

HANDS OFF DETECTION REQUIREMENTS FOR UN R79 REGULATED LANE KEEPING ASSIST SYSTEMS

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ABSTRACT

Lane Keeping Assist Systems (LKAS) are a key component of (semi-) automated driving functions, allowing for more comfortable driving on highways or in traffic jams. Today, all of those systems are designed to be driven “hands on”. However, one can observe a certain misuse of these types of systems, particularly if they allow for extended “hands off” driving without warning the driver. The United Nations is amending UN regulation 79 on “Steering equipment” to add some technical requirements to LKAS in order to address driver misuse related safety concerns. Entering into force on April 1st 2018 for type approval of new vehicle types, and applicable to all new production vehicles from April 1st 2021 on, R79 will require LKAS-equipped vehicles to provide a means of detecting that the driver is holding the steering control. There are, in principle, two technologies that vehicle manufacturers use today to determine whether the driver is holding the steering wheel: a capacitive sensor in the steering wheel rim for direct information about whether the hands are holding the steering wheel, or a torque sensor for indirect information via steering activity on the steering wheel. So future LKAS will have to evolve and provide an improved hands off detection performance, combined with an appropriate warning sequence starting, at the latest, 15 seconds after the driver removes their hands from the steering wheel. The new requirements are applicable to vehicle categories M and N.

INTRODUCTION

Today, an increasing number of vehicle models are available with Advanced Driver Assistance Systems (ADAS) that can take longitudinal control of the vehicle or support the driver with lateral control. These ADAS are paving the way to Automated Driving (AD), a key trend in the automotive industry. By combining longitudinal and lateral control, a vehicle would meet the AD Level 2 definition of SAE (Society of Automobile Engineers) International’s standard J3016. And while the driverless car (Level 5) may be the ultimate goal, we are not there yet: in the foreseeable future, the driver will remain a key element in the AD concept. But their role is likely to shift away from being a “driver” (up to Level 2) and move towards becoming an “operator” (under Level 3 & 4), and ceding control to the vehicle. This requires a transition of control responsibilities that has to be monitored precisely to avoid any misunderstandings. “Hands on” / “Hands off” detection is going to be one of the key monitoring elements, and additional driver monitoring needs can be expected for those future automated driving functions. In a first phase, the UN regulators have now decided to address system misuse that has

been observed with Level 2 systems, and will require monitoring that verifies whether the driver is holding the steering wheel.

WHY “HANDS OFF DETECTION”?

Initial Need For HOD

A frequently quoted key article of the Vienna Convention on Road Traffic says that “the driver shall at all times be able to control his vehicle”. Vehicle manufacturers concluded during the development of Traffic Jam Assist or similar functions that drivers might potentially misuse the system by removing their hands from the steering wheel and letting the vehicle do the driving on its own. From the point of view of system safety, and from a liability perspective, this was considered a misuse that should be prevented. After consideration, BMW decided that all vehicles with a Traffic Jam Assist system would have to be supplemented with a reliable “hands off” detection sensor to ensure that the driver keeps their hands on the steering wheel while using this function. Existing steering torque sensors were not considered to be robust enough as they do not provide reliable hands on/off information when the vehicle is at a standstill or is driving on straight,

smooth roads, especially at low speeds. IEE developed a capacitive “Hands Off Detection” (HOD) sensor integrated into the steering wheel rim to overcome those concerns. This HOD sensor allows the vehicle to detect precisely if the driver has his hands on the steering wheel, and if he does not, to initiate an appropriate warning cascade. The IEE HOD sensor has been in production since the end of 2013.



Figure 1. “Hands off” detection scenario

System Misuse – “Hands Off” Driving

LKAS (Lane Keeping Assistance System) on the market today are designed to be operated “hands on”. The vehicle manuals also include corresponding information for and warnings to the vehicle owner. However, an increasing number of drivers are misusing the systems and removing their hands from the steering wheel, particularly for LKAS in combination with Automatic Cruise Control (ACC). Some drivers may only want to test the limits of the systems, while others may have a poor understanding of the system limitations and believe that “hands off” operation is possible under certain circumstances. There are plenty of videos on social media platforms documenting this misuse. The scenarios range from drivers that let the vehicle do the steering while keeping their hands next to the steering wheel, to others who fully rely on the vehicle while having their hands on their lap or even using both hands for eating and drinking. In some extreme cases the driver has even left the driver’s seat, meaning he would no longer have the opportunity to intervene if there is a system error [1]! A fatal crash of a Tesla S operated in AutoPilot-mode happened in May 2016. Driver misuse of the system is believed to have played a

