Technical Requirements of UN-R 140 Electronic Stability Control Systems

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JAPAN AUTOMOBILE STANDARDS INTERNATIONALIZATION CENTER

1. What is ESC (VSC by Toyota)?

1. What is ESC?

2.7.
"*Electronic Stability Control (ESC) System*" means a system that has all of the following attributes:

2.7.1.
That improves vehicle directional stability by at least having the ability to automatically control individually the braking torques of the left and right wheels on each axle to induce a correcting yaw moment based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;

1. What is ESC?

2.7.2.
That is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;

2.7.3.
That has a means to determine directly the value of the vehicle's yaw rate and to estimate its side-slip or side-slip derivative with respect to time;

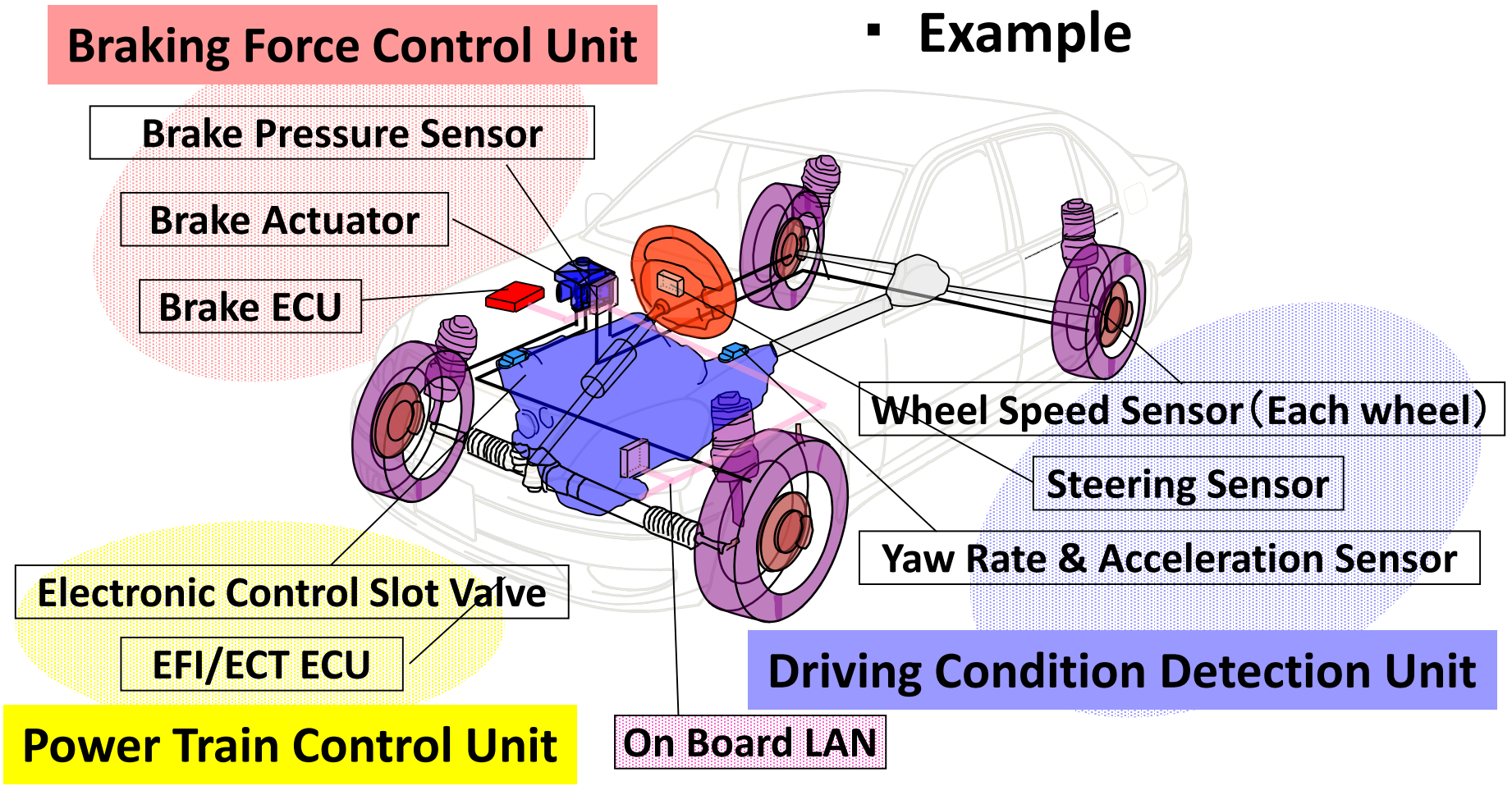
2.7.4.
That has a means to monitor driver steering inputs; and

