ETACS Functionality Development for the OUTLANDER

Takeo NAGAMORI* Takashi INOUE* Yasuyuki MIZUTANI*
Yukihiro NISSATO* Hiroshi HYODO* Naoki KAWASHIMA*

Abstract

Mitsubishi Motors Corporation's (MMC's) unique body-system electronic controller, Electronic Time & Alarm Control System (ETACS) has been advanced in order to take on the role of core ECU for the entire electronics system in vehicles from the conventional body control system[(1)]. In the new OUTLANDER, ETACS performs a gateway for vehicle communications. Also it distributes power, and switches electronic component's variations to establish proper Controller Area Network (CAN) bus communication structure. With the integration of these significant functions, ETACS achieves considerable advantages for development, production, and retail processes.

Key words: *Electronic Equipment, Electronics Control, Multiplexing, Diagnosis*

1. Foreword

The vehicle mounted ECUs are desired to achieve development-related "Seeds", such as wiring minimization or performance enhancement, through using communication network. At the same time, it has to satisfy production or retail process "Needs". For example, ECU is being required to reduce its number of variations, and to implement full diagnosis function or assurance of traceability. In the new OUTLANDER, a new-generation platform [(2)] for electronics has been adopted with the ETACS that designated as a core ECU thereof. This infrastructure has made possible to satisfy "Seeds" and "Needs" above, including to apply switching variation of ECUs (variant coding) [(3)] with this network communication. These systems will be described hereinafter.

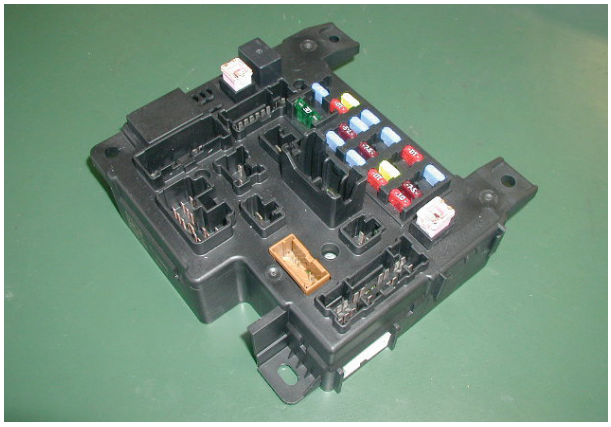


Fig. 1 Outer appearance of ETACS

2. ETACS system configuration

The appearance of the ETACS is illustrated in **Fig. 1**, and the overview of the system is provided in **Fig. 2**. Approximately thirty different switches, auto-light sensor, and external temperature sensor are connected directly to the ETACS. In terms of networks, the communication system comprises four CAN and LIN, and as the central unit thereof, the ETACS exchanges signals with the various networks. Furthermore, based on the various numbers of data obtained from switches and communication network, the ETACS controls most of body electronics components such as power door locks, exterior lights, and windshield wipers.

3. Overview of the evolution of ETACS functionality

3.1 Junction-block unification

Although reduced wiring is an inevitable consequence of the practical implementation of communication networks, this project has achieved optimum harness routes through the integration of junction blocks and fuse boxes, which had traditionally been separate components. Furthermore, by integrating the wire-to-wire joints into ETACS, this development has also given rise to further harness reduction.

3.2 Power control

This implementation of the ETACS is provided with functionality for the control of all vehicle power using relays and based on data from the ignition switch (**Fig. 3**). This adds a high level of convenience when, for example, post-fitting remote-control engine starters, which are in high demand in colder regions. If this type of post-fitting operation were to be performed in a standard vehicle, it would be necessary to insert bypass circuit into the ignition switch, and furthermore, special modification would also have to be performed on the immobilizer. In the new OUTLANDER, however, since the ETACS is capable of controlling the vehicle's entire power system, there is no need to insert bypass circuit

