# Study of KWP2000, CAN, and UDS Communication Protocols for Automotive Diagnostic

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***Abstract*—Diagnostic systems must be used to monitor and control parameters as the number of embedded electronic components in automobiles increases. All sectors of the economy, from development to production to after-sales, depend on diagnostic systems to do their tasks. It takes a lot of work to create one for an automobile component or system. However, ISO and SAE have identified a variety of diagnostic system types depending on the types of systems and specific diagnostics from the manufacturers. In certain circumstances, the length can even more than double. The three communication standards that the diagnostic tools in a car network utilize to communicate with one another are KWP2000, CAN, and UDS. This article covers the necessary tools and applications for each diagnostic and service communication protocol in addition to introducing them.**

***Keywords—Diagnostic Protocol, Automotive Communication Bus, Automotive Diagnostics, CAN, KWP, UDS, OBD .***

## I. INTRODUCTION

In addition to providing an introduction of a few diagnostics and service communication protocols, this paper also lists the appropriate tools and apps for each. A diagnostic determines the root cause of a vehicle problem by locating, assessing, and classifying symptoms. The techniques for system behavior improvement, Electrical and electronic equipment is always keeping an eye on detection and communication. Diagnostic methods are used to determine the underlying cause of an abnormal operation in order to correct it. For OEM and supplier, the functional diagnostic requirements, as well as their implementation, development, specifications, and features, are kept in a shared database. Product engineering, production, after-sales, and suppliers must all have open lines of communication. Diagnostic capabilities could be applied during the development, manufacturing, and maintenance phases of a drive system. The first modification and data maintenance for diagnostic needs must be done using a common database, such as ODX.

## II. AUTOMATIC PROTOCOLS

Diagnostic qualities can be used in the design, production, and maintenance phases of an automobile system. The first modification and data maintenance for diagnostic needs must be done using a common database, such as ODX. To complete all diagnostic systems, computer devices that can handle data transmission must be employed.. They will be thoroughly examined, and a comparison study will be conducted. Certain diagnostic tools needed for creation, debugging, and certification will be made accessible in order to deliver specific services. OEMs and suppliers with a clearer overall perspective.

## III. DIAGNOSTIC COMMUNICATION OF VEHICLE

A vehicle is composed of the engine, as well as other sectors such as user and industry standards, basic components such as the chassis, body, transmission supervision, and others. The block arrangement ,the layout and structure of a motor ECU used to manage and operate a vehicle system are depicted in Figure 1.

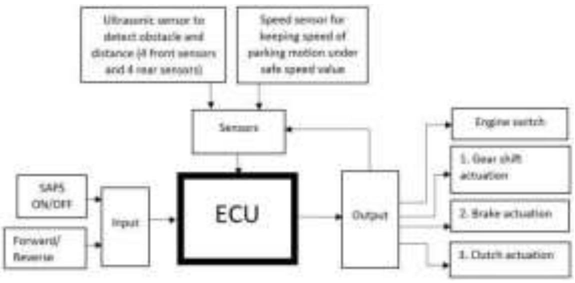


*Figure 1 shows the architecture and block diagram of the engine ECU.*

The schematic representation of the ECU Figure 2 depicts the control of a combustion engine. It depicts the principal input and output signals. The electrical requirements of the ECU must correspond to the driving conditions.

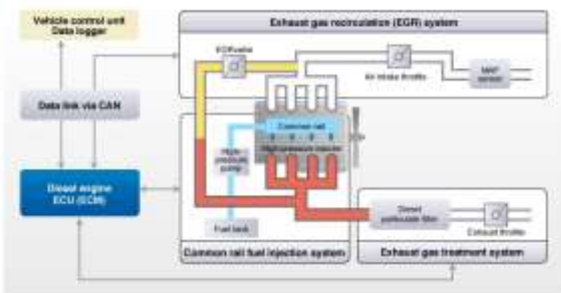


*Figure 2: Electrical engine management utilizing an ECU*

Automobile functions either weren't handled at all or were implemented in an overly complicated manner employing electro - mechanical approaches or discrete circuit boards. The vehicle industry underwent a transformation in the mid-1970s as a result of the introduction of circuit boards in a variety of applications. Before the early 1990s, point-to-point networks were used to transmit data concerning mass, expense, complex, and reliability problems. In certain contemporary automobiles, up to 60 ECUs or more are now the norm. These ECUs interact with one another via a Gateway Control Unit utilizing a number of automotive bus protocols, Handling the sheer complexity of ECUs in automobiles in an automotive bus topology poses a challenge for OEMs and automotive vendors.

