Electrical-System Design for LANCER EVOLUTION X

Morihito SHIOTANI* Youichi SENOO* Tsukasa ITO*

Abstract

With the LANCER EVOLUTION X, Mitsubishi Motors Corporation (MMC) adopted its first ever trunk-mounted battery with a view to delivering superior performance through a reduction in the proportion of vehicle weight borne by the front wheels. Since the battery is the central part of the power-supply circuitry, changing its location had a significant effect on the electrical systems. Nevertheless, MMC was able to mount the battery in the trunk while ensuring component commonality with the GALANT FORTIS (the vehicle on which the LANCER EVOLUTION X is based). An overview is given in this paper.

Key words: *Electric Equipment, Battery, Wiring Harness (W/H), New Model*

1. Introduction

To improve the motion performance of the LANCER EVOLUTION, it was considered essential to reduce the load at the front of the vehicle. One solution was to use an aluminum cylinder block for the engine to reduce its weight, and another was to relocate the battery to the trunk. Combined, these measures reduced the proportion of vehicle weight borne by the front wheels and thus improved the front-rear vehicle weight balance (by 2 to 3 % compared with the predecessor model). This paper outlines the technologies used for relocating the battery to the trunk, and the development of the wiring harnesses necessitated by the relocation.

2. Relocation of battery to trunk

2.1 Technologies to counter flammable gas from battery[1]

The first challenge in installing the battery in the trunk was to deal with flammable gas emanating from the battery.

Charging a lead acid battery causes electrolysis to occur in the water of the electrolyte, producing oxygen gas at the positive plates and hydrogen gas at the negative plates. As a result, the quantity of the electrolyte decreases. This hydrogen gas is not a problem when the battery is in the engine compartment, because it escapes to the open air through openings such as gaps around the engine hood. If the battery is installed in the trunk, however, hydrogen gas will be trapped inside and could cause an explosion if it ignites.

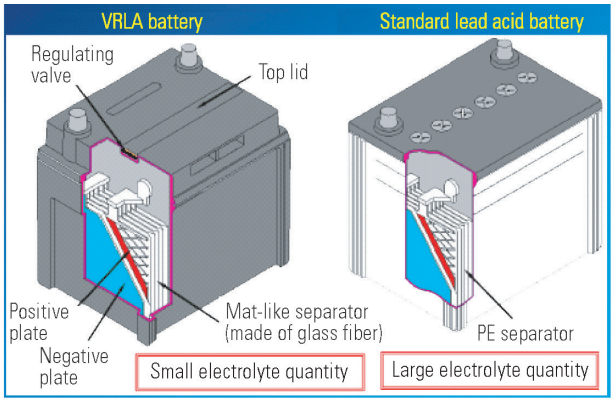
To prevent the risk of explosion, a valve regulated lead acid (VRLA) battery is used with a hose added for draining gases. **Fig. 1** shows the VRLA battery together with relevant information. The VRLA battery is a sealed unit with a gas-pressure regulating valve as a vent to the outside. Oxygen gas is produced at the positive plates earlier than the hydrogen gas at the negative plates, so it can be fed to the negative plates to make it recombine with the hydrogen produced there to form water, thus preventing the generation of hydrogen gas and loss of electrolyte. This process is known as "oxygen absorptive reaction on negative plates" and takes places with 100 % probability, so no gases are released to the outside. However, if an overcharge or over-voltage state occurs due to a malfunctioning alternator or other causes, part of the oxygen gas cannot be absorbed at the negative plates, so hydrogen gas is produced at the negative plates and the quantity of electrolyte decreases as a result. The resulting gas pressure forces the regulating valve to open the way out of the battery. The drain hose connected to the valve and installed passing through the trunk floor can then convey the gas from the vent to the outside.

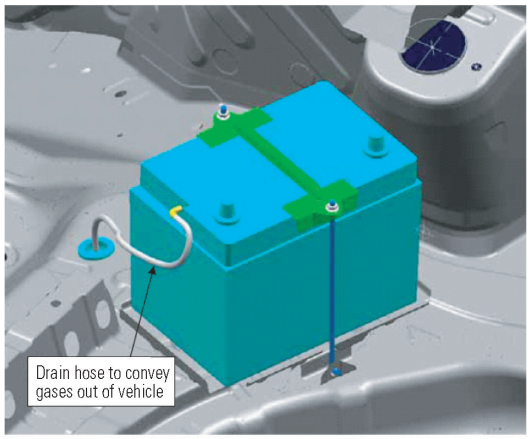
Another candidate means of preventing the accumulation of hydrogen gas in the trunk was to use a sealed box to house the standard lead acid battery. However, the VRLA method was finally selected rather than the sealed box method because of the following difficulties of the latter: If the wiring from the battery is routed on the floor, the battery harness constituting the wiring makes it impossible to keep the box hermetically sealed. On the other hand, if the wiring is routed under the floor, the box can be kept completely sealed but the hydrogen gas trapped inside the box could cause an explosion.

