NEW TECHNOLOGIES

Development of Next Generation Diagnosis Functions

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Abstract

Mitsubishi Motors Corporation (MMC) has developed the following new functions for diagnosing electronically controlled systems:

- **"CAN Bus Diagnosis Function" for diagnosing the controller area network (CAN) communications bus**
- **"MUT-III/Pro-METS" (Multi-Use Tester III/Mitsubishi ECU Test System for Production), a software development tool compatible with the new communications protocol "KWP*2000 on CAN"**

MMC has also developed the following functions for utility applications, not limited to diagnosis:

- **An ECU variant coding function to minimize ECU types**
- **An ID data read function to ensure parts traceability**

*** KWP = Keyword Protocol**

Key words: *Multiplexing Diagnostics, Electronics*

1. Introduction

MMC started introducing the CAN communications system as the new in-vehicle communications system in its products beginning with the new Mitsubishi COLT. To enable the diagnosis system to accommodate this new communications system, MMC has introduced the following next generation diagnosis tools for more efficient, thorough and effective inspections and diagnoses:

- "E-tester" for development
- "Pro-METS" for manufacturing
- "MUT-III" for service

The Pro-METS and MUT-III are new diagnosis tools originally developed by MMC and they share the same communications interface and diagnosis database. In addition, they are designed in compatible with the "Common Access to Electronic Systems of Automotive Requirements (CAESAR)" System on which the E-tester (the tester used by DaimlerChrysler as a standard diagnosis tool) is based. Adaptation of CAESAR prevents the differential of diagnostic data between MMC's original tester and E-tester.

Although the new in-vehicle communications system offers many advantages, their complexity makes it difficult to identify the causes of problems of a defect or fault. To counter this difficulty, MUT-III incorporates a CAN bus diagnosis function capability for diagnosing the CAN bus. On the other side, the ECUs are compatible with the new communications protocol, KWP2000 on CAN. This communications protocol has very high extensibility and allows completely new functions to be incorporated, such as the ECU variant coding function (which is essential in the strategy for minimizing the number of ECU types) and the parts traceability function. These functions were developed using cutting-edge technologies that are new to the Japanese automobile industry. This cross-field development serving diverse functions was realized through collaboration among the development, production, and service departments of MMC.

2. New diagnosis system "Pro-METS" for manufacturing

The Pro-METS was developed as a new ECU diagnosis system for the delivery inspection of vehicles whose diagnosis communications depend on the CAN system. This ECU diagnosis system was developed with the following target features:

(1) Capable of diagnosing ECUs through CAN communications system
(2) Capable of diagnosing ECUs also through conventional communications system
(3) Flexible designation of any diagnosis items
(4) Interface function to accommodate the diagnosis needs of future ECU functions (such as the ECU variant coding function)
(5) Shared use by all MMC plants for ECU diagnosis and other purposes

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2.1 Features

Since the Pro-METS uses the same V.C.I. (vehicle communication interface) of the new service-use diagnosis tool MUT-III (described in the next section), the Pro-METS can share the diagnosis information database with MUT-III. This eliminates the need to check diagnosis items that have already been checked at the development stage again during service operations.

In order to minimize the work when developing hardware systems, the Pro-METS is configured utilizing personal-computer functions for controlling inspection terminal devices and the V.C.I., and a server is used for data storage and management.

Inspection data are accumulated in the inspection result database in the server together with vehicle specification data to ensure traceability.

2.2 Overview of Pro-METS system

Fig. 1 shows an overview of the Pro-METS. The system consists of the Line Side Station (LSS) and multiple Mobile Test Terminals (MTTs). The LSS is a server that stores and manages ECU diagnosis data, vehicle specification data and the MTTs, whereas the MTT is an inspection terminal.

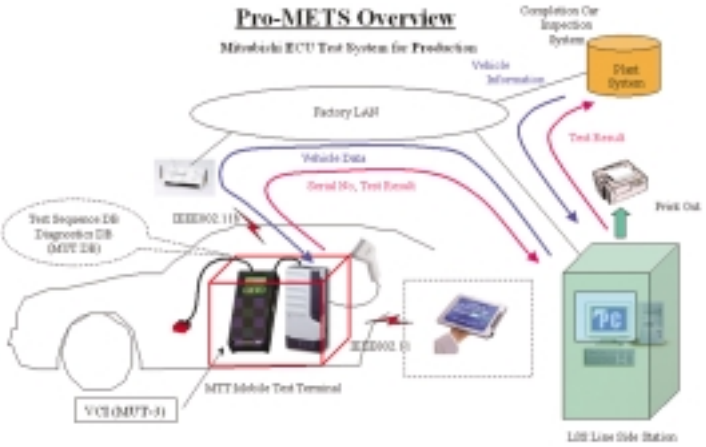

Fig. 1 System overview of Pro-METS

2.3 Extensibility

Fig. 2 shows the three variations of the Pro-METS system. Owing to the new generalized basic functions they have in common, these variations assure that the Pro-METS system can be adapted to suit delivery inspections conducted in a variety of factories, from mass production plants to small-scale knockdown production plants.

