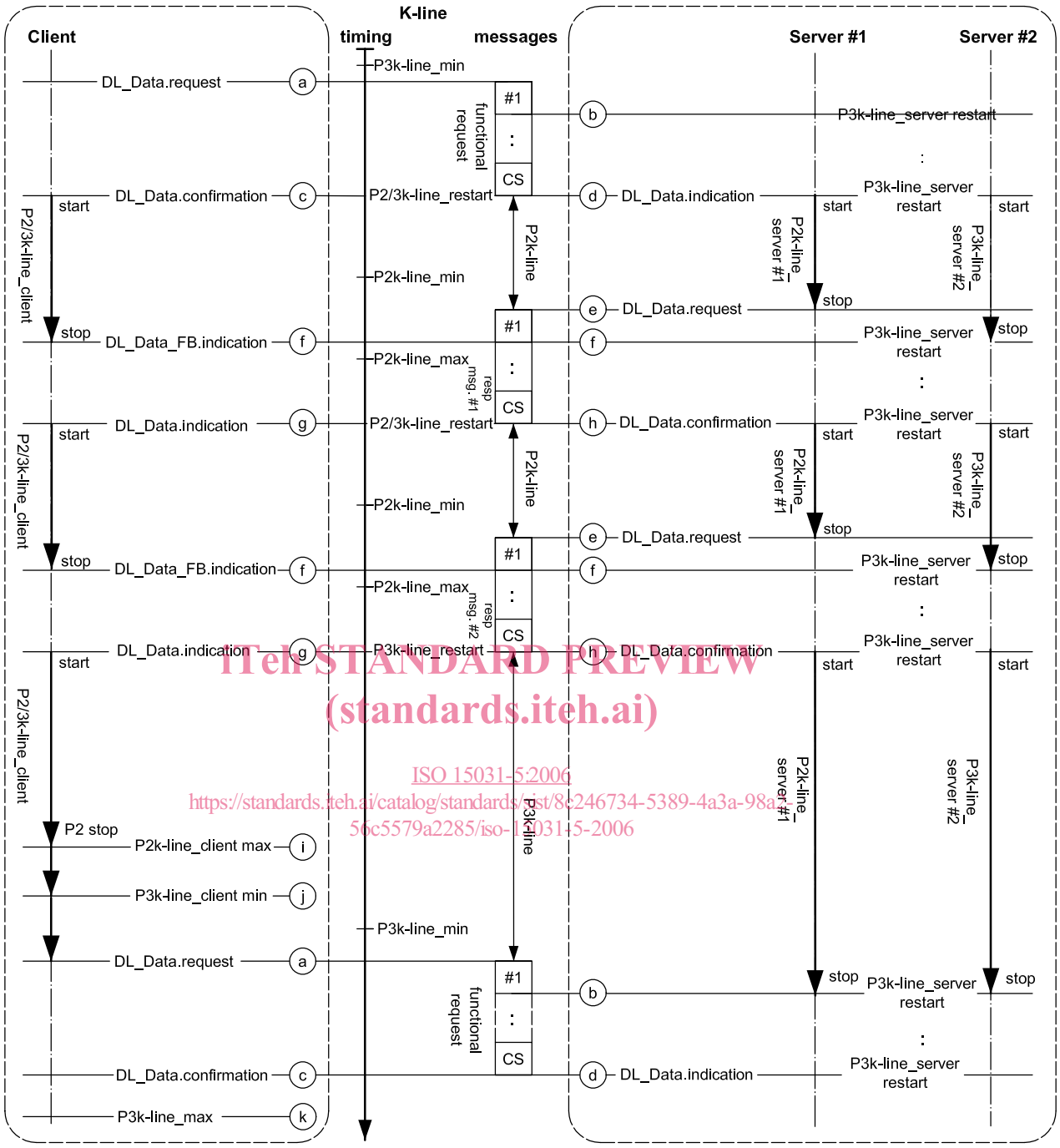

Figure 1 — ISO 9141-2 and ISO 14230-4 protocol client and server timing behaviour

Figure 1 shows the client and two (2) initialized servers connected via K-line (either ISO 9141-2 or ISO 14230-4 protocol). The relevant events for the client and both servers are marked and described.

a) The diagnostic application of the client starts the transmission of a functionally addressed request message by issuing a DL_Data.request to its data link layer. The data link layer transmits the request message to the servers.

b) Both servers and the client receive a byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) either restarts the $P2_{K\text{-}line}$/$P3_{K\text{-}line}$ timers or time stamps the received byte.