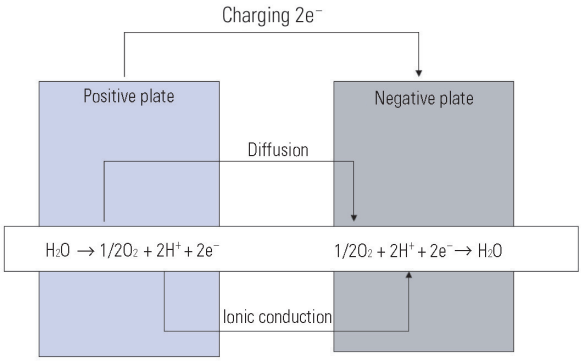
2.2 Battery protection and maintenance considerations

A plastic trim is used from a practical viewpoint to protect the battery from the potential impact with moving baggage during sudden braking. The trim has a lidded opening that is needed when replacing the battery, disconnecting the battery cable before servicing electrical components and connecting the cable to the negative terminal as the final process before shipping the vehicle from the factory, whereas a maintenance-free battery does not require any access through the trim for inspecting the electrolyte level and replenishing it.

* Electronics Engineering Dept., Development Engineering Office







Oxygen absorptive reaction on negative plate

$1/2O_2 + Pb \rightarrow PbO$

$PbO + H_2SO_4 \rightarrow PbSO_4 + H_2O$

$PbSO_4 + 2H^+ + 2e^- \rightarrow Pb + H_2SO_4$

Fig. 1 VRLA battery

In addition, a booster cable connection terminal is provided at the joint terminal block inside the engine compartment for convenience in case of a dead battery.

3. Effects of trunk-mounted battery on electrical components

3.1 Differences from the conventional vehicle

Due to the trunk-mounted battery, it was necessary to split the battery positive cable between the starter and battery into two harnesses, i.e., the starter harness and battery harness. The joint terminal block for connecting them is provided in the engine compartment. The LANCER EVOLUTION X shares the same power supply circuit with the OUTLANDER and GALANT FORTIS by using the same relay box and junction block.

3.2 Effects of trunk-mounted battery on engine starting performance and charge-discharge balance

The trunk-mounted battery requires longer cables, which increases the wiring resistance. This disadvantage for engine starting performance was compensated for by specifying the use of a low-viscosity engine oil, resulting in engine starting performance equivalent to the LANCER EVOLUTION IX.

However, the increased resistance of the wiring between the battery and alternator might have caused false sensing of the battery voltage and ultimately an incorrect charge-discharge balance. Therefore, to confirm the actual effect of the increased wiring resistance on the vehicle, charge-discharge balance tests were conducted under both winter and summer conditions. The results showed that the difference between the sensed and actually measured battery voltages was 0.1 V on average and 0.5 V at maximum. Thus, the sensed battery voltage was sufficiently accurate to prevent over-charging and over-discharging (**Fig. 2**).

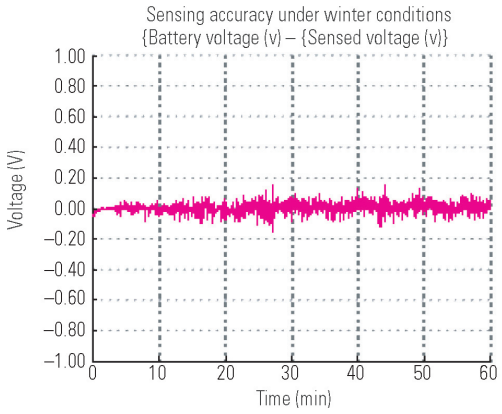


Fig. 2 Results of charging and discharging verification test

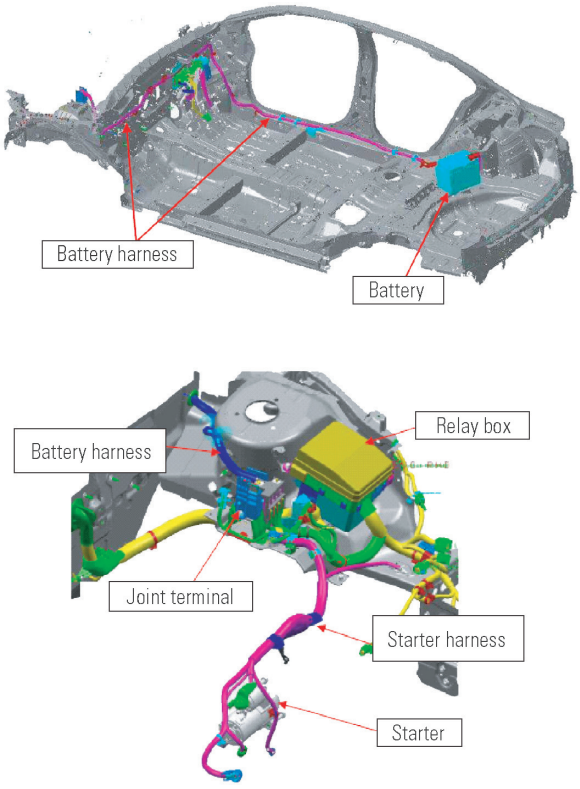


Fig. 3 Layout of wiring harness

Table 1 Battery harness layout comparison

	In-cabin	Under-floor
Workability at factory	○	×
Number of battery harness portions	2	3
Susceptibility to damage by flying stones and heat	○	△
Shared use of parts (cost effectiveness)	○	△
Increase of radio noise	△	△
Handling of parts	○	×
Adaptability to dirt racing (anti-ground-contact merit)	○	△

