

Design of Electromagnetic Actuators

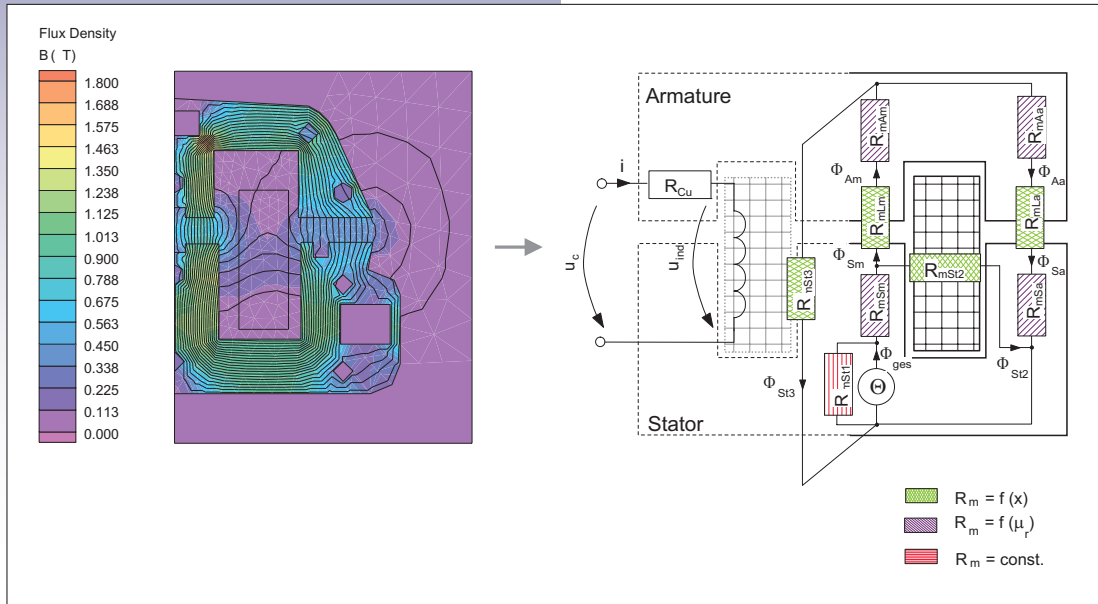


Fig. 1: Flux density distribution of a contactor obtained by stationary FEM calculation and derived magnetic equivalent network used for simulation of dynamic behaviour

Problem

In many fields, such as industrial automation, handling and automotive applications, the demand for small, reliable and cost-effective actuators with an improved performance compared with today's solutions will increase during the next years.

The efficiency of electromagnetic actuators and drives can be significantly increased by means of electronic circuits for excitation and control. Due to the resulting system complexity, an efficient and optimal design of such actuators is possible only when computer based modelling and simulation is used within the design process.

For typical electromechanical devices, the effects of the different physical domains (e. g. mechanical, electrical, thermal, magnetic) have to be arranged and optimized. The resulting partial systems must be designed with respect to the overall system behaviour. This is especially true as actuator dimensions decrease and function integration increases.

The main advantages of using modelling and simulation within the design process are:

- better understanding of the underlying physics,
- easy calculation of quantities that are difficult to measure,
- parameter variation for sensitivity analysis, adjustment and optimization,
- reduced number of necessary prototypes and tests.

A prerequisite for the successful use of simulation is the availability of tools and methods that allow for multi-domain modelling and simulation at system level. The development and refinement of such methods and tools is still very much topic of current research.

Approach

The Institute of Precision Engineering of Dresden University of Technology has an extensive knowledge in the area of computer aided simulation and design of actuators, especially in the field of electromagnetic actuators and drives.

An advantageous approach for multi-domain modelling at system level is to describe the system with a set of differential and algebraic equations that are solved by the simulation software. Rather than using domain-specific model descriptions like netlists or block diagrams, mixed system modelling can be easily done with a behavioural description language like VHDL-AMS or MODELICA.

Using magnetic equivalent networks to model the magnetic system of electromagnetic actuators, system dynamics can be calculated with little computational effort. Higher accuracy can be achieved when the Finite Element Method (FEM) is

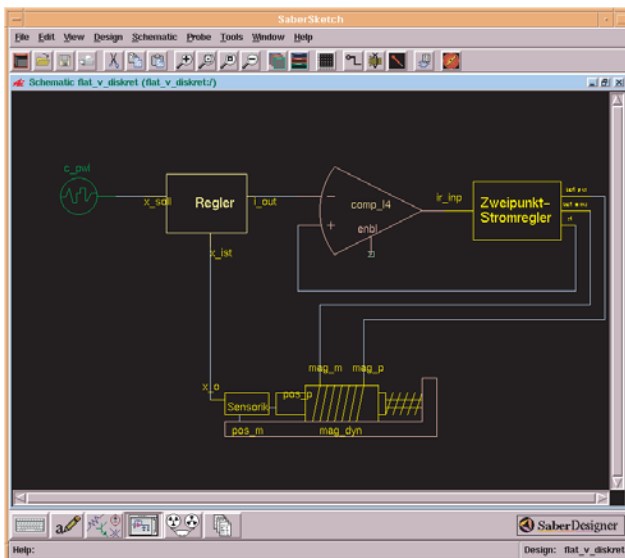


Fig. 2: System simulation of a position controlled solenoid drive with SABER

used for field calculations. However, due to the high computational effort only stationary field distributions can be obtained from FEM calculations with today's computers. Parameterization of magnetic reluctances from FEM results is a promising way to obtain efficient but accurate models for dynamic simulation (figure 1).

At the Institute of Precision Engineering, the following simulators are used:

commercial:

- SABER with VHDL-AMS (figure 2),
- DYMOLA with MODELICA.
- FEM: ANSYS

- USAN: A development of the Institute of Precision Engineering for the dynamic simulation of mechatronic systems with a strong emphasis on electromechanical actuators and drives. A PASCAL-like notation is used for model description. An extensive library with electromagnetic and mechanical components is available. Also, an optimizer module is included in the package.

Besides simulation, prototype design as well as measurements and tests are a substantial part of the work of the Institute. The CAD system Pro/Engineer is used for design. Prototypes are manufactured in the workshop of the Institute. A wide range of mechanical, electrical and magnetic quantities can be measured on various test benches.

Applications

- controlled contactors (figure 3),
- motor circuit breakers,
- position controlled electromagnetic linear drives,
- miniaturized electromagnetic actuators, e. g. for grippers with high gripping frequencies or additional locking mechanisms in locking systems

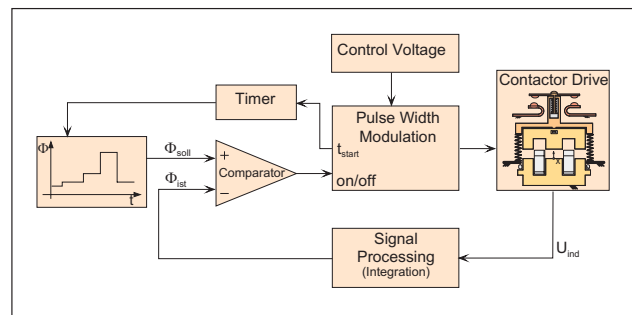


Fig. 3: Velocity control of the electromagnetic drive of a contactor for reduction of contact bouncing

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