Tire force sensing technology has been considerably researched and developed in recent years. Various brake torque sensors in particular have been invented by various companies and research institutes for use in active safety systems. At the same time, many companies have developed control logics for using brake torque sensors to optimize the force of each tire. However, conventional control logics for maximizing the effectiveness of sensor capabilities have some problems from the viewpoint of practical use in that they are not sufficiently robust against error or disturbances.

We propose a novel and practical method for making the best use of brake torque sensors. We call this control logic an Adaptive Slip ratio Control System (ASC-S). ASC-S overcomes the above-mentioned weaknesses in conventional control logics, making it possible to control brake force flexibly and precisely. ASC-S can improve the performance of not only an Anti-lock Braking System (ABS), but also a Vehicle Dynamics Control (VDC) system.

The features of ASC-S in comparison with conventional methods can be summarized in three aspects. First, ASC-S can make full use of the vehicle's road-hugging ability, achieving 95% efficiency in relation to the desired stopping distance. Second, ASC-S is based on fixed slip ratio control used in ABS, making it easy to apply this novel method to traditional ABS control logic. Third, ASC-S is robust against sensor error, especially brake torque and actual vehicle velocity, which are difficult to measure and estimate accurately. These features indicate that the proposed method is more practical, stable and robust than conventional ABS.

ASC-S consists of three parts, designated as A, B and C. Part A is a slip ratio controller, consisting of a PI controller and serving to make the measured slip ratio λ correspond to the reference adaptive slip ratio λ^*. This part has the same function as traditional ABS. Part B is a nominal brake force-slip ratio model that defines the desired brake force Fx^* in proportion to λ^*. Part B is the core of the proposed logic because it determines the performance of ASC-S. Part C is a brake force feedback controller, which consists essentially of a brake force error integrator. This part has two roles. Its main role is to change λ^* from brake force error and the previous slip ratio reference. Its secondary role is to make Fx^* conform to the brake force Fx estimated by the brake torque sensor.

We analyzed the stability of this novel method and designed and optimized the gain of each part according to the mathematical conditions. The appropriate controller gains and logic architectonics make it possible not only to prevent the tires from locking, but also to maintain the maximum braking force automatically.

Finally, experiments were conducted on various roads with an experimental vehicle fitted with an original brake torque sensor and comparisons were made between traditional ABS and the novel ASC-S under the same conditions. The experimental results show that ASC-S is 20% better than conventional ABS with respect to braking distance. The results also show that ASC-S is more robust against road conditions than conventional ABS.