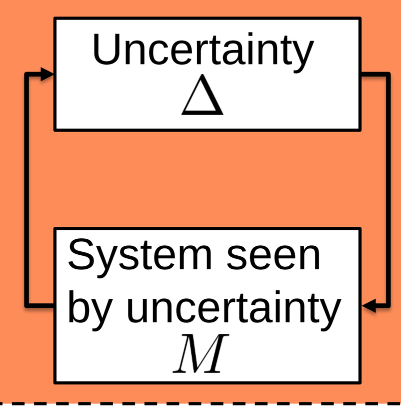
ROBUST STABILITY ANALYSIS OF ORBIT FEEDBACK CONTROLLERS

S. Gayadeen, M.T. Heron and G. Rehm, Diamond Light Source, UK

ROBUST STABILITY TEST

- A control system is "robust" if it is insensitive to differences between the actual system and the model of the system which is used to design the controller. These differences are referred to as **uncertainty**.
- Robust control design procedure:
  1) Find a representation of the model uncertainty.
  2) Determine whether the system remains stable for all "real" processes.
     a) Use **small gain theorem:** If the uncertainty norm <1, then the closed loop is robustly stable if and only if, the system 'as seen by' the uncertainty <1.

Structure for robust stability analysis



ROBUST STABILITY ANALYSIS

Determine uncertainty descriptions

Δ

Singular Value Decomposition

- Response matrix uncertainty: compare ideal and real response matrices
- BPM uncertainty : compare ideal and real left singular vectors
- Corrector uncertainty: compare ideal and real right singular vectors
- Singular values uncertainty: compare ideal and real singular values

Harmonic Decomposition

- Response matrix uncertainty: compare ideal and real response matrices
- BPM uncertainty : compare ideal and real left harmonic matrices
- Corrector uncertainty: compare ideal and real right harmonic matrices
- Fourier coefficients uncertainty: compare ideal and real Fourier coefficients

↓

Determine system seen by uncertainty

M

↓

Determine size of uncertainty

$\|\Delta\|_\infty$

↓

Determine size of system

$\|M\|_\infty$

↓

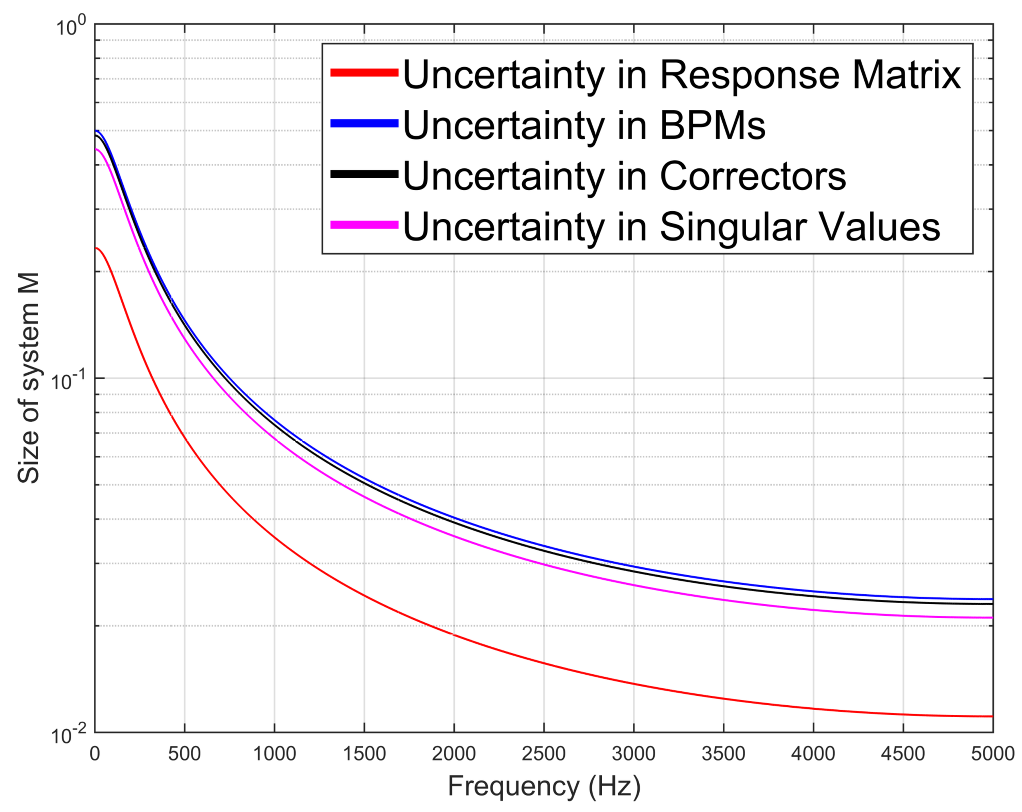
If both are <1 :