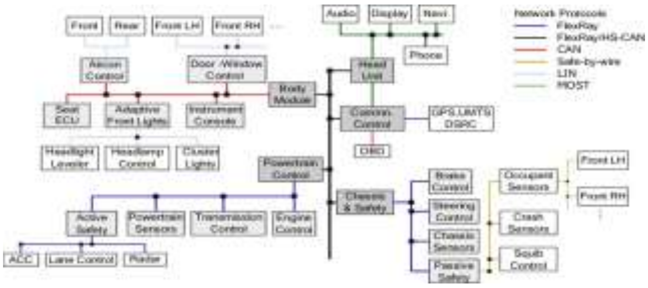

*Figure 3: Design of vehicular network.*

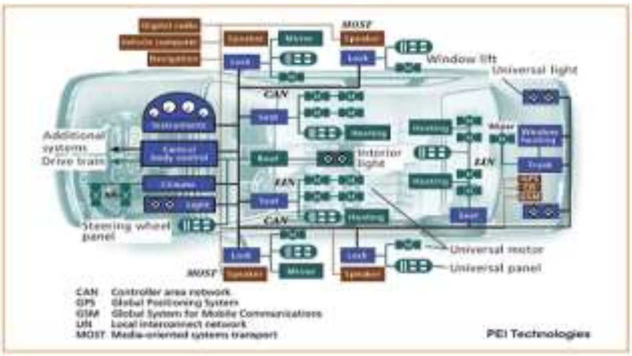

*Figure 4: diagnostic communication system for vehicles*

## IV. KWP-2000 – KEYWORD PROTOCOL 2000

The OEM on-board automobile diagnostics employ KWP2000, as a communication protocol. OBD Communications via K-line between Tester and Vehicle are covered by two significant International Standardization documents, ISO 9141[10] and ISO 14230[4]. A inspector can manage the diagnostic operations of a vehicle's Electronic Control Unit by using the widely used diagnostic service criteria provided by ISO 14230[4]. With node-to-node interconnections, also known as bus conversions, there is just single ECU on the link. The Data Link Layer is covered in ISO 14230-2[5], while ISO 14230-3[6] contains all the prerequisites for providing diagnostic services. A vehicle management and tribunal system needs to be operational or controlled in order to use the protocol stack as a multi-user bus system.

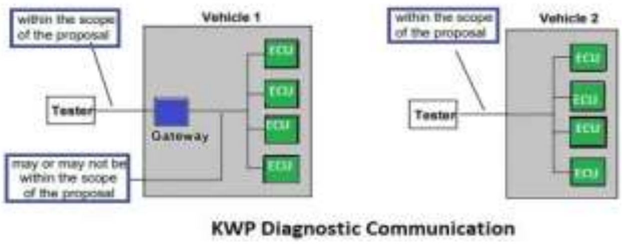


*Figure 5:KWP-2000 Structure.*

According to Wake-Up at 5 baud, the Key method is not needed to keep up with new technologies until the tester specifically requests it.. All configured ECUs should interface and initialize at a data rates of 10,400 after the Wake-up procedure. [5]


*Figure 6: K-line Method*

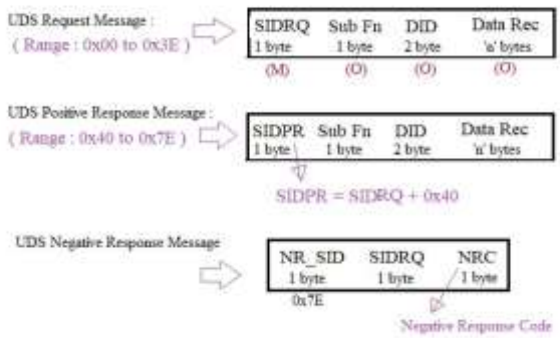


*Figure 7: Organization for Messaging*

For continuous and diagnostic communication routing protocol is used between ECUs. To improve communication, electronics regulates CAN frame production and bus adjudication.

## V. CAN PROTOCOL DIAGNOSTICS

Controller Area Network, is a sequential communication system that complies with ISO standards. Many electronic control systems have been created in the automobile industry in an effort to increase comfort, safety, cut emissions, and regulate costs. In order to address the necessity for a transmission mechanism between ECUs, Robert Bosch GmbH in Germany created CAN in 1986, exchange of digital information between road vehicles using the Controller Area Network (CAN) for high-speed communication, ISO 11898, released in 1993, is a description of the CAN protocol. IS APPLICABLE and may be used in the multi-master paradigm. CAN transfers signals across the CAN bus.