2.7.5.
That has an algorithm to determine the need, and a means to modify propulsion torque, as necessary, to assist the driver in maintaining control of the vehicle.

1. What is ESC?

PURPOSE : Assist vehicle stability when cornering by avoiding under/over steer, with controlling engine torque and each wheel braking torque by sensor inputs

- **Example**



2. General requirements

5.1.
Vehicles equipped with an ESC shall meet the functional requirements specified in paragraph 6. and the performance requirements in paragraph 7. under the test procedures specified in paragraph 9. and under the test conditions specified in paragraph 8. of this Regulation.

Extract from 5.1.1.
As an alternative to the requirements of paragraph 5.1., vehicles of categories M1 and N1 with a mass in running order of more than 1,735 kg may be equipped with a vehicle stability function which includes roll-over control and directional control and meets the technical requirements and transitional provisions of Regulation No. 13, Annex 21.

2. General requirements

5.2.
The ESC shall be so designed, constructed and fitted as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

5.3.
In particular, the ESC shall be so designed, constructed and fitted as to be able to resist the corroding and ageing phenomena to which it is exposed.

2. General requirements

Extract from 5.4.
The effectiveness of the ESC shall not be adversely affected by magnetic or electrical fields.

Extract from 5.5.
The assessment of the safety aspects of ESC, with respect to its direct effect on the braking system, shall be included in the overall safety assessment of the braking system as specified in Regulation No. 13-H requirements associated with complex electronic control systems.

3. Functional requirements

6.1.
Is capable of applying braking torques individually to all four wheels and has a control algorithm that utilizes this capability;

6.2.
Is operational over the full speed range of the vehicle, during all phases of driving including acceleration, coasting, and deceleration (including braking), except:

6.2.1.
When the driver has disabled ESC;

6.2.2.
When the vehicle speed is below 20 km/h;

Extract from 6.2.3.
While the initial start-up self-test and plausibility checks are completed, not to exceed two minutes

6.2.4.
When the vehicle is being driven in reverse.

6.3.
Remains capable of activation even if the antilock braking system or traction control system is also activated.

4. Performance requirements

Extract from 7.

the vehicle with the ESC system engaged shall satisfy the directional stability criteria of paragraphs 7.1. and 7.2., and it shall satisfy the responsiveness criterion of paragraph 7.3.

Where a vehicle has been physically tested in accordance with paragraph 8., the compliance of versions or variants of that same vehicle type may be demonstrated by a computer simulation,

