

Safety of Doors for “AXIEZ” MITSUBISHI Standard Elevators

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Elevators are used by large numbers of unspecified individuals, from young children to elderly persons, as a means of vertical transportation inside buildings. Therefore, for elevator doors that open and close automatically, it is important to take safety measures to prevent them from hitting passengers upon closing, trapping fingers/hands in the gap between the entrance pillar upon opening, passengers tripping when entering and exiting, and the like. This paper introduces technologies for enhancing safety around doors.

1. Multibeam Door Sensor

Mitsubishi “AXIEZ”-series standard-type elevators come standard with Multibeam Door Sensor <2D> which is a two-dimensional sensor designed to detect passengers or objects between doors in a noncontact manner when the doors close. We have also developed a new Multibeam Door Sensor <3D> for detecting passengers who are on the landing side over a wider area.

In addition to the functionality of the Multibeam Door Sensor <2D>, the <3D> version has the ability to perform reversal, and open the doors which were closing, upon detecting a possible passenger on the landing side. This ability to detect passengers approaching from the landing side enhances passenger safety. The conventional 3D sensor-based scheme uses a photobeam projector which emits near-infrared rays on the landing side and a photobeam receiver installed on a door edge which receives light reflected off an object. The presence or absence of an object is detected by determining the optical power of the reflected light captured by the photobeam receiver. On the other hand, our new Multibeam Door Sensor <3D> employs an optical distance sensor based on triangulation, which measures the distance from the doors to a possible object and thus detects the presence or absence of an object within predetermined geographical boundaries. Figure 1 shows the configuration of the Multibeam Door Sensor <3D>. Each of the left- and right-hand doors is fitted with two optical distance sensor modules at different heights. Each of these four optical ranging sensor modules in all performs detection. Since distance measurements are not dependent on the size, reflectance and the like of an object, stabler detection operation can be achieved compared with conventional

3D-method sensors. Furthermore, the Multibeam Door Sensor <3D> can detect beds and carts which are not easily detected with conventional methods due to their smaller size and insufficient amount of reflected light compared with humans.

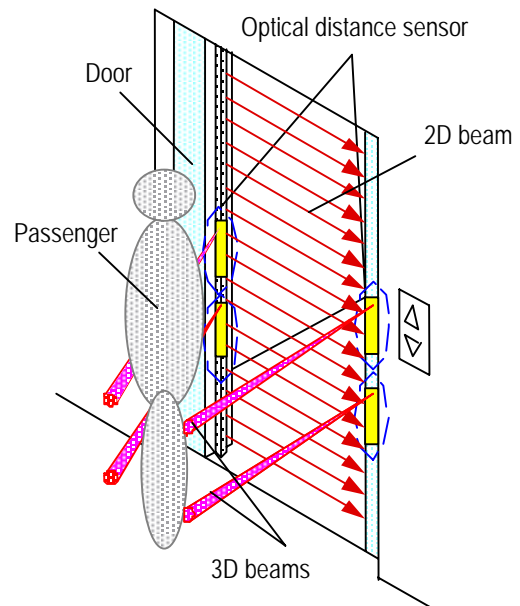


Fig. 1 3D-Multi beam door sensor

2. High-sensitive Door Opening Sensor

Typically, the gap between the door and the entrance pillar is approximately 5 mm, which is hard for a hand or the like to enter. However, the soft hands of children (infants in particular) could be drawn into this gap, so a sensor to detect the intrusion of fingers or hands into the gap while the doors are opening is adopted.

The door height is approximately 2 m from the floor to the top, and there is an opening-side space that spans from top to bottom into which the doors retract while opening. A sensor carefully monitors access to this open side, using a “beam shading method” by which detection is achieved by the blocking of a beam to ensure a high degree of detection reliability. However, since the beam shading method requires the photobeam projector and photobeam receiver to be placed on an imaginary straight line (i.e. within the same line of sight), they can hinder passengers getting on or off, the photobeam projector can be damaged by collision with entering/leaving carts, and false detections can be

caused by dust accumulation on the light-emitting surface. We have therefore installed a special prism for the light-emitting window of the photobeam projector so that the light beam is projected upward without sticking out from the photobeam projector from the pillar. Figure 2 shows the configuration of the high-sensitive door opening sensor.