### *A.CAN Protocol Features:*

Message-based addressing is a method that CAN use. Giving each communication a unique identification is part of this. The Identifier classifies the message's content. Priority Assignments: The bus access priority indicated by the 11-bit or 29-bit identification is determined by the bit arbitration mechanism used by CAN[8]. Any communication rate that is appropriate for the size of the network may be employed, It might be feasible to distinguish between these errors. In order to prevent an error-prone unit from interfering with the communication of other reliable units, this function helps decrease the unit's communication priority [1]. The unit is also disconnected from the bus if there is a continuous data fault on the bus. The most common CAN bus medium, twisted pair, supports a maximum data transfer rate of 1Mbps. Coaxial cable or fiber optics are two more transmission techniques that might be employed.

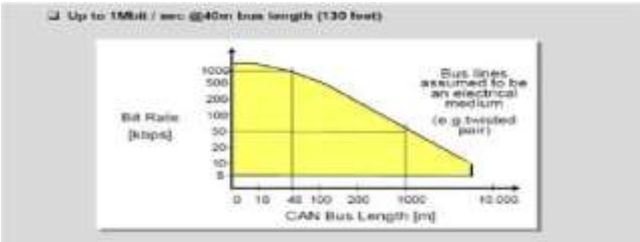


*Figure 8: Depicts the relationship between data transmission rate and bus length.*

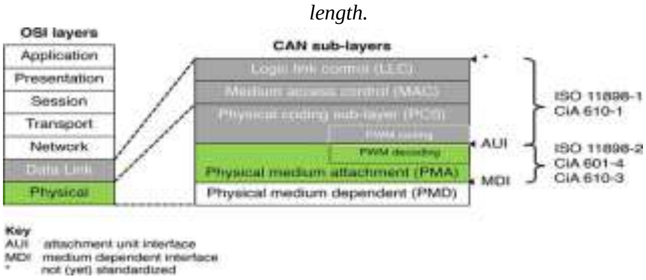


*Figure 9: Levels of the CAN protocol as defined by ISO/OSI.*

*B.CAN Message Format:*

The size of the identifier is the only distinction among both message formats supplied by the CAN protocol. The CAN conventional frame[1] A has an Identification size of 11 bits, but the Extended frame has an Identification range of 29 bits.

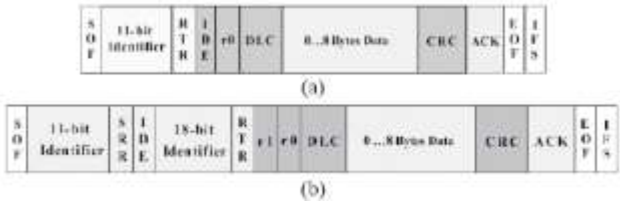


*Figure 10: Two types of CAN frames are available: standard and extended.*

In the beginning of the data frame, there is just one dominant bit. Arbitration field: The arbitration field is made up of the RTR bit that follows the Identifier bits in the field (Remote Transmission Request). The identity is 11 bits long for ordinary Data frames and 29 bits long for extended Data frames, respectively. Priority is given to the RTR bit. CRC stands for Cyclic Redundancy Check. Validation is performed on the SOF, arbitration field, control field, and data field. In a message, it can find up to five mistakes. This field is terminated by the CRC delimiter, a recessive bit delimiter [11]. If no other nodes on the bus have detected any mistakes relating to the CRC, the initial bit of the acknowledgment field is important. An error frame is transmitted in this situation.

*C. CAN Bus Arbitration scheme:*

Arbitration is used to resolve bus access conflicts. Every device has the capacity to begin a message transmission whenever the CAN bus is open. Each transmitting device delivers its identity during the arbitration phase [1,] which is compared to the bus amount. If numerous units begin transmitting a communication simultaneously, any differences are resolved in the tribunal field of each delivered frame, commencing with the initial bit.

*Figure 11: The Scheme*

*D. CAN Control Structure:*


*Figure 12: ISO 11898 CAN (125 kbps to 1 Mbps)*

The building of the CAN Control System Resistive Model is shown in Figure 12. In order to lessen the impacts of reflection on the bus line, the ISO-11898[7],CAN High Speed, standard suggests that network wiring technology is akin to a single line design. To avoid signal duplications along the bus, it is necessary to utilize twisted pair cables, either insulated or unprotected, having a nominal impedance of 120 ohm and terminated with a 120 ohm resistor at either end.