* Electronics Engineering Dept., Development Engineering Office

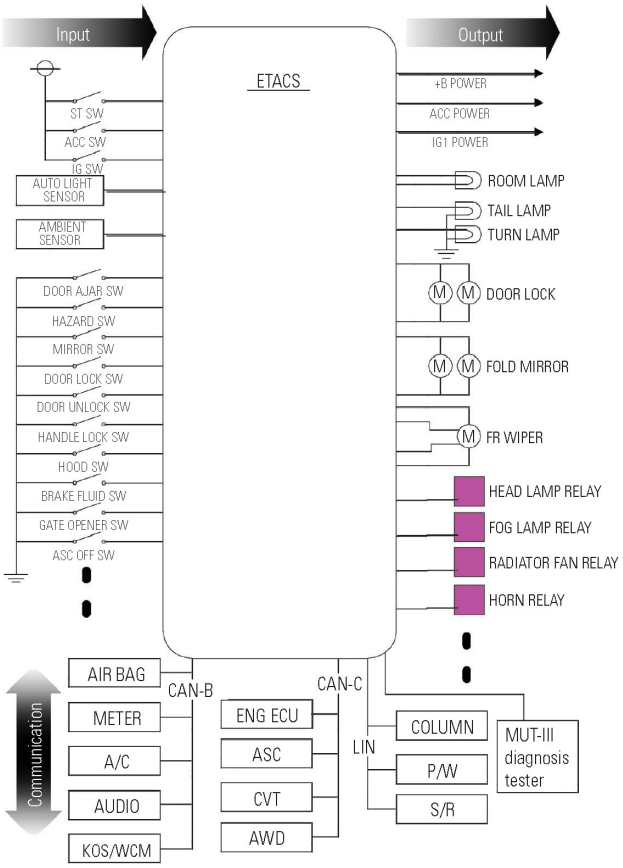


Fig. 2 Overview of the system

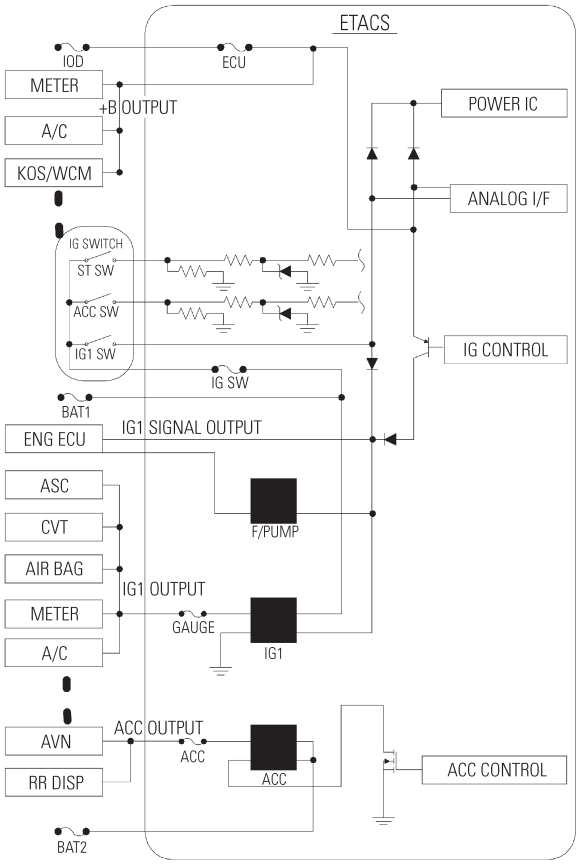


Fig. 3 Ignition control

into the ignition switch, and also since the CAN already incorporates the functionality of the immobilizer, making this available through the action of the ETACS simplifies the post-fitting of a remote-control engine starter.

3.3 Gateway

The conventional ETACS featured gateway functions between a pair of communications busses (CAN and SWS); however, this project provided functions for four such busses – namely, CAN for the powertrain & chassis, CAN for the mid-speed body & AV, LIN for the low-speed body, and CAN for diagnosis – and made it possible for ECUs to be deployed on the corresponding communications busses. Furthermore, CAN for diagnosis is dedicated to the communication with a diagnostic tester, and the ETACS acts as a firewall in order to realize physical isolation and security protection. (For more details, refer to the separate report, Development of a Next Generation Electronics Platform).

3.4 Data coding

The major distinguishing characteristic of the new OUTLANDER's ETACS is data coding, which is classified into the following three types. In order to respond suitably to the needs of production plants, dealerships, and customers, the functionality of ETACS can be switched without the need for parts replacement.

