Development of a Rain-Light Sensor

Shinichi KATO* Toshinori YAGI*

Abstract

Mitsubishi Motors Corporation (MMC) has developed a rain-light sensor that controls the auto-light system and the rain-sensitive wiper system. It is installed in the new GALANT FORTIS. The rain-light sensor controls the headlamps and windshield wipers, sending an activation request to ETACS[1] (Electronic Time and Alarm Control System). This data consists of vehicle information from ETACS, ambient light intensity, front light intensity and raindrop detection. Regarding the auto-light function, the rain-light sensor distinguishes between entering a tunnel and passing under a bridge, using front and ambient illumination sensors. It prevents the headlamps from blinking when the vehicle passes under a bridge. The rain-sensitive wipers have newly designed lenses to ensure uniform distribution of sensitivity for raindrops and improve the timing for the first wipe when there are fewer raindrops on the windshield glass.

Key words: *Rain-Light-Sensor, Auto-Light, Rain Sensitive Wiper, Electronic Control, Convenience*

1. Foreword

Automatic lighting and rain-sensitive wiper systems are commonly found even in B-segment vehicles in Europe, to relieve drivers from having to frequently operate lighting and wiper controls when driving at high speed on roads with many tunnels at short intervals, for example. In addition to increasing comfort in this manner, they also improve safety by making the vehicle more recognizable to other vehicles in the twilight.

In Japan, the auto-light system has recently become popular, but the rain-sensitive wiper system is not yet widespread. This paper introduces the rain-light sensor developed by MMC for its new GALANT FORTIS as a comfort-oriented device that increases driving pleasure and safety by making the vehicle more visible to other vehicles.

Fig. 1 Location of rain-light sensor

2. System configuration

The rain-light sensor forms an ECU that integrates both automatic lighting and rain-sensitive wiper functions into a single unit. It is directly mounted on the windshield glass surface as shown in **Fig. 1**. This device consists of the sensor that works as a control unit and the optical coupler bonded to the glass. The control unit has two raindrop sensors and two light sensors for the automatic lighting function. **Fig. 2** and **Fig. 3** show the appearances of the rain-light sensor and optical coupler, respectively.

Fig. 4 is a block diagram of the rain-light sensor system. The rain-light sensor constitutes a slave node in the local interconnect network (LIN) that has the Electronic Time & Alarm Control System (ETACS) as the master node and performs the following functions: It transmits requests for turning the auto-light on and off and activating the rain-sensitive wiper to the ETACS based on data provided by ETACS such as the vehicle speed, outside temperature and vehicle specifications, including destination, and also based on signals from the lighting and wiper switches on the steering column switch that works as another slave node. Based on these requests, the ETACS controls the operation of the headlamps, other exterior lamps and windshield wipers.

The GALANT FORTIS' rain-light sensor uses the vehicle speed data that is transmitted by an anti-lock brake system (ABS), whereas it receives the meter-calculated outside temperature data via the ETACS, both transmitted through the in-vehicle communications network and the gateway function[2] provided by the ETACS. The ETACS also retains and supplies data coding information[3], which includes the destination and other vehicle specification information, to the sensor. Via the ETACS, the auto-light customization information to be displayed for the user on the navigation screen is also supplied.

* Electronics Engineering Dept., Development Engineering Office

Fig. 2 Appearance of rain-light sensor

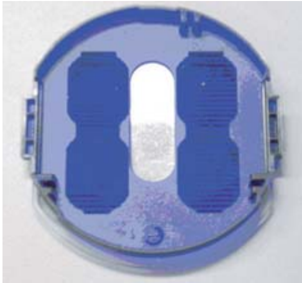

Fig. 3 Appearance of optical coupler

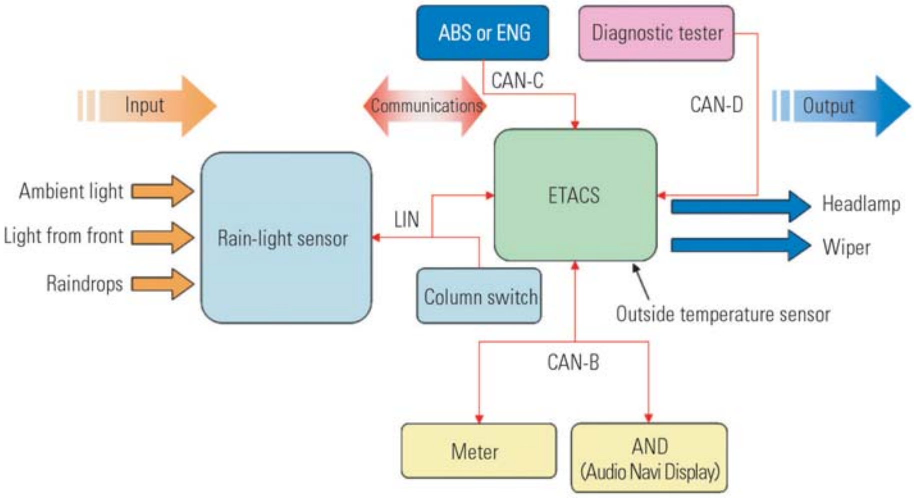

Fig. 4 Structure of rain-light sensor system

The rain-light sensor obtains all necessary data through this communications network, using only three harnesses that are for its power supply, grounding and LIN communications. This configuration allows the system to be applied easily to those models that share the same electronic platform as the new GALANT FORTIS.