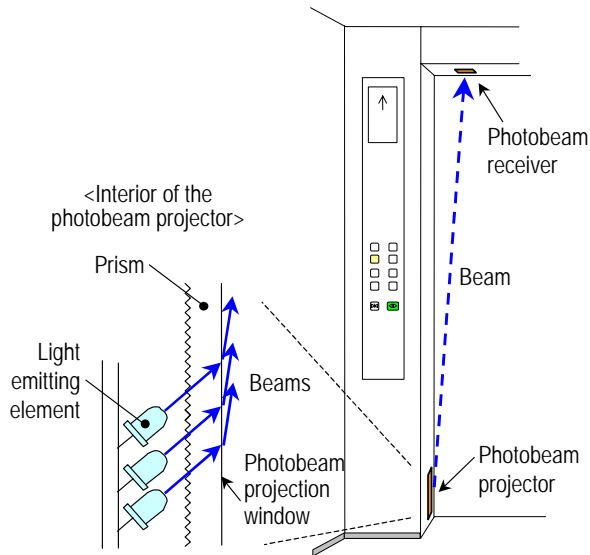


Fig. 2 Door sensor

In accordance with the state detected by the sensor, the doors are optimally controlled. The operation flow when the doors open is summarized in Fig. 3.

First, when the elevator arrives at a floor, if the high-sensitive door opening sensor detects a passenger or the like before opening the doors, an announcement saying "The doors will open. Please stand clear of the doors." is played to warn passengers that the doors will open, and prompt them to step back from the open side into which the doors are about to retract. If the sensor no longer detects an obstacle before the

announcement ends, the doors start to open normally, to keep the elevator functioning smoothly. If the sensor still detects an obstacle even after the caution message has been announced, and the doors open slowly while the door-opening warning buzzers sound.

If no sensor detection has occurred before the doors start opening and the sensor then detects an obstacle during normal opening operation, the doors are stopped once, then slowly opened to their fully opened position while the door-opening warning buzzer sounds. This is to make the passenger realize that he/she came too close to the elevator's door-housing structure, and to give them time to back away from the doors.

3. 10-mm Sill Interval

In the "AXIEZ" series, the sill interval (gap) has been reduced from 30 mm to approximately 10 mm, as was typical of the conventional series, in line with universal design. Figure 4 shows a sketch and a photograph of the elevator sill. The elevator doors are opened and closed as the car-door-mounted coupling device of the car door equipment driven by the door motor catches hold of the hall-door-mounted coupling device of the landing door equipment. When reducing the gap in the sill to approximately 10 mm, there was the problem of the hall-door-mounted coupling device of the landing doors, which is located above the doors, interfering with the sill of the car when the elevator travels upward/downward. To reduce the sill opening to a minimum while eliminating this equipment interference, we have provided a protrusion and an indentation only at the position where the coupling devices of the hall doors on the landing side are found above and below. This arrangement avoids interference between the landing and the car equipment and reduces the sill gap to approximately 10 mm. This not only reduces the