significant role. NHTSA noted in its investigation report that “The Florida fatal crash appears to have involved a period of extended distraction (at least 7 seconds)” [2]. Some media reports after the crash mentioned that the driver had possibly been watching a video [3], and therefore did not see and did not react to the crossing truck. Regulatory authorities, alerted by the multitude of documented cases of overreliance and system misuse, decided to tackle this issue. As vehicle manual information was apparently not effective enough to prevent those drivers from using their ADAS in a non-authorized way, it was decided to address the issue with a technical solution, by upgrading the UN Regulation 79 (Steering equipment) with a “hands off” detection requirement for LKAS-equipped vehicles. Drivers intending to misuse the systems should be alerted and thus the misuse should be prevented.

REGULATION FOR AUTOMATICALLY COMMANDED STEERING FUNCTIONS (ACSF)

Upcoming HOD requirement for LKAS

Today the LKAS systems are still almost unregulated, and that many vehicles “tolerate” the misuse is documented in a multitude of internet videos. The United Nations Informal Group on Automatically Commanded Steering Functions (IG ACSF) is currently reviewing regulation 79 on “steering systems” to define technical requirements for ADAS and AD-related steering functions. Among the new definitions are ACSF category B1 and ACSF category B2. Category B1 basically covers LKAS that must be driven “hands on”, while B2 is aimed at future continuous lane guidance systems that can be operated “hands off”. The UN has recently decided to upgrade the technical requirements that have to be met by B1 “hands on” lane keeping systems.

In countries applying the UN R79, the new requirements will enter into force on April 1st 2018 for type approval of new vehicle types, and will be applicable to all new production vehicles from April 1st 2021 on [4]. The regulation covers vehicles of category M (carriage of passengers) as well as category N (carriage of goods). The regulation requires vehicles fitted with an LKAS to be equipped with a means of detecting that the driver is holding the steering control. The regulation also describes an escalating warning strategy as shown in Figure 2.

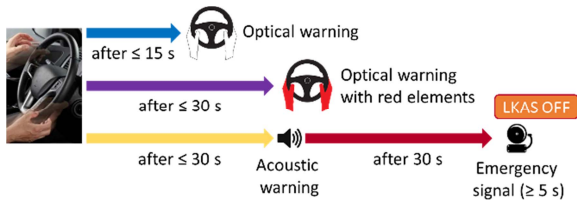


Figure 2. Escalating warning strategy

Drivers misusing the LKAS function by going “hands off” must be warned by an optical signal after 15 seconds at the latest. Then, at the latest after 30 seconds, parts of the optical signal must turn red, and an acoustic alert must be triggered. After 30 seconds of acoustic warning, an emergency signal of at least 5 seconds must sound as a final warning, and the LKAS must be deactivated. Hence, a reliable “hands on” detection system will be needed in order to meet the regulatory requirement. At the same time, it should avoid false positive warnings for drivers that effectively have their hand on the steering wheel.

Hands Off Detection Test Method

The hands off detection and the warning cascade are tested at two different driving speeds. ACSF B1 systems typically have a speed range within which they can operate, from the lowest speed v_{smin} to the maximum speed v_{smax} . In a first test, the vehicle shall be driven with an activated LKAS with a vehicle test speed between $v_{smin} + 10$ km/h and $v_{smin} + 20$ km/h on a track with lane markings at each side of the lane. The driver releases the steering wheel and continues to drive until the LKAS is deactivated automatically. The test is passed if the warning cascade meets the requirements illustrated in Figure 2. A second test must be carried out with a vehicle test speed between $v_{smax} - 20$ km/h and $v_{smax} - 10$ km/h or 130 km/h whichever is lower.

From “Hands On” To “Hands Off”

In a next phase, the IG ACSF will define the technical requirements for ACSF Category B2. A vehicle that will be type-approved in the future and meets those requirements can be continuously operated “hands off”, provided it is done within the system boundaries defined by the regulation and the vehicle manufacturer. One of those regulatory boundaries is limiting the use to road sections with a physical or constructional separation of traffic moving in opposite directions and which has at least two lanes for the direction the vehicle is driving. With regards to the AD

Levels, such systems can be a “Hands Off”-Level 2, or Level 3, or Level 4.

