

# TCR Turbocharger Boost Monitoring Method

**2020-08-11** | This document describes the turbocharger boost monitoring method applicable in TCR series. For clarification requests, please contact the authors. Changes since last version are **marked**.

## 1 Method Description

The purpose of this monitoring method is the detection of advantages gained by competitors beyond the parameters set by the Balance of Performance definition. For practical purposes in the context of turbocharger boost pressure, the following is defined:

*The competitor has gained an advantage when the turbocharger boost pressure produced by the engine of the car exceeds the limit defined by WSC technical department on more than 0.3 % of all measured data points per lap.*

### 1.1 Measurement

Measurements of turbocharger boost pressure are taken in the intake manifold of the engine using the “TCR Scrutineering Turbocharger Boost Pressure Sensor” as specified in the TCR ECU Installation Manual, hereinafter referred to as the “boost sensor”. The sampling rate is 100 Hz for the boost sensor. Engine speed (RPM) is sampled at 100 Hz. Intake air temperature measured via TCR scrutineering sensor is sampled at 10 Hz.

In the following, the boost sensor values are also referred to as  $p_{ManifoldScrut}$  and the values measured by the scrutineering intake air temperature sensor are also referred to as  $t_{Manifold-Scrut}$  respectively, as these names are the names of the channels in the scrutineering data logger. All values are given in their original naming.

### 1.2 Conditions

The monitoring will be applied if

- more than 300 ms have passed since the last gear shift request
- pedal position exceeds 90 %:  $predPedal(t) = rPedal(t) > 0.9$

### 1.3 Smoothing

The boost pressure is smoothed using *Exponential Moving Average* with an alpha of 0.1, i.e.

$$pManifoldSmoothed(0) = pManifoldScrut(0) \quad (1)$$

$$pManifoldSmoothed(t) = 0.1 \cdot pManifoldScrut(t) + (1 - 0.1) \cdot pManifoldSmoothed(t - 1) \quad (2)$$

where  $pManifoldSmoothed$  is the smoothed value and  $t$  is one time step.

### 1.4 Limit

The limit as defined by WSC is defined by

- a set of interpolation support points for turbocharger boost pressure ([mbar]) at different engine speeds ([1 / min]), published via *TCR Technical Bulletins*
- a correction factor ( $cFactor$ , [mbar/°C]) used in a formula which is function of air intake temperature ([°C])

and calculated via linear interpolation between the interpolation points using engine speed at time step  $t$  (denoted  $fEngRpm(t)$ ) and adding an offset for temperature correction, i.e.

$$limit(fEngRpm(t)) = interpolation(supports fEngEpm(t)) + correction(tManifoldScrut(t)) \quad (3)$$

where  $interpolation(supports, fEngRpm(t))$  is not further explained and

$$correction(tManifoldScrut(t) \leq 40^{\circ}C) = 0 \quad (4)$$

$$correction(tManifoldScrut(t) > 40^{\circ}C) = (tManifoldScrut(t) - 40^{\circ}C) \cdot cFactor \quad (5)$$

Be advised:

- Below the RPM range where interpolation points are given, the first interpolation point will be used as a limit.
- Above the RPM range where interpolation points are given, the last interpolation point will be used as a limit.

### 1.5 Violation

A violation of the boost limit for a lap is registered if at more than 0.3 % of all time steps  $t$  in a lap the limit is exceeded by  $pManifoldSmoothed$ . A "lap" is defined as the collection of data points at all time steps between two lap trigger events as recorded by the scrutineering data logger.

## 2 Block Diagram

The following block diagram is executed for every time step. The *counter* is initialized with the value 0 and reset to 0 after each lap.

