

# Design of Controllers With Fixed Order for Hydraulic Control System With a Long Transmission Line

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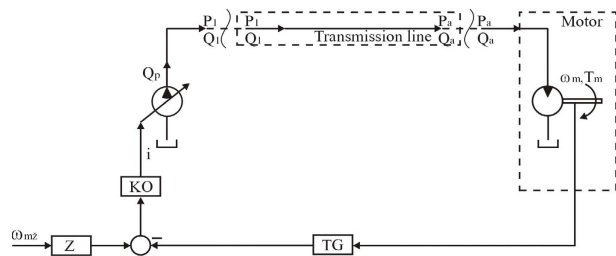
*This paper presents the problem of describing the system, a pump-controlled motor with a long transmission line, by means of a mathematical model with lumped parameters, where the long transmission line is divided into  $n$  equal "II" segments. The obtained mathematical model is of high order but by applying the corresponding methodology in this paper, its order will be reduced, which considerably increases its use value. From the aspect of control, here it is important how to solve the problem of control of high order facilities because controllers with fixed order are present in industrial practice (P, PI, PID), and the high order facility should be controlled. This paper represents the beginning of research in defining the methodologies of synthesis of controllers with fixed order for the systems with long transmission lines.*

**Keywords:** control system, modelling, transmission line, controllers, distributed parameters, lumped parameters.

## 1. INTRODUCTION

Increasingly strict and wide requirements regarding displacement hydrostatic power transmitters have recently appeared in the sense of simultaneous accomplishment of high power exploitation degrees, high speed of response with the reduction of price [1-3]. This particularly refers to high power systems and systems of variable load (building and mining machines, agricultural machines, transportation machines, machine tools, etc). It is obvious that these requirements result in the need for more intense development of systems with displacement control in relation to the systems with damping control. One of the main preconditions for quality and reliable operation of high power systems is stable and quality operation of the system for automatic regulation of hydrostatic power transmitter, the pump controlled motor with long hydraulic lines (Fig. 1). The authors of this paper have considered the problem of dynamic behaviour of such systems in a very systematic way, and the results are presented in paper [4-5]. The existence of a long transmission line in this system makes its dynamics more complex to a considerable extent, because the physical values, pressure and flow, which characterize the transfer of energy along the long transmission line depend both on the time coordinate and the space coordinate. Dependence of these physical values on the space coordinate, too, conditions that during mathematical description of the long transmission line the space distribution cannot be neglected, so that it is described by a model with distributed parameters. Models with distributed parameters are described by differential equations and

the model thus obtained is of infinitesimally high order [6-10]. In addition to mathematical modelling of the long transmission line by means of a model with distributed parameters, it is possible to describe the long transmission line by common differential equations, i.e. a model with lumped parameters [1-5] because solving common differential equations makes considerably fewer difficulties in comparison with solving partial differential equations.



**Figure 1. Symbolic diagram of a closed system of automatic control of a pump-controlled motor with a long transmission line**

This paper presents the problem of describing the system, a pump-controlled motor with a long transmission line, by means of a mathematical model with lumped parameters, where the long transmission line is divided into  $n$  equal "II" segments. The obtained mathematical model is of high order but by applying the corresponding methodology in this paper, its order will be reduced, which considerably increases its use value. From the aspect of control, here it is important how to solve the problem of control of high order facilities because controllers with fixed order are present in industrial practice (P, PI, PID), and the high order facility should be controlled [10-14]. This paper represents the beginning of research in defining methodologies of synthesis of controllers with fixed order for the systems with long transmission lines described by means of mathematical models of high order, and it treats the methodology of designing P regulators, whose introduction can significantly

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