This presentation gives an overview of an exploratory study on the application of multivariable control techniques for electromechanical motion systems currently used at Philips CFT. The objective is to extend SISO manual frequency response function based loopshaping techniques towards MIMO control problems. Cases will be presented where multivariable control techniques outperform conventional scalar techniques.

A major difference of multivariable systems compared to scalar systems is the property of directionality, see e.g. [5]. Directionality has a major influence throughout the control problem. This means that not only the multivariable nature of the plant but also the multivariable nature of disturbances and performance objectives must be taken into account. When designing a multivariable controller, directionality properties may be exploited.

Integral relations for multivariable systems, see e.g. [2] or [1] point out that for some cases effects of non-minimum phase behavior in the plant may be reduced when multivariable control is applied. Then a so-called spatial tradeoff of sensitivities is possible in addition to the frequency wise trade-off as in scalar systems (water-bed effect). However, motion systems at Philips CFT do not have such defects, hence this spatial trade-off has negligible effect. As motion systems typically show dominant rigid body behavior, in the frequency region of interest, static decoupling procedures may be applied. Then, from a plant point of view, decentralized control (sequentially designed scalar controllers) leads to satisfactory performance. Decentralized controllers can be designed using manual loopshaping techniques, see e.g. [6]. These multivariable controllers closely resemble those derived using characteristic loci techniques, see e.g. [4], [3].

A new area, quite unexplored, is the use of the multivariable character of disturbances. In many practical applications disturbances are highly coupled as they often relate to the same underlying physical process, e.g. floor vibrations, pumps, reaction forces on metro frames, etc. Tools are proposed to derive multivariable properties of such disturbances. Furthermore, multivariable control solutions based on manual loopshaping are presented that exploit these properties.

Next, an overview is given of manual loopshaping techniques for non-square multivariable design. Cases are presented that show performance limiting properties (e.g. fast-slow systems, mode dynamics, etc.). These cases illustrate that performance can be increased using non-square multivariable control. These control design techniques are strongly related to the conventional scalar loopshaping procedures and offer a relatively simple way to use the power of multivariable control in a practical environment.

References