Failsafe Door Latch without Lock Cylinder

Despite increasing levels of digitalization, cars are still equipped with lock cylinders to ensure the door can be unlocked at any given time. Kiekert's ReactiWake locking system guarantees this on a purely electronic level, thus creating new opportunities in vehicle design and operating concept. Besides reduction in complexity in the aftermarket, the supply processes associated with a mechanical replacement key dispense completely and also the free positioning of the latch and exterior handles by designers.

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TODAY'S MECHANICAL LOCK CYLINDERS

Just a few decades ago, vehicles were equipped with a variety of latches with different lock cylinders, meaning drivers often required multiple keys. Nowadays, although doors are generally unlocked via remote control or smart phone app, virtually all passenger cars still have a lock cylinder in the driver's door that is only required when the vehicle's battery or key fob battery is flat.

From a design and engineering perspective, it is desirable to eliminate this one last lock cylinder, too. Why? There is a mechanical connection between the lock cylinder and the door latch that is conceptually similar to, say, the short half-shaft between the vehicle transmission and the wheels. This "paddle" transmits for instance the rotary movement of the key bit to release the lock and, in certain, rare cases, to open the door. However, this proven, tamper-proof connection inevitably demands proximity between the door latch and the lock cylinder. This means the position of the door handle is determined by the location of the lock cylinder, **FIGURE 1**.

DIGITAL LOCK CYLINDERS FOR THE FUTURE

The absence of a lock cylinder, with locking and unlocking taking place purely electrically, considerably increases design freedom. **FIGURE 2** presents the development from the visible over the hidden cylinder up to its absence. Designers can locate external door handles wherever they wanted to – and conversely, the position of the lock inside the door would be independent of the exterior design. However, the question is how to dispense with the lock cylinder without losing the ability to unlock or open the doors in the event of a power loss.

There are two reasons for a power loss: external and internal. Either the remote control is without power, here simply changing the battery would help. Or the door is unlocked using a smart phone app and, usually, Near Field Communication (NFC).

A power loss inside the vehicle is more critical, leaving the locking system unresponsive to the external radio signal. This is highly improbable in practice, as the 12-V battery usually informs the driver when its State of Charge (SoC) is low. A more likely scenario arises from the vehicle standing unused for extended periods and the battery losing its charge.

Kiekert has developed a concept as fallback solution [1] that secures electric unlocking even when there is no power supply, thus dispensing with the need for a lock cylinder. The core elements are the ReactiWake control unit with buffer battery and encryption as well as a smart phone app, which helps unlock the vehicle in the event of a power loss.

CONTROL UNIT WITH POWER SUPPLY FOR 15 YEARS

The ReactiWake control unit is connected between the existing door control unit and the central locking electric motor for the door latch. First, the unit consists of a buffer battery with high long-term stability, which is independent of the vehicle electrical system and guarantees power supply for 15 years. If so desired, the control unit can be connected to the 12-V vehicle electric system as well as the existing CAN or LIN bus

system. This can make sense if additional diagnostic or information functions are required.

The second major element of the control unit is its control electronics, which incorporate at least one redundant part of the digital key required for unlocking the doors. Because the OEM carries out the cryptography, it can define how this is shared among the control units. For instance, when the control unit is activated, the partial key can be linked via NFC to its counterpart stored in the smart phone. Metaphorically speaking, the control unit takes on the role of a digital lock cylinder, while the smart phone holds the digital key bit, **FIGURE 3**.

FIGURE 1 The mechanical connection between lock cylinder and latch demands their physical proximity (© Kiekert)

FIGURE 2 Past and present: In the future, cars will not need mechanical lock cylinders (© Kiekert)

BENEFITS OF THE NEW CONCEPT

The absence of the lock cylinder and key bit delivers a substantial reduction in complexity, especially in the aftermarket. By way of comparison: There are currently several thousand different key bits for each vehicle model produced by an OEM, all of which are individually manufactured and must be reproducible for each specific vehicle in the event of loss. With ReactiWake, encoding is no longer mechanical, but carried out via individual encryption of the radio signal. Even simple 64-bit encryption provides 2^{64} keys, and their administration shifts entirely to the software level. 128-bit is already the norm. This dispenses entirely with the production and logistics processes associated with a mechanical key, as well as extensive administration effort for fleet operators and rental companies.