3. Rain-light sensor functions

3.1 Automatic lighting function

(1) Basic function

The automatic lighting function turns on and off the headlamps and other exterior lamps according to the intensity of ambient light when the lighting switch is in the AUTO position and the ignition switch in the ON position. The function also allows the user to advance the light-on time in two steps and retard it also in two steps using the customization function on the navigation screen.

The light-on timing in the twilight for the headlamps is set different from the other exterior lamps on models for the Japanese market, whereas the headlamps and other exterior lamps are set to light up simultaneously on models for other markets.

(2) Improvements over the conventional automatic lighting system

The conventional auto-light sensor, which detects only the ambient light intensity, used to respond to momentary dips in light intensity such as when passing under a bridge, and so a distance and time filter was incorporated to ignore signals showing rapid changes in light intensity. However, this filter caused a delay in illumination of the headlamps when the vehicle entered a tunnel.

With the rain-light sensor on the new GALANT FORTIS, the automatic lighting function detects not only the ambient light intensity but also the intensity of the light ahead of the vehicle, as schematically indicated in **Fig. 5** by the blue line and red line, respectively. By processing these two light intensity data together, the automatic lighting function determines whether the vehicle has entered a tunnel, in which case it immediately turns on the headlamps, or simply has passed under a bridge, in which case the function does not trigger the headlamp-on control. Being also able to distinguish the conditions for lighting the headlamps upon entering a tunnel from those in the twilight, this logic enables the new automatic lighting function to cause the headlamps to turn on earlier in the twilight and thus the vehicle to be more recognizable for other drivers than with the conventional function, while preventing momentary illumination of the headlamps in the shade of trees and under bridges.

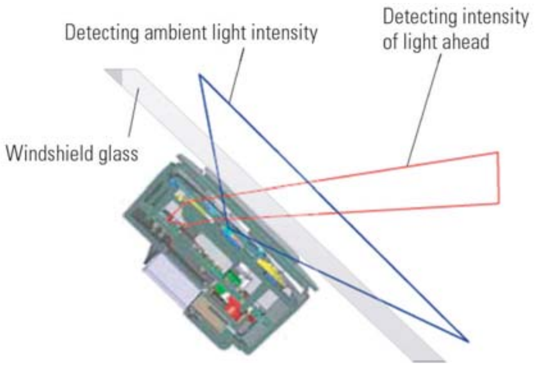

Fig. 5 Outline of light detection

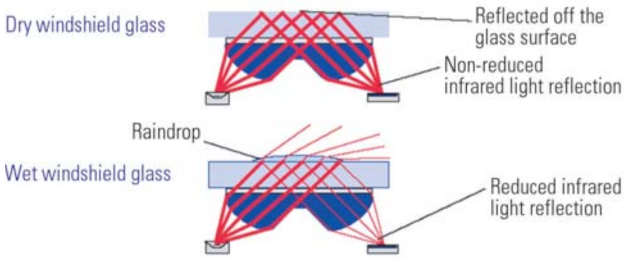

Fig. 6 Outline of raindrop detection

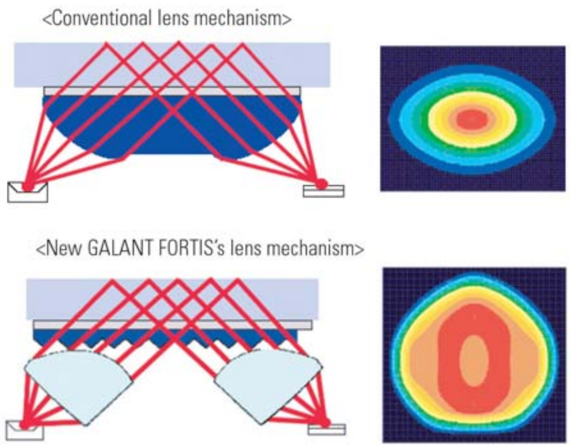

Fig. 7 Optimized lens shape

3.2 Rain-sensitive wiper function

(1) Basic function

The rain-sensitive wiper function causes the wipers to operate intermittently or in the low- or high-speed mode according to the amount of raindrops on the windshield when the wiper switch is in the AUTO position and the ignition switch in the ON position. The driver can vary the sensitivity to raindrops using the dedicated knob.

