Ain Shams University
FACULTY OF ENGINEERING
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DYNAMIC RESPONSE OF A FOUR WHEEL STEERING VEHICLE

By

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A THESIS

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Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Mechanical Engineering (Automotive).
This work included in the thesis was carried out by the author from 2003 to 2010.

No part of this thesis has been submitted for the degree or a qualification at any other university or institute.

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Nomenclature

Symbol	Description	Unit
CG	Centre of Gravity	[m/s^2]
C_f	Front tire cornering stiffness for 4WS	[kN/rad]
C_r	Rear tire cornering stiffness for 4WS	[kN/rad]
$C_{\alpha f}$	Front tire cornering stiffness for 2WS	[kN/rad]
$C_{\alpha r}$	Rear tire cornering stiffness for 2WS	[kN/rad]
F_{xf}	Front tire longitudinal force	[N]
F_{xr}	Rear tire longitudinal force	[N]
F_{yc}	Lateral force at CG	[N]
F_{yf}	Front tire lateral force	[N]
F_{yr}	Rear tire lateral force	[N]
g	Acceleration of gravity = 9.82	[m/s^2]
I_z	Mass moment of inertia of the vehicle about Z-axis	[kg.m^2]
L	Wheelbase	[m]
l_1	Distance from CG to front axle for 2WS	[m]
l_2	Distance from CG to rear axle for 2WS	[m]
l_f	Distance from CG to front axle for 4WS	[m]
l_r	Distance from CG to rear axle for 4WS	[m]
m	Vehicle curb weight	[kg]
R	Turning radius	[m]
U	Vehicle longitudinal speed for 4WS	[km/h]
V	Vehicle lateral speed for 4WS	[km/h]
V_x	Vehicle longitudinal speed for 2WS	[km/h]
V_y	Vehicle lateral speed for 2WS	[km/h]
$\dot{V}$	Lateral acceleration for 4WS	[m/s^2]

$\dot{V}_y$	Lateral acceleration for 2WS	[m/s^2]
α_f	Side slip angle of front tire	[rad]
α_r	Side slip angle of rear tire	[rad]
β	Vehicle slip angle at CG	[rad]
δ_f	Front wheel angle	[rad]
Ω_z	Yaw angle	[rad]
$\dot{\Omega}$	Yaw rate for 4WS	[rad/s]
$\dot{\Omega}_z$	Yaw rate for 2WS	[rad/s]

Summary

This work is concerned with the study of the effect of steering with four wheels compared to steering with front wheels only on the dynamic response of the car.

The study included the performance of road tests on two cars of the same brand and car manufacturer, one of which is steered by the conventional front wheel while the other is steered by the four wheels. The dynamic response was measured and recorded by using sensors connected to a PC system. Vehicle speed, steering wheel angle, lateral acceleration and yaw rate were measured. The different measuring instruments were assembled on a steel chassis and mounted in the luggage compartment. The tests included the measurement of the dynamic response during two manoeuvres: lane change and slalom tests.

A mathematical model was developed to simulate the dynamic performance of the cars using computer software (Matlab-Simulink).

The results showed that the lateral acceleration of the four wheeled vehicle is less than that of the two wheeled vehicle, and the yaw rate of the 4WS car is better than that of the 2WS.

The results of the mathematical model were validated to a great extend by the experimental work.

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