Faculty of Engineering
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Estimation of the Brake Clamping Force in an Automotive Brake by Wire System

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By

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The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

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Summary of the M.Sc. Thesis

“Estimation of the Brake Clamping Force in an Automotive Brake by Wire System”

Braking systems are one of the most important systems in automotive technology; as it directly affects passengers’ safety. This guided many researchers towards its development over years. Several automotive companies are already using - or have used - various drive by wire systems in their vehicles. The substitution of electronic systems in place of mechanical and hydraulic controls is known as “brake-by-wire” technology. The benefits of applying electronic technology are improved performance, safety and reliability with reduced manufacturing and operating costs.

A test rig has a series of sensors that monitor both the brake pedal displacement and the DC motor current, in addition to the fly wheel speed and automatically adapt the braking performance to maintain safety. When a force is applied to the brake pedal, information is electronically passed through the system, the external situation is evaluated, and the brake motors apply the correct amount of current to decelerate the rotor disc.

A mathematical model for the BBW system was derived using Simulink and validated via an experimental setup where Arduino – based – controller was implemented to perform both control and data acquisition tasks. It is observable that all the readings show good correlation between experimental and simulation results which lead to developing of fuzzy control logic that was validated experimentally. Such that the proposed model can be used in future researches concerning BBW as it showed better brake control performance.

Nomenclature

List of Greek Symbols

θ_m	The motor rotor angular displacement
$\gamma_{DCMgear}$	The DC motor gear head reduction ratio
γ_{lm}	The ratio of the load speed (i.e. power screw rotational speed) to the motor rotor speed
μ_s	The friction coefficient between the materials of both power screw and nut
β	The thread angle half
μ_p	The dynamic friction coefficient at the contact surface between the brake pad and the rotor disc
γ_{mean}	The mean radius of the brake pad frictional surface
θ_f	The flywheel angular displacement

List of Alphabetic Symbols

V	Input voltage to the DC motor
K_b	Back emf constant
T_f	The resisting torque induced from the friction in the power screw thread
S_{EMBA}	The electromechanical brake actuator(EMBA) displacement
P_s	The power screw pitch
K_t	The torque constant
L_a	The inductance
F_{EMBA}	The force that presses the brake pads against the rotor disc
Pad_{cl}	The clearance between the brake pads and the rotor disc

F_{DS}	The force induced by compressing the set of disc springs
d_m	The power screw mean diameter
T_b	The braking torque induced by the EMBA and imposed on the rotor disc
J_f	The flywheel inertia
D_f	The flywheel damping coefficient

<u>List of Acronyms</u>

ABS	Anti lock Braking System
TCS	Traction Control System
ESP	Electronic Stability Program
ACC	Adaptive Cruise Control
BBW	Brake By Wire
ECU	Electronic Control Unit
EHB	Electro-Hydraulic Brake
HCU	Hydraulic Control Unit
EMB	Electro-Mechanical Brake
ANN	Artificial Neural Network
CW	Collision Warning
CA	Collision Avoidance
MPC	Model Predictive Control
MPB	Magnetic Particle Brake
MR	Magneto-rheological
ER	Electro-rheological

WDB	Wafer Disc Brake
RMSE	Root Mean Square Error
CHB	Conventional Hydraulic Braking
EMBA	Electro-Mechanical Brake Actuator
TEFV	Totally enclosed fan ventilated
F/ V	Frequency To Voltage conversion
FSR	Force Sensing Resistors
AI	Analogue Inputs
AO	Analogue Outputs
FLS	Fuzzy Logic System
r.p.m	Revolution Per Minute
r.p.s	Revolution Per Second
BOA	Bisector of Area
SOM	Smallest of Maxima
MOM	Mean of Maxima
LOM	Last of Maxima
COG	Center of Gravity
kHz	Kilo Hertz
PWM	Pulse Width Modulation
FSR	Force Sensitive Resistor
FLS	Fuzzy Logic System
FLC	Fuzzy Logic Control

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