Type 1 is for use in mass-production plants, where the production data provided from a plant's higher hierarchy system and stored in the LSS are used for automatic delivery inspection of ECUs. Type 2 is for use in mid-scale plants where the LSS is used for storing and managing vehicle specification data (not production data) and data from the LSS can be used as delivery inspection data. Type 3 is a standalone version of the Pro-METS for small-scale knockdown production plants, where it is used on its own for rather slow diagnosis. MMC's Okazaki plant, where the new Mitsubishi COLT is manufactured, uses the Type 1 Pro-METS system.

The MTT can be used as a mobile terminal when it is combined with an IEEE802.11x wireless LAN.

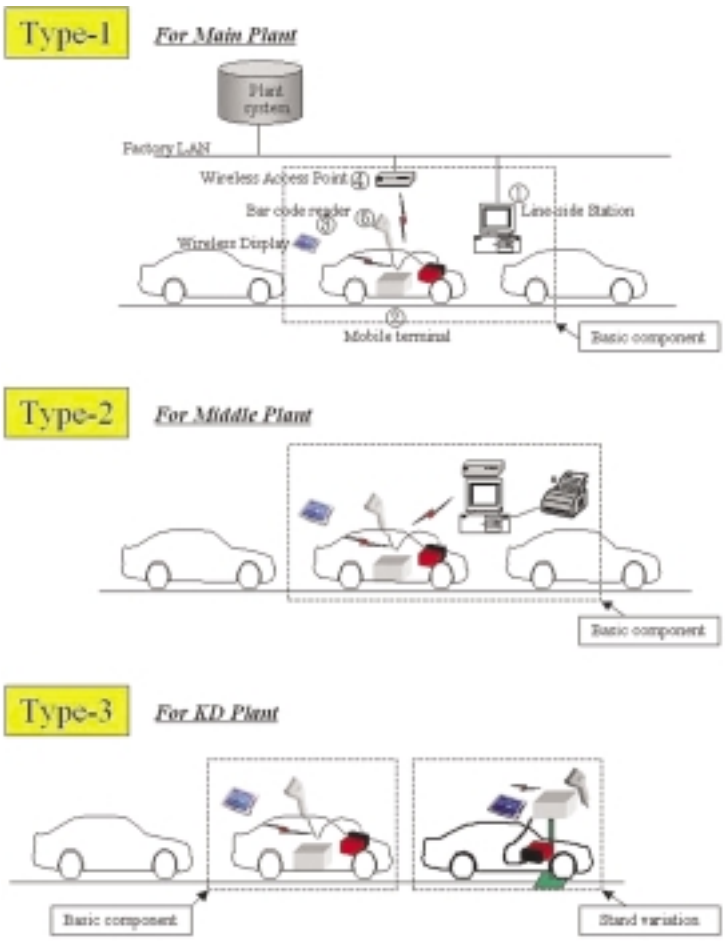

Fig. 2 Variations of Pro-METS

2.4 Pro-METS's future prospects

In order to accommodate the increasing complexity of ECU variant coding and contents of ECU inspection while guaranteeing consistent quality standards for all ECUs in all vehicles produced in all MMC and affiliate factories around the world, MMC will continue to upgrade the functions of the Pro-METS.

3. New diagnosis system "MUT-III" for use by service personnel

3.1 Overview

In accordance with releasing new products that introduce CAN communications systems, MMC has

Fig. 3 MUT-III

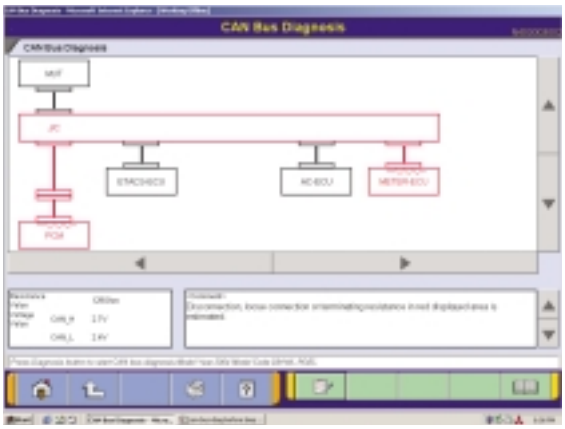

Fig. 4 CAN bus diagnosis

developed the MUT-III as a next generation diagnosis tester for servicing these new and future vehicles (**Fig. 3**).