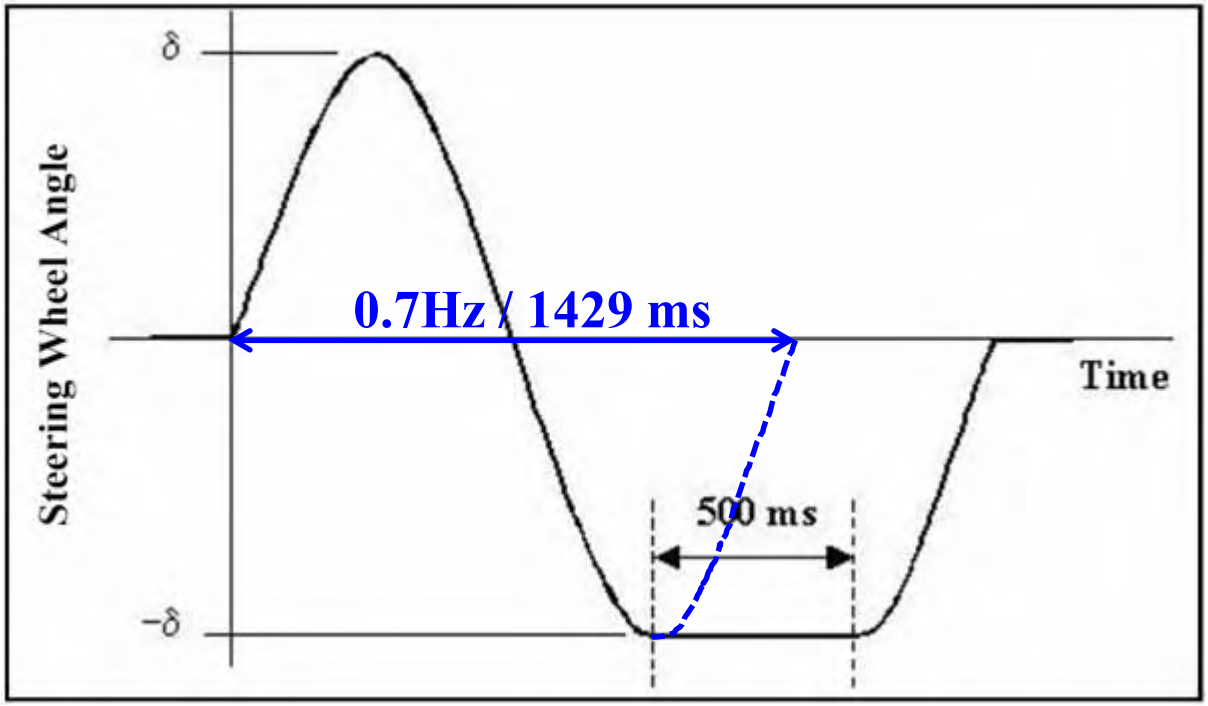
4. Performance requirements

Extract from 9.9.

Sine with Dwell test of oversteer intervention and responsiveness

a sine wave at 0.7 Hz frequency with a 500 ms delay beginning at the second peak amplitude

One series uses anticlockwise steering for the first half cycle, and the other series uses clockwise steering for the first half cycle.



Extract from 9.9.1.
in high gear
at 80 +/- 2 km/h.

Extract from 9.9.2.
The steering amplitude for the initial run of each series is 1.5 A

4. Performance requirements

Extract from 9.6.

Slowly increasing steer procedure

a constant vehicle speed of 80 +/- 2 km/h and a steering pattern that increases by 13.5 degrees per second until a lateral acceleration of approximately 0.5g is obtained.

Extract from 9.6.1.

"A" is the steering wheel angle in degrees that produces a steady state lateral of 0.3g for the test vehicle.