(1) Variant coding

Performed at the final stage of a production plant's assembling line, variant coding is a process whereby data pertaining to a vehicle's equipment specification is written to ECUs and the functionality thereof is switched. In this way, it is possible to significantly curtail the increase in part numbers that had come about in line with the recent trend for increased ECU functionality. **Fig. 4** presents an overview of the variant coding process. In said final stage of a production plant's assembling line, equipment specification data required for the switching of functions in the ETACS and other ECUs (hereinafter "coding data") is written using an inspection tool known as Pro-METS. In addition to switching its own functions based on coding data, the ETACS also forwards this data to the CANs and LIN. Accordingly, the ECUs connected to these networks perform function switching based on the coding data.

Up to 100 different items of coding data are used, and this comprises both the basic equipment information pertaining to vehicle type, destination market, and engine and transmission models, as well as unique specification-related information for the detailed switching of functions in the ETACS and in ECUs for the combination meter, the air conditioner ECU, and other similar components.

(2) Option coding

Coding data also contains information relating to the specifications of additional equipment fitted at deal-

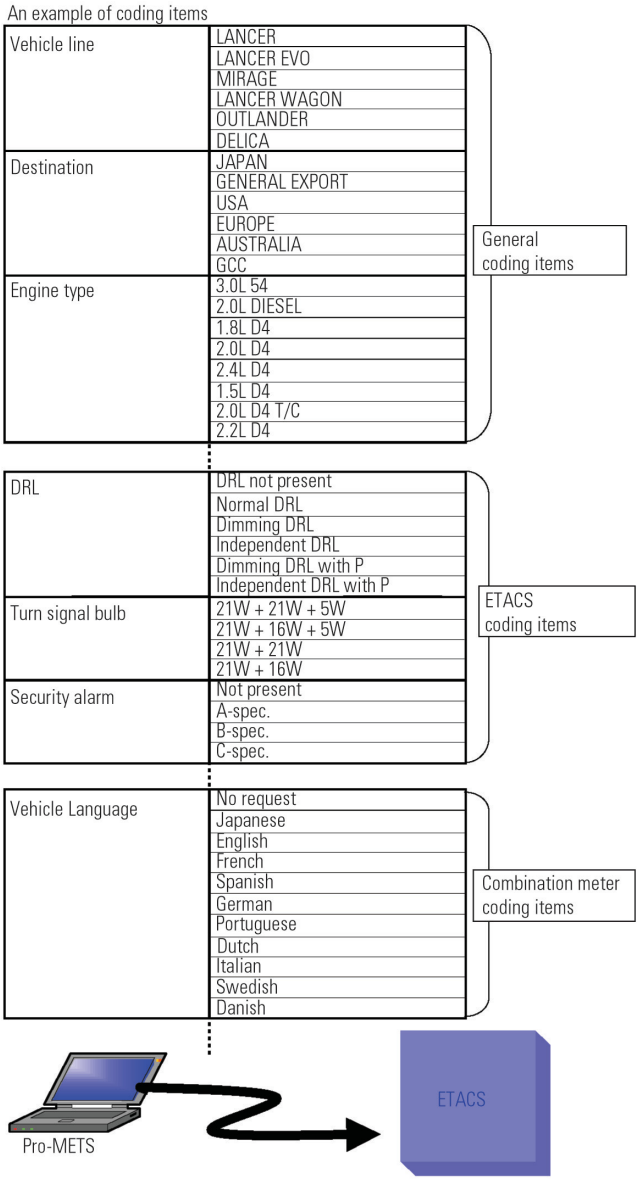


Fig. 4 Example of variant coding items

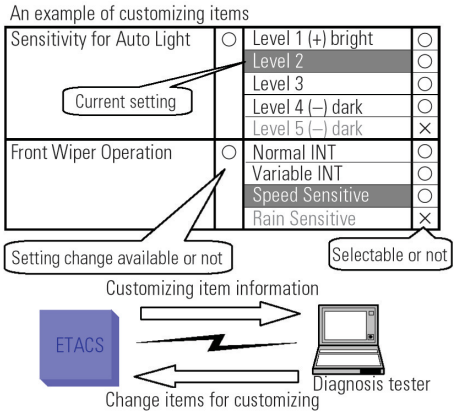


Fig. 5 Example of customizing items

erships. For example, a specific item of coding data is used to indicate whether or not the vehicle is fitted with fog lamps; however, it is often the case that this component is an optional extra that is fitted at the dealership. Overwriting of such items of coding data can be carried out at the dealership in question using a diagnostic tester. However, only certain items of data can be overwritten at dealerships and all others are protected from accidental overwriting. For example, the lighting mode of fog lamps varies from country to country, and another coding item is used to identify the relevant mode. Since a country's fog-lamp lighting mode is defined by law, overwriting of the corresponding coding item at a dealership is not possible.