BATTERY AND OPERATING CONCEPT

The integrated buffer battery is designed to last 15 years. Unlocking requires around 1.1 to 1.3 A, which is available at all times for the entire duration. In normal operation, the system does not replace the existing no-touch locking and unlocking concept, but is instead "dormant", with a power demand of almost zero. It is also not involved in the everyday locking and unlocking processes, because the main code exists inside the door control unit, and communication between key fob, smart phone, etc. can bypass ReactiWake altogether.

The system only wakes up when the user launches a wake-up sequence via a smart phone in order to unlock the vehicle when the vehicle's battery is flat. In principle, this can also be another device. What matters is the ability to connect with the ReactiWake control unit. Doing this via the internet does not make sense, as it may not be available in certain circumstances, such as in underground garages.

Kiekert has developed a smart phone app for the waking procedure and unlocking procedure, **FIGURE 4**. The overall system has been prepared for demonstration in a show car. The app contains the partial code necessary to provide the user access to the ReactiWake control unit. If required, it guides the user interactively through the procedure of "waking" the system and enabling unlocking via battery power. The interactive app guide is important, because this waking procedure is an absolute exception and must therefore be as straightforward as possible. In the current system, waking and unlocking happens in the following sequence:

- The app prompts the user to pull and hold the exterior door handle for 5 s.
- This closes a micro-switch and the user receives feedback on his/her smart phone.
- The user holds the smart phone close enough to the lock to enable communication.
- The control unit compares its digital partial code with the one on the smart phone.
- Hereupon, the control unit unlocks the latch and the vehicle can be opened.

FIGURE 3 Distribution of the digital key between the ReactiWake control unit in the door and the smart phone in the hand (© Kiekert)

ACTIVATING WHEN THE VEHICLE BATTERY IS FLAT

A pertinent question is how the ReactiWake control unit is activated when there is no power supply from the vehicle battery. This occurs in the following sequence: In its base condition, the system monitors the SoC of the 12-V battery at widely spaced intervals and using just the tiniest amount of power. The vehicle electrical system can provide this information via the bus system. On reaching a critical threshold, the electronics switch over to the integrated buffer battery. It is then able to react throughout the entire battery lifespan and, when required, provide sufficient electricity to unlock the latch.

Part of the system is the electronic micro-switch which, similar to a relay, recognizes when the exterior door handle has been pulled for 5 s. The switch then activates the connection between the buffer battery and the control electronics, which then actuates the central locking motor. A 12-V connection makes sense, as it facilitates additional functions. For instance, diagnostic data could be used to inform the smart phone app that the state of the buffer battery is critical.

The functionality described makes non-availability of this fallback scenario highly unlikely. Aside from a technical malfunction, this can only arise if a car has not been used for more than 15 years. However, to provide a solution for this case, too, there is the option of external contacts to facilitate power supply to the system with the aid of a battery. The system would then unlock the vehicle door, likewise with the aid of the app and the sequence described before.

EXAMPLES OF SYSTEM TOPOLOGIES

The absence of the lock cylinder has direct cost benefits. More crucial, however, are the indirect benefits provided by the free positioning of the latch and exterior handles. Analogous to stationary network topologies, it also matters how the system including the ReactiWake control unit is integrated into the vehicle topology. Three variants of system architecture are presented here.

Variant 1 in **FIGURE 5** shows a retrofit solution that communicates with a control unit located centrally or integrated into the door but separately. A retrofitted solution such as this can be incorporated into current vehicle architectures, for instance, to create added value for cus-

FIGURE 4 The smart phone app provides interactive guidance to the waking and unlocking procedure (© Kiekert)