c) The completion of the request message is indicated in the client with DL_Data.confirmation. When receiving the DL_Data.confirmation, the client starts its $P2_{K\text{-}line}$ and $P3_{K\text{-}line}$ timer, using the default reload values $P2_{K\text{-}line\_max}$ and $P3_{K\text{-}line\_max}$.

d) If the last message byte is received, each server checks whether the received message includes a target address which matches the 33 hex address. If the result is a match (server #1 and #2), then the completion of the request message is indicated in the servers via DL_Data.indication and each server determines whether it supports the request and has a message available to respond with. If a server determines that the address in the received message is different from 33 hex, or if the address is a match but no response needs to be sent (server #2), the P2 timer is stopped. Since the $P3_{K\text{-}line}$ timer has already been restarted, no further action is required. If a response message is available and has to be sent (server #1, but not server #2), then the transmission of the response message shall be started after $P2_{K\text{-}line\_min}$ timing is expired.

e) Server #1 starts the response message by indicating a DL_Data.request from the application to the data link layer and at the same time stops its $P2_{K\text{-}line}$ timer.

f) Both servers and the client receive a byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) restarts the $P2_{K\text{-}line}$/$P3_{K\text{-}line}$ timers or time stamps the received byte and the client issues a DL_Data_FB.indication to the application layer.

g) The completion of the response message is indicated in the client with DL_Data.indication. When receiving the DL_Data.indication, the client starts its $P2_{K\text{-}line}$ and $P3_{K\text{-}line}$ timer, using the default reload values $P2_{K\text{-}line\_max}$ and $P3_{K\text{-}line\_max}$.

h) Both servers have received the last byte of a message via a receive interrupt by the UART. The ISR (Interrupt Service Routine) either resets the $P2_{K\text{-}line}$/$P3_{K\text{-}line}$ timers or time stamps the received byte. The completion of the response message (e.g. length and checksum check) is indicated in server #1 via DL_Data.confirmation. If server #1 does not want to send further response messages, it stops its P2 timer. In server #2 the message is received and the $P3_{K\text{-}line}$ timer is restarted, but no DL_Data.indication is forwarded to the application because the target address does not match the 33 hex (target address of this message is the tester address F1 hex).

i) The client application detects a $P2_{K\text{-}line\_max}$ timeout, which indicates that all response messages from all servers are received.

j) The client application indicates that $P3_{K\text{-}line\_min}$ is reached and that the $P3_{K\text{-}line}$ timing window is now open to send a new request message [see a)].

5.2.2.5 Definition for SAE J1850

For SAE J1850 network interfaces, the on-board systems shall respond to a request within $P2_{J1850}$ of a request or a previous response message. With multiple response messages possible from a single request message, this allows as much time as is necessary for all ECUs to access the data link and transmit their response message(s). If there is no response message within this time period, the external test equipment can either assume no response message will be received, or if a response message has already been received, that no more response messages will be received. The application timing parameter value $P2_{J1850}$ is specified in Table 4.

Table 4 — Definition of SAE J1850 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{J1850}$	0	100	Time between external test equipment request message and the successful transmission of the ECU(s) response message(s). Each OBD ECU shall attempt to send its response message (or at least the first of multiple response messages) within $P2_{J1850}$ after the request message has been correctly received. Subsequent response messages shall also be transmitted within $P2_{J1850}$ of the previous response message for multiple message responses.

5.2.2.6 Definition for ISO 15765-4

For CAN bus systems based on ISO 15765-4, the (all) responding ECU(s) of the on-board system shall respond to a request message within $P2_{CAN}$. The table below specifies the application timing parameter values for P2.

Table 5 — Definition of ISO 15765-4 application timing parameter values

Parameter	Minimum value (ms)	Maximum value (ms)	Description
$P2_{CAN}$	0	50	Time between external test equipment request message and the receipt of all unsegmented response messages and all first frames of segmented response message(s). In case the vehicle's network architecture uses a gateway to report emissions-related diagnostic data, all unsegmented response messages and all first frames of segmented response message(s) shall be received by the external test equipment within $P2_{CAN}$.
$P2^*_{CAN}$	0	5000	Time between the successful reception of a negative response message with response code $78 and the next response message (positive or negative message). A negative response message with NRC 78 hex shall not be used as a response message to a service $01 request.

5.2.2.7 Implementation guidance example for ISO 15765-4 protocol

5.2.2.7.1 Functional OBD communication during defaultSession

Figure 2 graphically depicts the timing handling in the client and two (2) servers for a functionally addressed request message during the default session. A description follows the figure that references the points marked in Figure 2.