(3) Customization

The term "customization" is used to describe the modification of detailed functions by the individual user. For example, the ETACS facilitates the setting of theft alarm, adjustment of the lighting threshold of auto-lights, and other similar customization actions through the use of a diagnostic tester at the dealership in question. The conventional ETACS also has the customizing function but it is limited. Although customizable items will depend on the equipment specification of the vehicle in question (for example, it will only be possible to modify the lighting threshold of auto-light for vehicles fitted with this component), it is not possible for the diagnostic tester to determined those that are customizable and those that are not; accordingly, it was required that all menu items be displayed. In the case of this OUTLANDER, however, customizable items are sent to the diagnostic tester based on coding data, and only those which can be modified are displayed on the tester's screen (**Fig. 5**).

3.5 Vehicle number correlation

As the ETACS records the coding data specific to the vehicle, installation on a vehicle with different equipment will result in the ECUs becoming unable to function correctly. A process for preventing this outcome is described below. In the production plant, variant coding is performed on the ETACS after the vehicle identification number (VIN) has been written to the engine ECU. At this time, the ETACS independently obtains the VIN sent from the engine ECU to CAN bus and stores it internally. In other words, this ensures that the VIN stored in the engine ECU and the ETACS are identical. In the unlikely event that, in the marketplace, an ETACS were to be removed from one vehicle and installed in another, it would identify non-conformity between its internally stored VIN and that in the new vehicle's engine ECU, and would send an error message on the combination meter. Upon receipt of this message, the combination meter would display "SYSTEM ERROR" to inform the owner that a non-genuine part had been installed.

3.6 Network diagnosis

In the case of conventional vehicles, diagnosis in optional functionality (i.e., whether this was due to failure or non-fitting) was required to be left to the discretion of the service technician in question. For example,

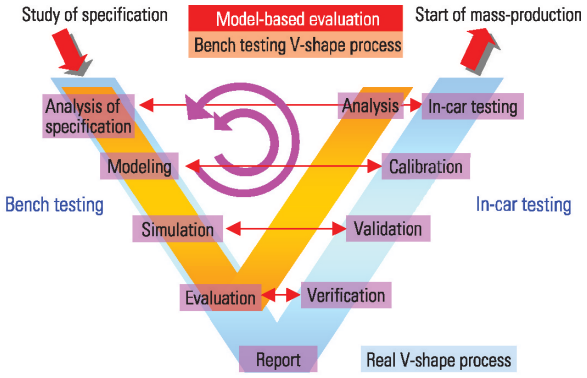


Fig. 6 Model-based evaluation

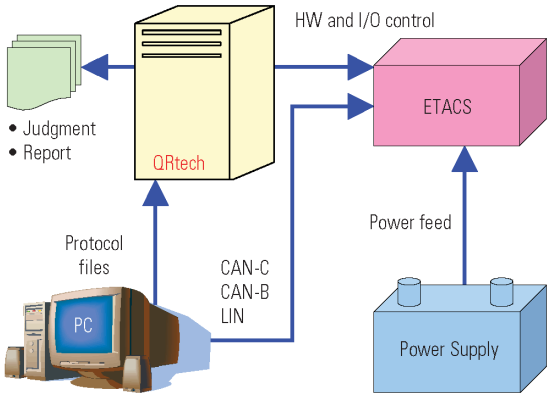


Fig. 7 Bench testing tool

since the sunroof ECU and the audio-system ECU are linked via a network, even if one of these systems were not present in the vehicle, it would be determined that a communication error had occurred. Nevertheless, diagnosis is carried out based on regulated coding data in the new OUTLANDER, and this improvement ensures that failure is not diagnosed with respect to the functionality of a non-fitted item of equipment. Furthermore, by functioning as a gateway, the ETACS can monitor the communication status of all ECUs, record distance traveled or time elapsed since the occurrence of a failure, and collect a wide range of diagnosis-related information in this way. (For more details, refer to the separate report, Development of a Next Generation Electronics Platform.)