*E.CAN Bus Error Handling:*

The CAN layer is implemented for safe packet transfer and includes debugging, and signalling. [13]. Five distinct methods may be used to identify errors in CAN: [1] The transmitter computes a 15 bit CRC from the message content to detect cyclic redundancy faults. Every receiver who receives the signal would do a fresh CRC computation and check it to the value provided. If a receiver notices an incorrect bit, it will signal an error, for example, in the 3-bit interframe gap, EOF, ACK delimiter, or CRC delimiter. If a message is not acknowledged, an ACK error is generated.To calculate the bit error, the transmitter "Reads back" each broadcast bit. A bit mistake is recognised if the observed value and the specified value disagree. By inserting: Additional bit faults are discovered.

## VI. UNIFIED DIAGNOSTICS SERVICE(UDS): ISO 14229-1

The UDS Protocol was created to meet the criteria for diagnostic systems employing CAN buses. Its foundation is the Keyword Protocol concept (KWP2000). By integrating ISO Standards 15765-3 and 14230-3, the UDS Protocol was developed (KWP 2000). (CAN diagnostics).

Table 1. UDS Diagnostics Functions

| Diagnostics functions | Examples |
|---|---|
| Communication Management | Session Control, Device Reset, Security Access, Communication Control |
| Data | Read Identifiers or Memory Write Identifiers or Memory |
| Stored Data | Read Diagnostics Information Clear Diagnostics Information |
| I/O Control | Control Input or Output |
| Reprogramming | Download and Upload of Data |

As was mentioned in the section on diagnostic services, several standards are utilized for various types of diagnostic services. A protocol-neutral standard, according to ISO 14229-1[9], is UDS. The Network Layer Service Definition is required to implement the message transfer rules. Fig. 17 displays the extra possibilities for the ISO 14229-1 protocol specification.

Table 2. OSI Layer specification of UDS

| OSI Layers | Enhanced Diagnostics on CAN (UDS) |
|---|---|
| Application Layer | ISO 14229-1 & ISO 15765-3 |
| Presentation Layer | N/A |
| Session Layer | ISO 15765-3 |
| Transport Layer | ISO 15765-2 |
| Network Layer | ISO 15765-2 |
| Data Link Layer | ISO 11898/SAE J1939 - 15 |
| Physical Layer | ISO 11898/SAE J1939 - 15 |

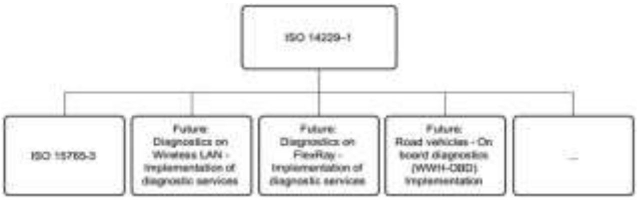


*Figure 13: ISO 14229-1 UDS Existing Standards and Possible Future Implementation.*

## VII. ODX – Open Diagnostic Data Exchange

ISO 22901 specifies the data format for the transmission of Electronic Control Unit (ECU) diagnostic and programming data between system suppliers, automakers, service centers, and diagnostic equipment from various manufacturers. A consistent diagnostic description format for ODX users should be available for OEMs, suppliers, producers, and the aftermarket to utilize in the creation of ECUs.

## VIII. COMPARISON ANALYSIS

The essential elements of the diagnostic techniques employed by the ISO Organization for Automotive Standards are shown in Table 3. The diagnostics communication protocols ISO 14230[3] and ISO 11898[7] are crucial for the future of automotive/vehicle communication applications as well as the whole global automotive sector. In the emerging trend of automotive diagnostic communication for passenger cars and commercial vehicles, which may be operated over a range of network technologies are utilized.

Table 3. Comparative Analysis of diagnostics protocols

| | KWP | CAN | UDS |
|---|---|---|---|
| **Standards** | ISO | ISO | ISO |
| Application | ISO 14230-3 | ISO 15765-3 | ISO 14229-1 |
| Presentation | N/A | N/A | N/A |
| Session layer | N/A | N/A | ISO 15765-3 |
| Transport | N/A | N/A | ISO 15765-2 |
| Network layer | N/A | ISO 15765-2 | ISO 15765-2 |
| Data link layer | ISO 14230-2 | ISO 11898 | ISO 11898 |
| Physical layer | ISO 14230-1 | ISO 11898 | ISO 11898 |

## IX. CONCLUSION

To ensure the correct functioning and monitoring of automotive systems, communication protocols and standards must be followed while implementing embedded electronic circuits. This paper highlights the core ideas of diagnostics network standards and relevant industry standards.. The OSI layers must be completed in order to further our knowledge of communication systems, and this can only be done by implementing the standards ISO 11898, CAN 2.0, ISO 14230-3, and UDS that were described in this article. This study has improved understanding of automobile diagnostic standards and ECU Connectivity with Testing Tool.

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