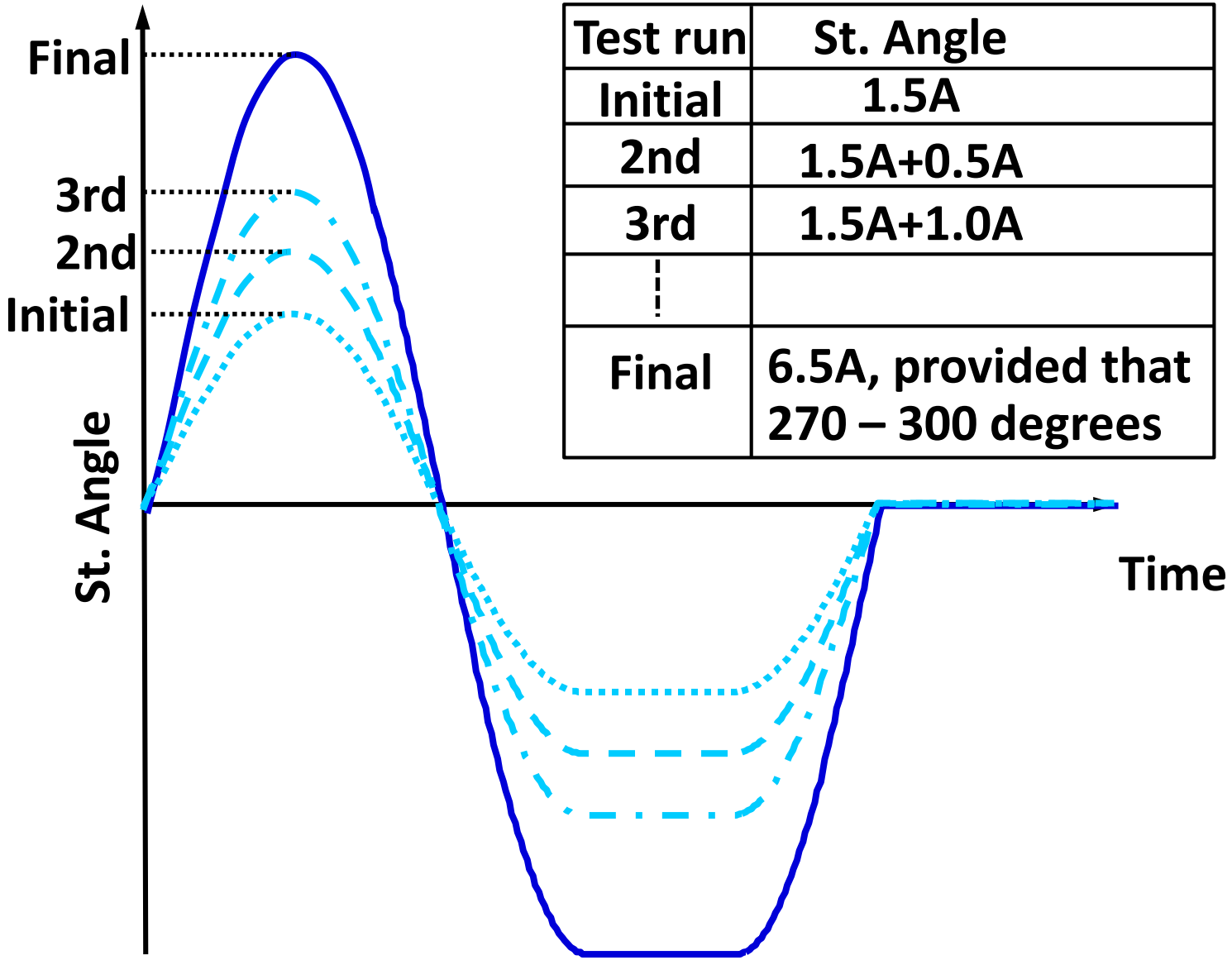
4. Performance requirements

Extract from 9.9.3.
In each series of test runs, the steering amplitude is increased from run to run, by 0.5 A,

Extract from 9.9.4.
The steering amplitude of the final run in each series is the greater of 6.5 A or 270 degrees, provided the calculated magnitude of 6.5 A is less than or equal to 300 degrees.
If any 0.5 A increment, up to 6.5 A, is greater than 300 degrees, the steering amplitude of the final run shall be 300 degrees.

Extract from 9.9.5.
Upon completion of the two series of test runs, post processing of yaw rate and lateral acceleration data is done

4. Performance requirements



Test run	St. Angle
Initial	1.5A
2nd	1.5A+0.5A
3rd	1.5A+1.0A
⋮	
Final	6.5A, provided that 270 – 300 degrees

4. Performance requirements

7.1.