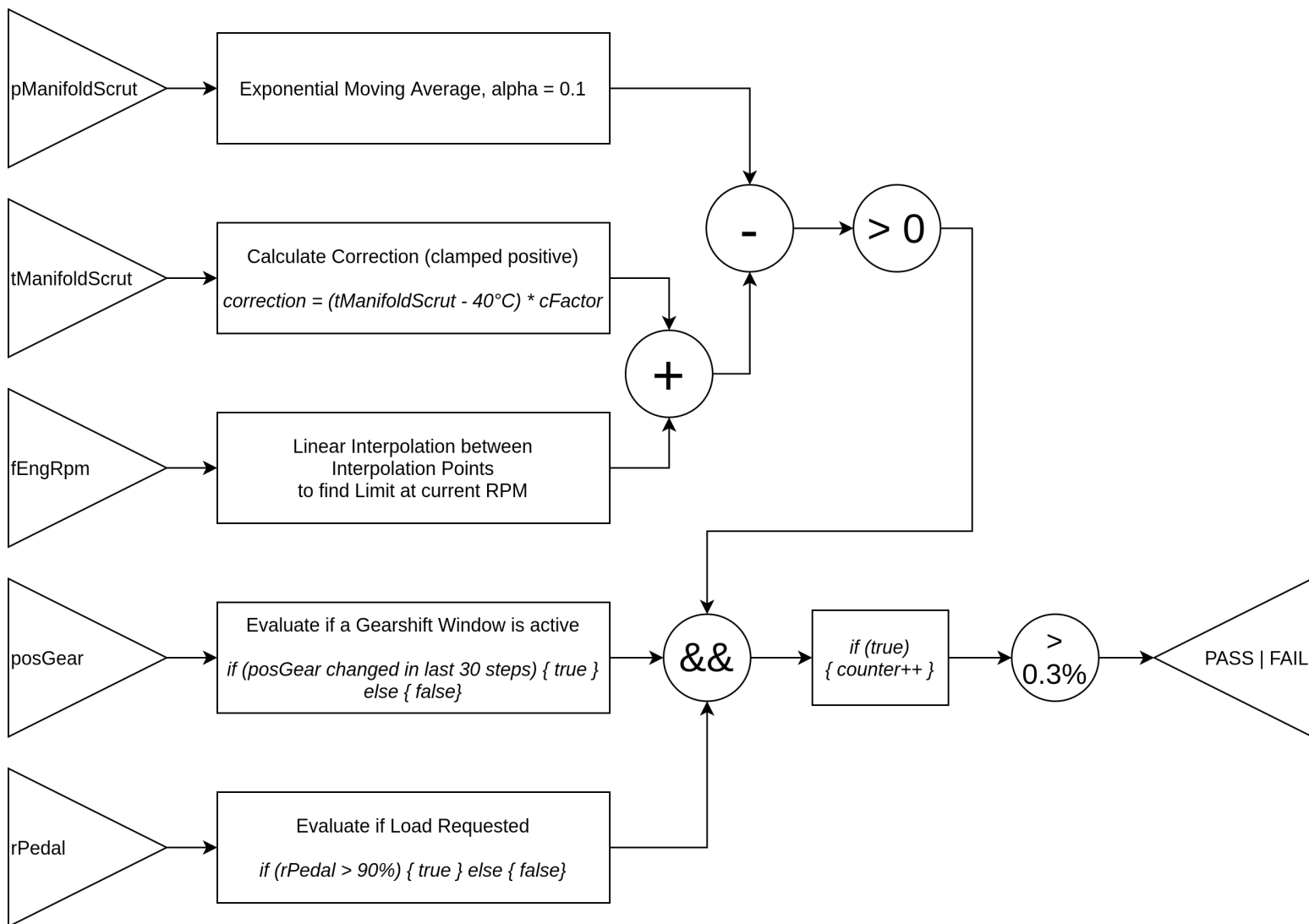


Figure 1: Boost Monitoring Method Block Diagram

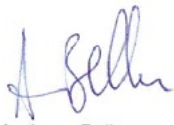
### 3 Document Information

This decision is with immediate application and valid until further notice on the subject.

#### Authors

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Florian Eich  
[florian@tcr-series.com](mailto:florian@tcr-series.com)



Andreas Bellu, TCR Technical Director

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Markus Krug  
[markus.krug@tcr-series.com](mailto:markus.krug@tcr-series.com)