○: There is no problem △: There may be a problem ×: There is a problem

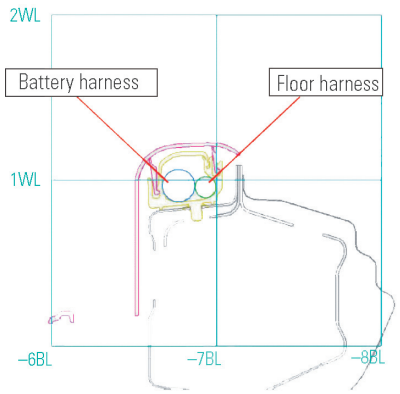


Fig. 4 Cross-sectional view of side sill

3.3 Battery harness

3.3.1 Battery harness layout

The battery harness is routed inside the cabin and connected to the starter harness at the joint terminal block located on the transmission mounting at the left side of the engine compartment (**Fig. 3**).

Table 1 compares the merits and demerits of the in-cabin and under-floor battery cable layouts. The initially considered under-floor layout of the battery harness was replaced by the in-cabin layout due to the following problems with the under-floor layout.

(1) With the under-floor layout, it takes a longer time to install the battery harness than is available in the manufacturing process.
(2) A battery harness divided into two portions must have connections at locations exposed to mud and water, increasing the chance of added electrical resistance due to secular change.
(3) A harness installed under-floor could be damaged by flying stones and heat, and the cables could be caught by obstacles and become detached.
(4) The under-floor layout forces the battery harness to cross the dash panel, which requires a drastic change from the common platform model in the layout of the engine compartment components, which is too costly.
(5) The under-floor layout requires plastic protectors which are too large for delivery boxes to accommodate them, causing problems in parts handling.

A battery harness installed inside the cabin must not adversely affect the appearance of such interior furnishings as the trim and carpet. This requirement was dealt with by limiting the equipment specifications to make the floor harness thinner and changing the sectional shapes of the trim and harness clips to enable the battery harness to be installed on the side sill (**Fig. 4**).

3.3.2 Radio noise

A battery installed in the engine compartment absorbs ripple noise from the alternator as it serves as a capacitor. This effect was not expected with a trunk-mounted battery and, furthermore, the noise that would be radiated from the battery might cause additional radio noise. However, actual drive tests showed that the cabin-installed harness had little effect on the radio noise and caused no practical problem. This is thought to be due to the relatively large separation between the harness and antenna feeder cable.

3.3.3 Safety considerations

The battery harness as well as the starter harness forms a battery-voltage circuit without any fuse, so it needs appropriate protection against short-circuits especially in the event of a collision. One measure taken to prevent short-circuit was to install the harnesses in a location where body deformation was the least likely in the event of a collision. The other measure was to provide full-length protection to the harnesses with corrugated or plastic protectors. Also, the joint terminal block for connecting the battery and starter harnesses was located on the transmission mounting where deformation was least likely in a collision, and plastic protec-

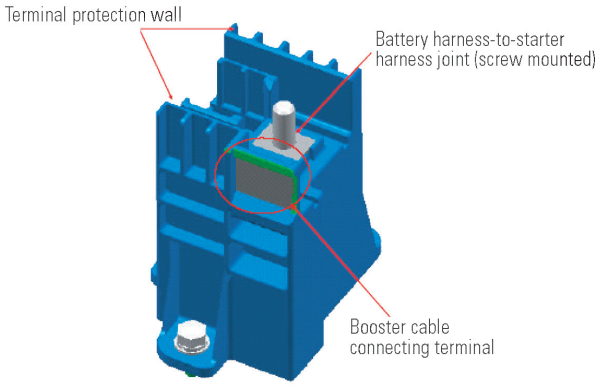


Fig. 5 Joint terminal

tion walls were provided there to prevent short-circuits at the connection (**Fig. 5**).

4. Conclusions

The trunk-mounted battery helped achieve the remarkable improvement in the motion performance of the LANCER EVOLUTION X over the predecessor model. There were various related problems during the development such as the engine starting performance and manufacturing requirements at the factory, but all of them could be solved successfully to complete the development. We sincerely thank Panasonic Storage Battery Co., Ltd. and all others concerned for their cooperation in the development.

References

(1) Japan Storage Battery edition, Latest practical secondary battery (Chapter 6, Mechanism and characteristics of lead acid batteries), 1995


Morihito SHIOTANI


Youichi SENOO


Tsukasa ITO