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On Electrohydraulic Pressure Control for Power Steering Applications Steering Handbook An Electric Power Steering System for Vehicles with Controlled Input to the Steering Power Steering Failure Study. Volume I: Executive Summary. Final Report Electric Steering Automotive Steering and Suspension Robust Control Design of Electric Power Steering Systems Robust Control for an Electric Power Steering System Toyota Power Steering (rack & Pinion Type) Design of an Electric Power Steering System Using a Model Reference Approach and Additional Column Or Rack Actuators Power Steering for Agricultural Tractors A New Power Steering System for Tractors Power Steering System with Travelling Condition Judgement Function Development of Electric Power Steering Control of Electric Power Steering Sheppard Power Steering Power Steering for Passenger Cars Power Steering Improving Steering Feel in Electric Power Steering Systems Automobile Power Steering Systems Power Steering 'road Feel'. Electric Power Steering for Control of Vehicle Dynamics Dynamics and Model-Based Control of Electric Power Steering Systems An Investigation of the Performance of a Power Steering System for Passenger Cars Study of Power Steering for Automobiles An Investigation of Noise and Vibration in an Automotive Power Steering System Fault Tolerant Control for an Electric Power Steering System Hornig's "direct Power" Steering System Bishop VARIATRONIC Power Steering System Power Steering with Natural Feel Development of an Electronically-controlled

Power Steering System Power Steering Fundamentals Model for Simulation of Power Steering System in MBS A Comparative Study of Power Consumption of Electric Power Steering System Non-integrated Power Steering System Power Steering in Automobiles The Evaluation of Drivers Responses to a Multi-characteristic Power Assisted Steering System Power Steering Ford power steering shop manual Modeling and Analysis of a Hydraulic Power Steering System for Use in Vehicle Simulation

This thesis deals with the Electrohydraulic Power Steering system for road vehicles, using electronic pressure control valves. With an ever increasing demand for safer vehicles and fewer traffic accidents, steering-related active safety functions are becoming more common in modern vehicles. Future road vehicles will also evolve towards autonomous vehicles, with several safety, environmental and financial benefits. A key component in realising such solutions is active steering. The power steering system was initially developed to ease the driver's workload by assisting in turning the wheels. This is traditionally done through a passive open-centre hydraulic system and heavy trucks must still rely on fluid power, due to the heavy work forces. Since the purpose of the original system is to control the assistive pressure, one way would be to use proportional pressure control valves. Since these are electronically controlled, active steering is possible and with closed-centre, energy efficiency can be significantly improved on. In this work, such a system is analysed in detail with the purpose of investigating the possible use of the system for Boost curve control and position control for autonomous driving. Commercially available valves are investigated since they provide an attractive solution. A model-based approach

is adopted, where simulation of the system is an important tool. Another important tool is hardware-in-the-loop simulation. A test rig of an electrohydraulic power steering system, is developed. This work has shown how proportional pressure control valves can be used for Boost curve control and position control and what implications this has on a system level. As it turns out, the valves add a great deal of time lag and with the high gain from the Boost curve, this creates a control challenge. The problem can be handled by tuning the Boost gain, pressure response and damping and has been effectively shown through simulation and experiments. For position control, there is greater freedom to design the controller to fit the system. The pressure response can be made fast enough for this case and the time lag is much less critical. This edited volume presents basic principles as well as advanced concepts of the computational modeling of steering systems. Moreover, the book includes the components and functionalities of modern steering system, which are presented comprehensively and in a practical way. The book is written by more than 15 leading experts from the automotive industry and its components suppliers. The target audience primarily comprises practicing engineers, developers, researchers as well as graduate students who want to specialize in this field. Many automobile manufacturers are switching to Electric Power Steering (EPS) systems for their better performance and cost advantages over traditional Hydraulic Power Steering (HPS) systems. EPS compared to HPS offer lower energy consumption, lower total weight, and package flexibility at no cost penalty. Furthermore, since EPS systems can provide assistance to drivers independent of the vehicle driving conditions, new technologies can be implemented to improve the steering feel

and safety, simultaneously. In this thesis, a neuromusculoskeletal driver and a high-fidelity vehicle model are developed in MapleSim to provide realistic simulations to study the driver-vehicle interactions and EPS systems. The vehicle model consists of MacPherson and multilink suspensions at front and rear equipped with a column-type EPS system. The driver model is a fully neuromusculoskeletal model of a driver arm holding the steering wheel, controlled by the driver's central nervous system. A hierarchical approach is used to capture the complexity of the neuromuscular dynamics and the central nervous system in the coordination of the driver's upper extremity activities. The proposed motor control framework has three layers: the first layer, or the path-planning layer, plans a desired vehicle trajectory and the required steering angles to perform the desired trajectory, the second layer (or the force distribution controller) actuates the musculoskeletal arm, and the final layer is added to ensure the precision control and disturbance rejection of the motor control units. The overall goal of this thesis is to study vehicle-driver interactions and to design a model-based EPS controller that considers the driver's characteristics. To design such an EPS controller, the high-fidelity driver-vehicle model is simplified to reduce the computational burden associated with the multibody and biomechanical systems. Then, four driver types are introduced based on the physical characteristics of drivers such as age and gender, and the corresponding parameters are incorporated in the model. Last but not least, a new model-based EPS controller is developed to provide appropriate assistance to each of the predefined driver types. To do this, the characteristic curves are tuned using a systematic optimization procedure to provide appropriate assistance to