Vehicles offering a “hands off” operation will need enhanced driver monitoring capabilities. Under Level 3 & 4, the driver no longer has the task of continuously monitoring the traffic environment. But, in particular for Level 3, the vehicle is not necessarily in a position to handle all traffic situations. And although Level 4 vehicles have some additional fall back capabilities, they will require the driver to take back the control at the end of the defined use case. So the driver will have to remain available to respond to either a possible transition request initiated by the system (e.g. in case of a sensor failure or a too complex traffic situation) or at the end of the use case (e.g. when leaving the highway). The draft regulation text for ACSF B2 requires that the vehicle will have to be equipped with a driver availability recognition system. The vehicle must verify the physical presence of the driver in the seat and, in the absence of any monitored driver activity for more than 3 minutes, the driver must prove his availability by a positive action. For example, by briefly touching the steering wheel the driver can confirm via a capacitive HOD sensor that he has not fallen asleep.

“Hands off” driving functions do not only entail engineering challenges, but also liability questions that have to be addressed. As “hands off” operation is neither allowed nor possible on all roads, there will be a need for transition procedures between manual and automated driving modes. This transition has to be monitored precisely, as a change in liability goes with the change of vehicle control. Obviously, in AD mode the driver is allowed to be “hands off”, but it is crucial to know exactly when he has finally ceded steering control to the vehicle, as well as when he takes back control of the steering or intends to override the automated mode. A reliable HOD can precisely monitor this transition of control. And should there be an incident with a (semi-) automated vehicle, the HOD signal can help to clarify the key question: "Who was in control of the vehicle when the collision happened?".

IEE’s HOD SOLUTION

Based on capacitive (electric field) sensing technology, HOD consists of a highly flexible multi-layer sensor mat integrated into the steering wheel, with a miniaturized electronic and the connecting cabling installed in the steering wheel’s

centre hub. The system measures the current flowing from the sensing electrode towards vehicle ground, which is proportional to the capacitance. If a driver touches the steering wheel, the capacitance, and with that the current, increases.



Figure 3. HOD Sensor Mat

By using an IEE-owned ASIC, the electronic can reliably classify and communicate the hands on / off status under all environmental conditions. More advanced classification is enabled by using a multi-zone HOD system, which determines, for example, between a left and/or right hand touch. The HOD sensor mat can be combined with steering wheel heaters.

HOD immediately detects when the driver takes their hands off the steering wheel. So with regards to the Regulation 79 warning requirements, the vehicle manufacturer can initiate the warning with high precision and repeatability, and select any warning time that is within the minimum regulatory requirements. HOD also overcomes the known weaknesses of torque sensors that have limited performance on straight roads with few or no irregularities. In such situations with almost no active steering input by the driver, HOD prevents false positive warnings to “hands on” drivers.

Therefore, HOD is a robust solution to monitor whether the driver has his hands on the steering wheel in any driving scenario. Its field of applications ranges from enabling regulatory compliance for basic LKAS to supporting the HMI concepts of advanced automated driving functions.

CONCLUSION

Regulatory authorities have taken a significant step to prevent drivers from misusing steering assistance systems that are designed for “hands on” use. Vehicles equipped with LKAS and approved under UN Regulation 79 will have to provide a means of detecting that the driver is holding the steering control. The regulation update will become effective for new vehicle types in April 2018 and for all new vehicles in April 2021. So the M and N vehicle categories will no longer be allowed to “tolerate” continuous misuse by drivers

that have taken their hands off the steering wheel. Simply providing written information to the driver via the vehicle manual that he has to keep his hands on the steering wheel is no longer sufficient. A technical sensing solution and a defined “hands off” warning strategy have to be implemented.

IEE’s HOD was the first capacitive steering wheel sensor on the market, and there is an increasing need for the technology. HOD is expected to become a key HMI element of vehicles with LKAS and future automated driving functions. Main benefits are reliable hands on/off detection to support the regulatory requirements, improved HMI, safe transition between manual and automated driving modes, as well as the clarification of liability questions.

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