3.7 Reprogramming

In accordance with increasing ROM capacity and functional complexity in recent ECUs, it has become more common to use flash ROM as a means of reducing lead time and eliminating risk. Although flash ROM is also being used in the ETACS of the OUTLANDER, this has been further advanced in order to enable a diagnostic tester to reprogram via the CAN bus without the need to remove the ETACS from the vehicle. Flash ROM was traditionally used at the development stage in order to allow reprogramming; however, by making this possible without the need for removal from the vehicle, the efficiency of development operations has been significantly enhanced. Furthermore, flash ROM is continuously used in post-production as the gateway and variant coding functionality provides support for situations where specification changes must be executed in short periods of time. This is advantageous in that old-part inventory is reduced to zero for changes in specifications.

4. Evaluation of reliability

4.1 Bench testing

The ETACS control volume can rise to the equivalent of hundreds of thousands of microprocessor commands. Furthermore, the increased number of man-hour at testing stages now required to evaluate more advanced, complex systems has become a serious problem. As a countermeasure, the focus has been shifted to model-based evaluation wherein loading conditions equivalent to those in an actual vehicle are recreated in a bench-test simulator, and operation is examined in a hypothetical manner, thus reducing the extent of evaluation required of subsequent in-car testing (**Fig. 6**).

QRtech® (from Qualified Real-time Technologies) is used as the simulation tool for model-base evaluation. In accordance with the input of special protocol created as a text file, this fully-automatic bench testing tool can simulate conditions equivalent to those in an actual vehicle operation, evaluate with respect to pass/fail criteria, and output the corresponding reports (**Fig. 7**).

As many as 42,000 different functional test patterns can be implemented using this model-base evaluation, and by also examining for software bugs, setting errors in microprocessor control resistors, and other design mistakes, it is possible to determine whether the ETACS is operating in accordance with design parameters.

4.2 In-car testing

For the ETACS that is a core of the new-generation electronic platform, it is difficult to reveal all the malfunctions by the bench testing of ECU only. It must be verified as a vehicle system formed by many components to evaluate its reliability. Therefore, a vast in-car testing hours of totally 2,400 hours were spent to confirm the system while placing stress on the following points:

- Operation check with respect to switch operation timing, transient input, and simultaneous operation of multiple functions
- Check of software filter with respect to communication data receive timings
- Operation check with respect to the power voltage fluctuation due to cranking
- Check of failsafe with respect to the switch input and erroneous data receipt that are not possible in real working conditions
- Operation confirmation and interference confirmation with respect to the data coding

5. Conclusion

In conjunction with a major system change to apply new generation electronic platform, the critical responsibility as core network component was assigned to the OUTLANDER ETACS. Thus, corresponding man-hours in the development have been taken, compare than typical conventional ETACS developments. The action was taken with the aim of realizing not only design-related benefits, but also significant advantages in terms of production, retail process and service. We are sure that these technologies become more common because of the convenience afforded by switching function by ECU variant coding, diagnosis and reprogramming functionality on many occasions. Of course, based on the system established for the OUTLANDER, it is our desire to continue development of unique MMC ETACS.

In concluding, we would like to express our sincere gratitude to our ETACS supplier, who have made great effort for design review of up to 4,000 hours, and to all others who contributed to this project.

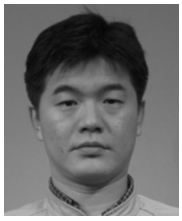
References

(1) Naoki Kawashima et al.: Multiplex Communication System for Column Switch and Instrument Panel Switches, Mitsubishi Motors Technical Review No. 10, 1998 (Japanese edition)

(2) Hiroki Fukatsu et al.: Development of a Next Generation Electronics Platform, Mitsubishi Motors Technical Review No. 18, 2006

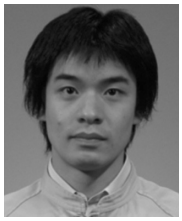
(3) Hiroki Takimizu et al.: ECU Variant Coding System, Mitsubishi Motors Technical Review No. 18, 2006


Takeo NAGAMORI


Takashi INOUE


Yasuyuki MIZUTANI


Yukihiro NISSATO


Hiroshi HYODO


Naoki KAWASHIMA