drivers with different physical strength, in order to have a similar road and steering feel. In this thesis, it is recommended that muscle fatigue be used as a measure of steering feel. Then, based on the tuned EPS characteristic curves, an observer-based optimal disturbance rejection controller, consisting of a linear quadratic regulator controller and a Kalman filter observer augmented with a shaping filter, is developed to deliver the assistance while attenuating external disturbances. The results show that it is possible to develop a model-based EPS controller that is optimized for a given driver population. Electric power steering (EPS) systems have been adopted by the automotive industry principally because of potential fuel savings over the more conventional hydraulic power steering. EPS lends itself to improvements in automobile steering feel and vehicle response as well as ultimately leading to steer-by-wire systems. This thesis proposes two adaptations of the standard column mounted electric power steering (C-EPS) system. In the first new configuration, an additional motor is placed between the C-EPS motor and the steering wheel for independent control of steering feel. In the second new configuration, an additional motor is placed between the rack and right tie rod for independent control of vehicle response. These new motors, combined with a model reference approach utilizing Proportional-Integral-Derivative (PID) control and linear quadratic regulator (LQR) control, allow for the independent tuning of desired steering feel and vehicle response, leading to new or improved functionality when compared to more traditional EPS systems: disturbance rejection, yaw damping, variable steering ratio, and increased linear tire behavior. Without additional motors, it can still be shown that the model reference approach is advantageous for

various traditional EPS functions: assist, return to center, and inertia compensation. These new or improved functions are tested under various conditions with various inputs and compared to a more traditional EPS system. The introduction of electric power steering (EPS) systems has allowed automotive OEM's to increase fuel efficiency and develop a myriad of driver assist functions such as park assist and active lane keeping. However, one of the biggest complaints about EPS systems is the lack of good steering "feel". This paper introduces a model reference feedback control system aimed at improving steering feel. Detailed nonlinear models of column-mounted and rack-mounted EPS systems are derived using bond graphs to analyze the dynamics of the system. Reduced order linear model of the EPS systems are then derived for control development. A torque feedback controller is developed that allows engineers to quickly and easily tune the "feel" of the steering system via four tuning parameters on a reference model. A return-to-center controller is also developed to center the steering wheel whenever the driver releases it from an off center position. The two control systems are integrated together using fuzzy logic so as to determine when to use the return-to-center controller. It is shown through simulation studies that the final control system gives great tracking performance and that the use of fuzzy inference system allows the controllers to switch smoothly and appropriately thus showing potential to improve steering feel. Automotive Steering and Suspension, published as part of the CDX Master Automotive Technician Series, arms students with the basic knowledge and skills they need to accomplish a variety of tasks in the shop. Taking a “strategy-based diagnostics” approach, this book helps students master technical trouble-shooting in order to address the

problem correctly on the first attempt. This report profiles the development and unlimited potential of electric steering technology--an innovation expected to fundamentally change the way automobiles are designed, produced, and marketed. Electric Steering offers information on how this revolutionary steering system evolved, and the effects its implementation will have on America's largest manufacturing industry. Chapters include: Steering Basics Electronic Steering The Market Drivers The Future and more A sample of fifty male and fifty female drivers took part in an:. experiment designed to evaluate a multi-characteristic power assisted steering system. Subjects drove a car fitted with the system for two one-hour periods on public roads and on two test-track sessions during which a number of driving performance variables including driving time and steering activity were recorded. Drivers completed a specially developed questionnaire after each road drive. A subsidiary task, which involved the visual monitoring of an illuminated display and verbal responses, was administered during the test-track sessions. Factor analysis and discriminant analysis were used to analyse data from the questionnaire, road drives and test- track sessions. Data were first factor analysed and the factors subsequently used as variables in the discriminant analyses. It was possible to discriminate between male and female drivers, and between groups of drivers allocated to the different power steering characteristics on the basis of the discriminant functions derived. Thus, reales were found to be more sensitive to the force feedback characteristics of the standard power steering than females, finding it difficult to judge the amount of effort required to steer the car and tending to 'over steer' under some circumstances. Males drove faster than the females on the Motorway with the

standard power steering, however, more slowly than females in urban driving, and drove faster and more accurately than females on the test-track. On the basis of the differences observed between drivers allocated to the different power steering characteristics, criteria were developed which allowed the specification of that characteristic which could be considerec 'optimal' for ordinary drivers of both sexes. This character- istic, termed "Speed Proportional Feel", provides the driver with full power assistance at low speeds, but increasingly inhibits the operation of the power assistance as vehicle speeds rise, gi.