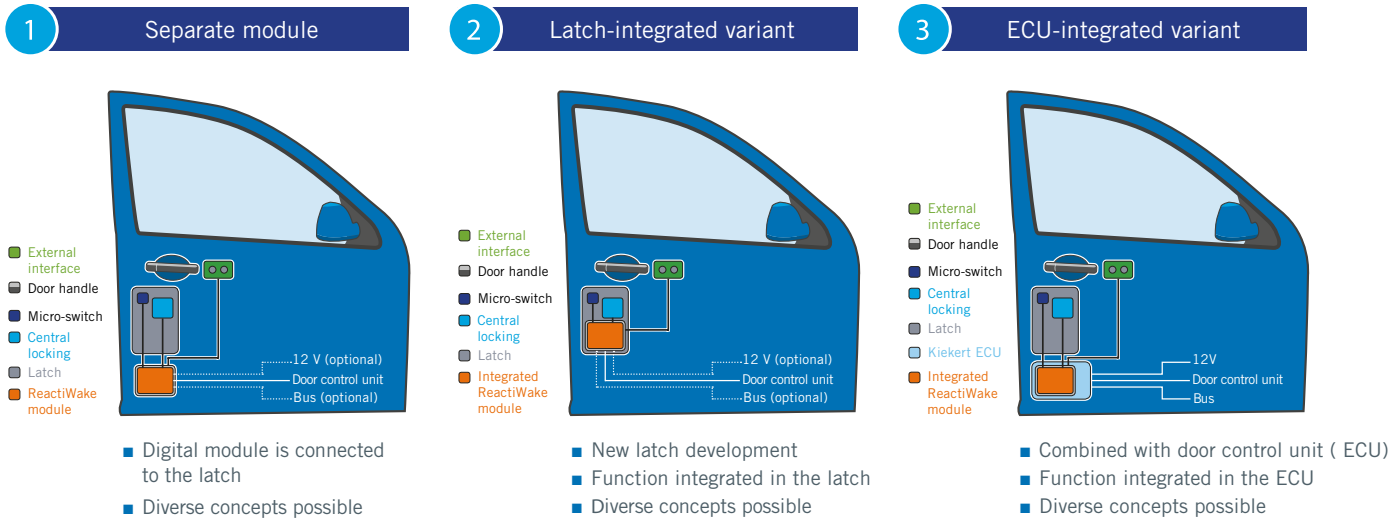

FIGURE 5 Three examples of system architecture: separate module, latch-integrated and ECU-integrated variant (© Kiekert)

tomers in higher equipment lines. The OEM and consumers thus benefit from the functional advantages described. There is ample scope for appealing operating concepts, such as a smart phone app paired with a display code, within a consistent human-machine interface design.

The variants 2 and 3 in **FIGURE 5** are envisaged for newly developed vehicles. Variant 2 features the ReactiWake control unit integrated into the door latch. The installation space for the small electronic module is non-critical as it dispenses with the entire mechanical interface from lock cylinder to latch, providing complete independence in latch design. This integrated variant has the benefit of minimal wiring harness complexity. The only requirement is the signal cable to the door control unit and an optional connection to the 12 V supply and bus system. In variant 3, ReactiWake is integrated into an existing door control unit (ECU). This makes sense if, for instance, the OEM intends to incorporate a door control unit into a new vehicle range anyway.

In general, the position depends upon the door functions envisaged within a vehicle and the options for structuring the system with the lowest possible cable complexity. An existing door control unit incorporating a large number of comfort and convenience functions, such as mirror adjustment and folding or dimming, window actuators and warning lights etc., presents an ideal opportunity for integrating the ReactiWake control unit, too. Conversely, vehicles with less functionality and just one central control unit benefit from the latch-integrated variant 2, as it avoids the need to run wiring to each door.

SUMMARY AND OUTLOOK

The digital locking system with ReactiWake control unit presented here by Kiekert facilitates the elimination of the lock cylinder in the driver's door while ensuring the car can be unlocked under all conceivable circumstances. Only such certainty with reliable electronic fallback level permits the design of doors and operating elements focused entirely on aesthetic and ergonomic aspects. It also enables a wide range of other functions that meet the real-life needs of drivers in keeping with the ever-increasing number of mobile devices.

Moreover, the system can be incorporated into a diagnostics concept that provides workshops and the driver with important information. Furthermore, it dispenses with the entire process chain associated with the encoding of mechanical keys, which is particularly useful when it comes to replacing a lost key, simplifying and speeding up the process considerably. For providers of car-sharing services, there are a number of highly interesting business models – culminating in a temporary loan of digital partial codes with limited validity periods.

REFERENCE

[1] Bendel, T.; Eggert, M.: Reliable Unlocking Without a Lock Cylinder. 9th International Benchmarking Conference, Doors & Closures in Car Body Engineering, Bad Nauheim, November 15 and 16, 2018