The yaw rate measured 1 second after completion of the Sine with Dwell steering input (time T0 + 1 in Figure 1) shall not exceed 35 per cent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) (ψ_{Peak} in Figure 1) during the same test run.

7.2.

The yaw rate measured 1.75 seconds after completion of the Sine with Dwell steering input shall not exceed twenty per cent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) during the same test run.

Directional stability criteria

$$\frac{\Psi_{1.0}}{\Psi_{Peak}} \leqq 0.35$$

$$\frac{\Psi_{1.75}}{\Psi_{Peak}} \leqq 0.20$$

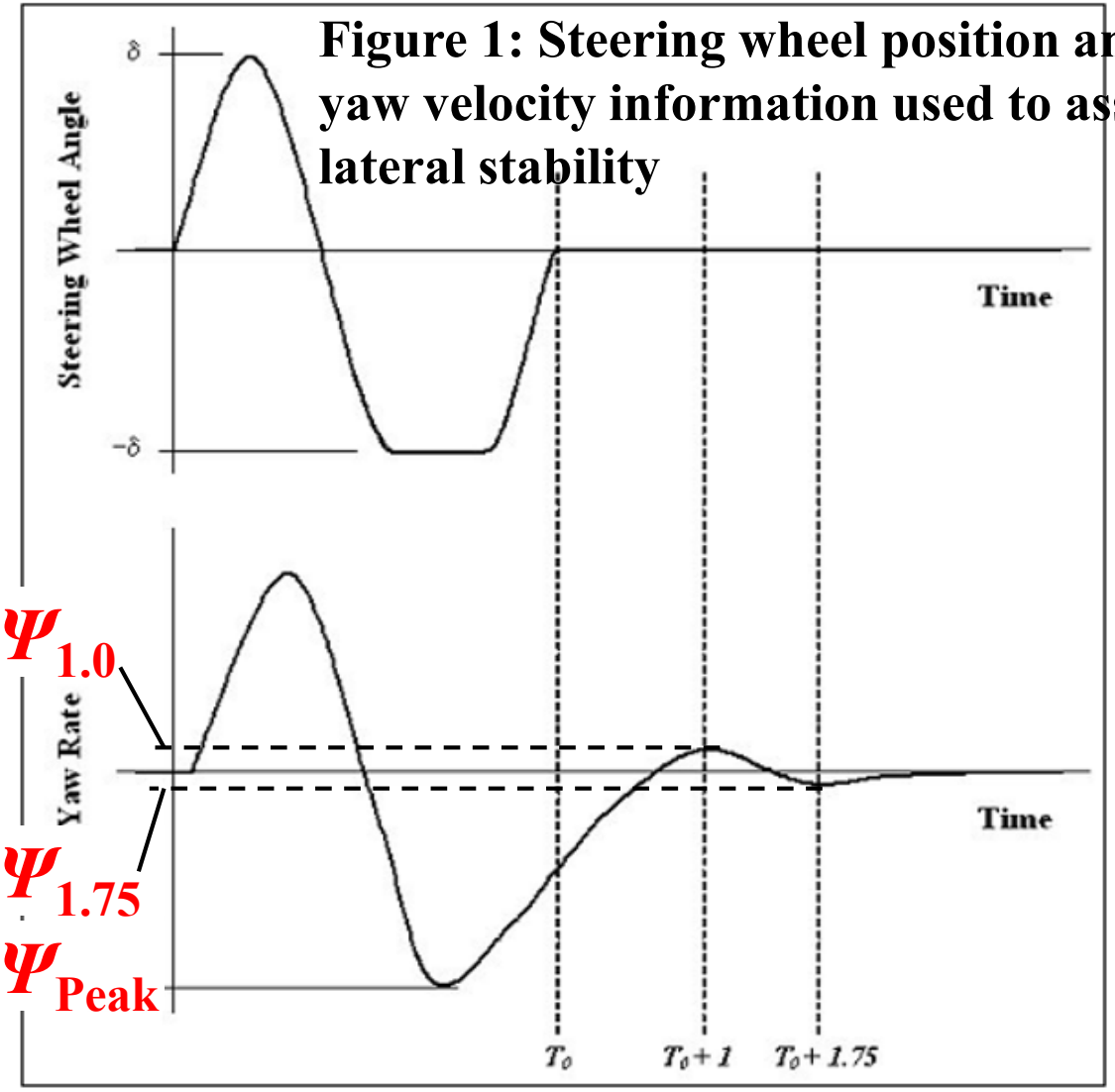


Figure 1: Steering wheel position and yaw velocity information used to assess lateral stability

7.3.

The lateral displacement of the vehicle centre of gravity with respect to its initial straight path shall be at least 1.83 m for vehicles with a GVM of 3,500 kg or less, and 1.52 m for vehicles with a maximum mass greater than 3,500 kg when computed 1.07 seconds after the Beginning of Steer (BOS).

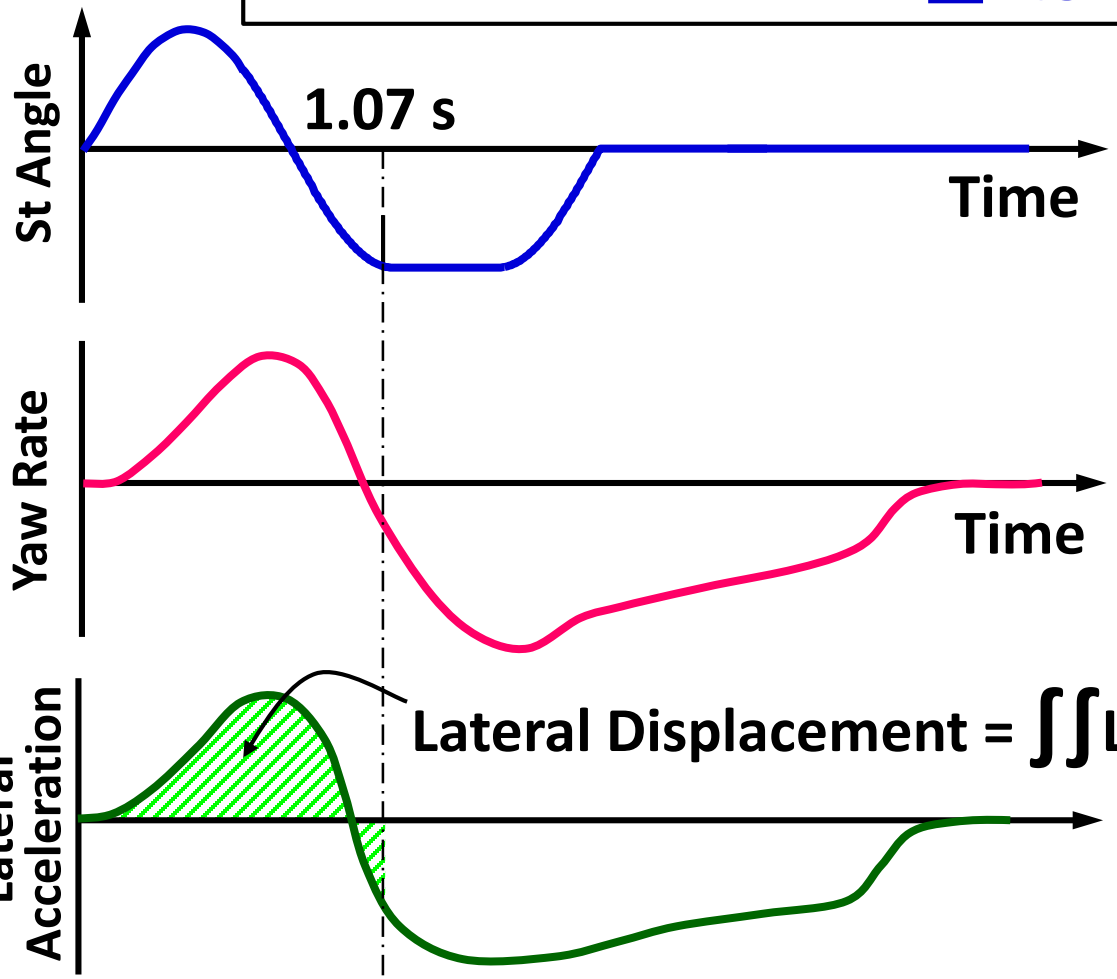
7.3.1.