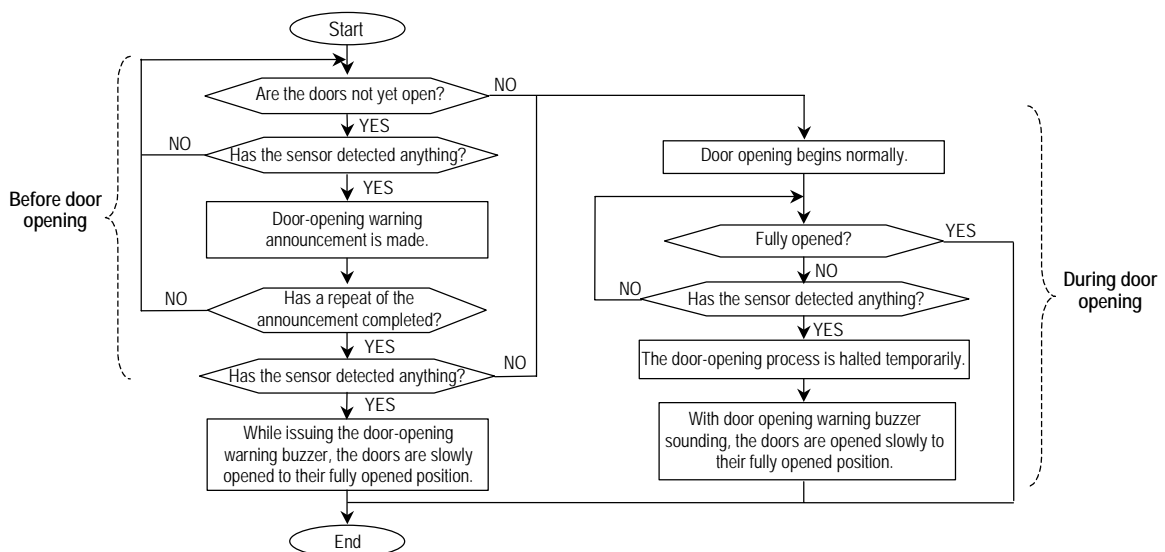


Fig. 3 The flow of door opening

chances of passengers tripping but also makes the wheels of wheelchairs and carts run more smoothly.

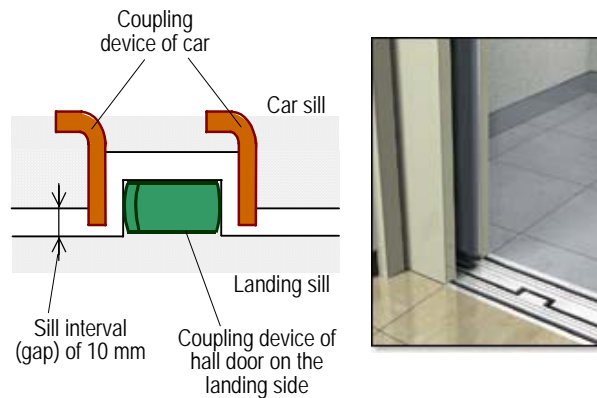


Fig. 4 Sill interval 10 mm

4. Sensitivity Enhancement of Door Load Detection

The door load detection function reverses the doors when the door motor torque exceeds a predetermined door load limit. However, since elevator doors may differ in design from floor to floor and may have suffered variations in door-mechanism load over the years, it used to be difficult to appropriately set the door load detection limiter. We have therefore made it possible to identify the motor torque value on a floor-by-floor basis after installation and to set the door load limiter accordingly. This process is shown in Fig. 5 and described below.

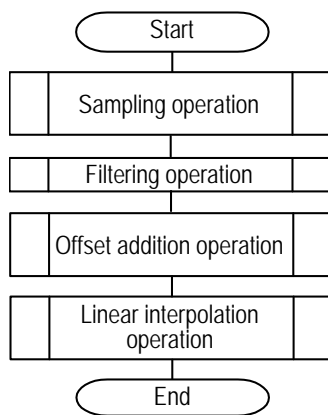


Fig. 5 The flow of the learning process

- **Sampling operation**

The whole range of door positions, from the fully closed position to the fully opened position, is divided into small sections and torque values measured at individual sampling points are buffered. Sampling is performed so as not to distort the torque waveform by varying the number of sampling points from section to section because the door torque can change abruptly in some sections and change gently in other sections.

- **Filtering operation**

To eliminate peculiar values and thereby prevent erroneous learning, filtering operation was conducted on buffered door torque values derived from several measurements made at each position.

- **Offset addition operation**

The door load limit value for each position is obtained by adding an offset value to the typical torque value that was determined by the filtering operation. The offset value to be added was determined and set such that load-detection sensitivity at the door edge becomes constant.

- **Linear interpolation operation**

The door load limit values determined by the learning operation at the individual positions are linearly interpolated to create a door load limit waveform. The same procedure is repeated on each floor to plot a door load limit waveform. With each successive door opening/closing operation, the waveform is updated to ensure optimum door load detection at all times.

This paper has introduced door safety technologies. We will continue to focus on enhancing the convenience and safety of elevators.

References

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