A personal computer (PC) is connected to the MUT-III unit and used as a system's control terminal, and communicates with a vehicle ECU through the V.C.I.. In addition to being able to handle all diagnosis functions covered by the conventional MUT-II tester, the MUT-III system can display data as easy-to-understand diagrams and graphs on a large screen of the PC.

Unlike the MUT-II, the MUT-III can retain data on all vehicles, from old to new models, classified according to destination in the PC's hard disk. This eliminates the awkward but essential job with the MUT-II, of switching the data list (communications protocol data and diagnosis item list database) by replacing the ROM pack with another according to the vehicle model and year model.

New functions that make use of the advantages of the PC are also being developed. For example, the workshop manual viewer is a useful function for mechanics as they no longer have to carry around a thick manual and search for relevant pages while working on a vehicle. The workshop manual viewer is currently available for certain vehicle models, and allows users to retrieve the pages containing the failure code for a particular problem at the push of a button.

3.2 CAN bus diagnosis function

The high-speed CAN bus used in the new in-vehicle communications system is of a two-wire structure that is highly resistant to failure, and will work even when one wire circuit becomes open. This high resistance to failure allows the bus to operate without notable adverse consequences even if small problems are present, but it prevents problems from showing up until they build up and appear as a fault, which makes diagnosis difficult. To overcome this situation, we developed a "CAN bus diagnosis function" which can identify the presence of abnormalities in the CAN bus and narrow down the source of the problem to a certain area.

This CAN bus diagnosis function is available on the MUT-III through a screen like that shown in **Fig. 4**. When the user presses the diagnosis button after selecting a vehicle model and ECU type, MUT-III automatically detects the presence of an abnormality based on the voltages of the CAN_H and CAN_L wires, the resistance between the two wires, and whether or not each ECU is sending signals. The results are then displayed on the screen. If the problem is an open circuit, the function can isolate the problem to a small area. In designing the CAN bus diagnosis function, we allocated the function of determining the presence or absence of problems to the Pro-METS and the function of narrowing down problems to suspect areas to the MUT-III.

4. Data sharing between diagnosis tools

As against the Pro-METS and MUT-III, we use the E-tester for development, which is used by DaimlerChrysler as the standard tool. Although the Pro-METS and MUT-III database differ from E-tester database at first after development, we later incorporated CAESAR (DaimlerChrysler's standard basic software for diagnosis communications) used in E-tester into the MUT-III in order to allow the tools to share the same database. This data sharing has effectively reduced data buildup lead-time and improved data reliability, and it will be applied to the Pro-METS in the near future.

5. "KWP2000 on CAN" protocol

Conventional MMC vehicles introduced the ISO9141 defined K-LINE technology for diagnosis communications. However, the new in-vehicle communication system allows the CAN technology to be used not only for control communications but also as a backbone network bus for diagnosis communications. To use the CAN bus for diagnosis communications, we adopted the ISO15765 defined "KWP2000 on CAN" communications protocol. All the above-mentioned new diagnosis tools are based on this protocol.

5.1 Features

The main features of the KWP2000 on CAN protocol

are as follows:

- It is becoming a global standard communications protocol. In North America, other communications protocols will no longer conform to the On-Board Diagnosis (OBD) regulations.
- The same CAN communications wire can be used for control and diagnosis, thus reducing the number of harnesses.
- Many standard functions (services) can be provided.
- High-speed communications of CAN provides high-speed data transfer, which in turn provides quick ECU flash reprogramming.

5.2 Application

KWP2000 on CAN allows any ECU connected to the CAN bus to have the diagnosis communication function without additional hardware. This capability of the protocol enables such ECUs as those of the Electronic Time Alarm and Control System (ETACS) and combination meter, which originally are not given full-scale diagnosis functions, to have diagnosis communications functions.

5.3 Functions

Next generation diagnosis functions made possible by adopting KWP2000 on CAN communications protocol include the following:

[Read-out ID data function]

This function is useful for storing and retrieving vehicle history data to ensure traceability. Data read by using this function include ECU software version, hardware version, and serial numbers.

[Diagnosis trouble code (DTC) related function]

Using DTCs compliant with the SAE standard (two-byte system), adding status data to present and past failures, and freeze-fame data, among others.

[ECU variant coding function]

This function is essential for reducing ECU types. The ECUs on each vehicle are programmed to their specifications by means of the ECU variant coding function, and the diagnosis tool uses these to send the specification data to the ECUs on the vehicle. This minimizes the number of basic ECU types required.

6. Acknowledgement

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