(2) Improved raindrop sensing

Fig. 6 shows how the rain-sensitive wiper function detects raindrops. A light emitting diode emits infrared light beams. A photodiode receives the reflection of the light beams from the windshield glass surface. If there are raindrops on the glass surface, the amount of infrared light reflected off the surface decreases, so the raindrops can be detected.

The problem with the conventional raindrop sensing system was that it did not have a sufficiently large sensing area or uniform sensitivity. The new rain-light sensor overcomes this problem thanks to an improved lens structure of the glass-attached part that enlarges the sensing area as shown in **Fig. 7**. Particularly, the peak sensitivity spot (the red colored area in the right part of **Fig. 7**), which was at the center of the sensing area with the conventional lens mechanism, is now widened to nearly the boundary of the sensing area, so that the high-sensitivity zone (the yellow area in the photos in the right part of **Fig. 7**) is substantially expanded. This improves the sensitivity of the system, enabling the wiper to start wiping more responsively at the beginning of rainfall. This eventually widens the range available for the user to adjust the sensitivity of the system during rainfall according to preference.

The raindrop sensing area is, however, only a part of the entire windshield glass surface and does not necessarily correspond to the user's field of view. To accommodate possible discrepancies between the driver's field of view and system-controlled wiper operation, a feature has been added that allows the wipers to be operated manually once if the driver operates the knob for a high raindrop sensitivity setting.

Another function of the system uses outside temperature data to prohibit operation of the wipers when starting the engine under very low temperature conditions to prevent the risk of damage to the wiper blades due to freezing on the windshield.

The rain-sensitive wiper system must sense only raindrops accurately while ignoring both the wiper blade moving past the sensor and the water collected by the wiper blade. The new GALANT FORTIS's system does this by using the wiper blade-position sensing signal from the ETACS provided via the LIN. To overcome the problem of the signal transmission interval of the LIN communications being 50 ms at the shortest, the on/off signal of the wiper auto stop switch is transmitted with a time stamp (showing the time elapsed after the on/off change).

3.3 Variations of the system

The Japanese market and European market models of the GALANT FORTIS are different in the automatic light-on timing and mode specifications. It is also necessary to change the parameter about the glass type, because the difference in light-on timing resulting from differences in light transmission characteristics of the glass used must be eliminated. The parameter showing the positional relationships between the location of the rain-light sensor and moving wipers is used for the determination to correct the movement of the wiper blade over the sensor.

The rain-light sensor can adapt itself to any of these different specifications by receiving the following data from the ETACS through the LIN communications system:

- Destination-dependent automatic lighting specifications information
- Automatic light-on timing adjustment information
- Glass type information
- Wiper movement vs. on-glass sensor location parameter

3.4 Fault detection function and diagnostics function

Each rain-light sensor needs to be calibrated when the power is first turned on in order to store in memory the amount of infrared light reflected off the surface of a dry windshield glass. When the power is turned on, therefore, the sensor must already have been installed on the windshield glass. In case the initial calibration fails to complete due to turning on the sensor power before the sensor is installed on the production line, the diagnostic system includes an arrangement to store such incomplete calibration as a fault that can be detected later using the diagnostic tester. The diagnostic system also stores fault codes if the automatic lighting function and rain-sensitive wiper function cannot be properly controlled due to a fault.

Each individual rain-light sensor unit is given a unique serial number, and specific software and hardware version information to enable future traceability.

4. System evaluation on actual vehicles

Through drive tests, the functionality of the rain-sensitive wiper and automatic lighting system has been evaluated by drivers in terms of the following items.

Evaluation points of rain-sensitive wiper function

- Wiper operation in light, medium, and heavy rain
- Wiper operation upon entering and exiting a tunnel during rainfall
- Wiper operation when driving in and out of a multistory parking lot during rainfall
- Wiper operation during snowfall (under low temperature)
- Dry wiping action in non-rainy weather

Evaluation points of automatic lighting function

- Headlamp on and off operations upon entering and exiting a tunnel
- Headlamp on and off operations when driving in and out of a multistory parking lot
- Non-operation of headlamps when driving under a bridge or overpass
- Light-on timing in the twilight (according to customized setting)

5. Conclusion

The new capability to sense both the intensities of ambient light and the light from the front has successfully enabled the automatic lighting function of the rain-light sensor system to prevent momentary operation of the headlamps under a bridge, while advancing the illumination timing of the headlamps in the twilight.

As to the rain-sensitive wiper function of the system, the new lens design has significantly raised the raindrop sensitivity of the sensor to start the wiping action. This allows the driver to select the sensitivity level for automatic wiper operation from a wider range of options.

We intend to develop a more advanced system that offers even greater comfort and safety by using the features of the communications network and the body system electronic controller ETACS that are now embodied in the new GALANT FORTIS.

Finally, the authors sincerely thank the people concerned at KOSTAL and all others who contributed greatly to this development project.

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Shinichi KATO

Toshinori YAGI