The computation of lateral displacement is performed using double integration with respect to time of the measurement of lateral acceleration at the vehicle centre of gravity, as expressed by the formula:

$$\text{Lateral Displacement} = \iint ay_{C.G.}\, dt$$

Responsiveness Criterion

Lateral Displacement ≧1.83 m (GVM ≦3500 kg)
≧1.52 m (GVM > 3500 kg)



1.07 s means ¾ of 0.7 Hz cycling.

Understeer

7.7.4.
Understeer information. An outline description of the pertinent inputs to the computer that control ESC system hardware and how they are used to limit vehicle understeer.

Understeer

- Technical Documentation

System Diagram

System, Hard Wear Layout

Each Hard Wear Function

Basic Operational Characteristics

Capability of Braking Torque of each Wheel

Control of Propulsion Torque

Control during Acceleration/Deceleration

ESC Active Vehicle Speed Range

Logic Diagram

Explanation of Basic Operational Characteristics

Under Steer Control Algorithm

7.4. ESC malfunction detection

The vehicle shall be equipped with a tell-tale that provides a warning to the driver of the occurrence of any malfunction that affects the generation or transmission of control or response signals in the vehicle's electronic stability control system.

7.4.1.1.
Shall fulfil the relevant technical requirements of Regulation No. 121;

Extract from 7.4.1.2.

the ESC malfunction tell-tale shall illuminate when a malfunction exists and shall remain continuously illuminated

Extract from 7.4.4.

The manufacturer may use the ESC malfunction tell-tale in a flashing mode to indicate ESC intervention

4. Performance requirements

Extract from 7.5.

The manufacturer may include an "ESC Off" control,

7.6.2.1.
Shall fulfil the relevant technical requirements of Regulation No. 121;

7.6.2.2.

Shall remain continuously illuminated for as long as the ESC is in a mode that renders it unable to satisfy the requirements of paragraphs 7., 7.1., 7.2. and 7.3;

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Special requirements for vehicles equipped with a vehicle stability function, EVSC (Electronic Vehicle Stability Control)

Extract from 5.2.1.32. of R13
The vehicle stability function shall include roll-over control and directional control and meet the technical requirements of Annex 21 to this Regulation.

Extract from 2.1.3. of R13 Annex 21
The vehicle stability function shall be demonstrated to the Technical Service by dynamic manoeuvres on one vehicle which has the same vehicle stability function as the vehicle type to be approved. This may be realized by a comparison of results obtained with the vehicle stability function enabled and disabled for a given load condition. As an alternative to carrying-out dynamic manoeuvres for other vehicles and other load conditions, fitted with the same vehicle stability system, the results from actual vehicle tests or computer simulations may be submitted.

Extract from 2.1.3. of R13 Annex 21
As a means of demonstrating the vehicle stability function any of the following dynamic manoeuvres shall be used:

Directional control	Roll-over control
Reducing radius test	Steady state circular test
Step steer input test	J-turn
Sine with dwell	
J-turn	
mu-split single lane change	
Double lane change	
Reversed steering test or "fish hook" test	
Asymmetrical one period sine steer or pulse steer input test	

Thank you!