Introduction
The magnetic field in electromechanical actuators is not completely confined to its volume. Therefore, placing multiple actuators close to each other, results in magnetic influence between these actuators. This effect is called electromagnetic crosstalk.

In the semiconductor industry and high-precision systems, (sub) nanometer accuracy is required. To achieve the required motion patterns, a two stage motion platform with actuators is applied. The long-stroke stage is used for the large movements and μm positioning, while a short-stroke stage is present for the accurate positioning. Accurate positioning is achieved due to the high predictability of the short-stroke stage. The large permanent magnets in the stator of the long-stroke stage produce a high magnetic flux density distribution in its vicinity. These strong magnetic fields influence the short-stroke actuators and, therefore, reduce the predictability of the short-stroke stage. This problem is illustrated in Figure 1.

Objective
In double-stage high precision machines, electromagnetic crosstalk causes positioning errors of the short-stroke stage. The desire for a more complex chip and simultaneously a smaller chip-size, makes that these positioning errors have a larger impact on the chip quality. Compensational techniques to reduce the crosstalk (for instance shielding with high permeable material) are investigated. For design purposes, a fast and accurate modeling method is desired which includes the possibility for parametric variations.

For shielding with high permeable materials, ideally, a shield with very large dimensions (preferably infinite) and a very high permeability is desired. This would strongly reduce (if not completely eliminate) the electromagnetic crosstalk (compare Figures 2(a) and (b)). Unfortunately, due to practical reasons (weight limits, cable entries, etc.) an ideal shield is not possible. Therefore, the modeling method should include the possibility to incorporate the finite dimensions and holes in the permeable material (as illustrated in Figure 2(c)).

Results
Fourier modeling extended with mode-matching technique is applied on various two dimensional situations. The developed general implementation of this modeling technique is capable of predicting the magnetic flux density in these (Cartesian) 2D situations with errors < 10%. In Figure 3(a) a test setup is shown to measure the force on the victim magnet, this is modeled according to the topology in Figure 3(b).

Using the Maxwell stress tensor the force acting on the moving magnet in the situation of Figure 3 is calculated, the results are given in Figure 5. From this figure it is clear that the semi-analytical model and the finite element analysis model (both assuming a linear permeable material) are in good agreement with each other. The visible difference between the measurements and the model are caused by saturation of the shield.

Conclusion
The semi-analytical model is capable of correctly describing the magnetic flux density as well as the electromagnetic force acting on a moving magnet in the shown situation. Therefore, the model can be used to predict influence of different shielding configurations on the crosstalk between actuators.