$\|\Delta\|_\infty \|M\|_\infty \leq 1$

Closed loop is robustly stable

SINGULAR VALUE DECOMPOSITION ROBUST STABILITY RESULTS

Sizes of M for uncertainties using Singular Value Decomposition

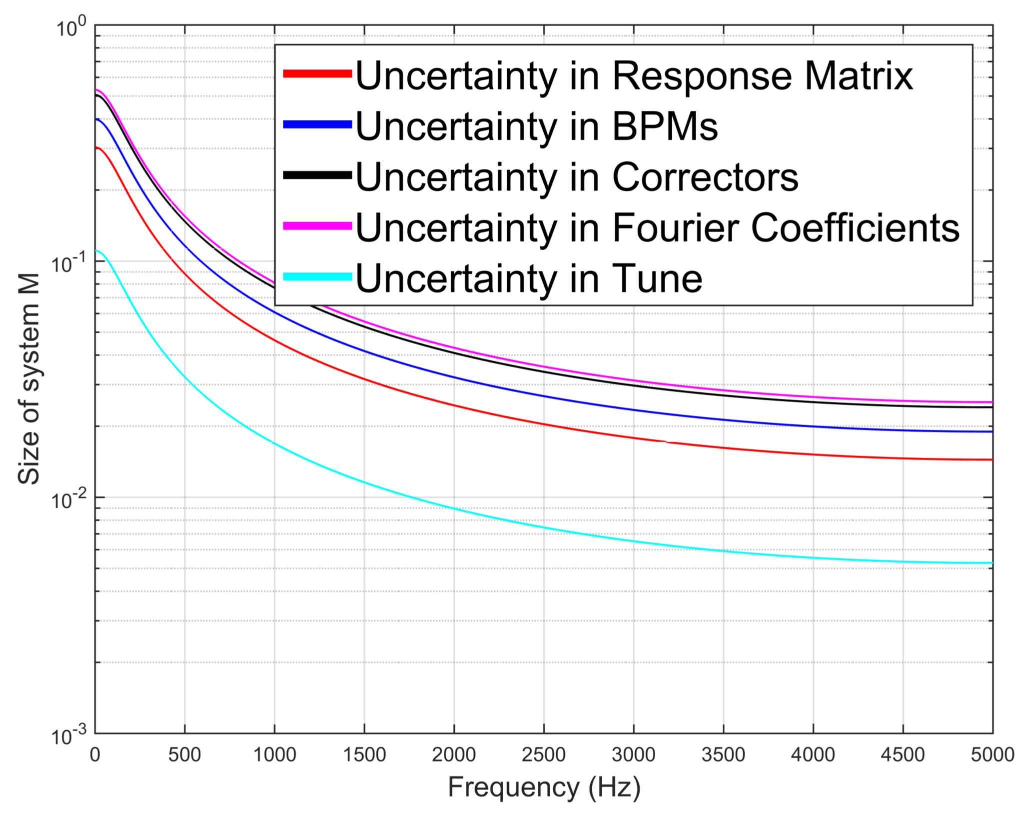


Uncertainty type	Amount uncertainty can increase by before yielding closed loop instability
Response matrix	4.3
BPMs	2.1
Correctors	2.3
Singular values	2

- The size of the uncertainties and systems represented by M are less than 1 so the system is robustly stable.
- (1 / maximum of M) gives the amount the uncertainty is allowed to increase by before the closed loop becomes unstable.

HARMONIC DECOMPOSITION ROBUST STABILITY RESULTS

Sizes of M for uncertainties using Harmonic Decomposition



Uncertainty type	Amount uncertainty can increase by before yielding closed loop instability
Response Matrix	4.3
BPMs	1.5
Correctors	1.4
Singular Values	2.5

- Using harmonic decomposition the uncertainties in BPMs and correctors are directly related to changes in beta function and phase advance at BPM and corrector locations respectively.
- The uncertainty in the Fourier coefficients is directly related to changes in the tune.
- The peak value of the tune uncertainty is 0.1109 which means that the **system seen by the uncertainty can increase by a factor of 9 before the closed loop system becomes unstable.**
- The result corresponds to **a 0.2% change in tune** i.e. for very small tune changes the closed loop is **guaranteed stable**.

For more information please visit www.diamond.ac.uk or contact Sandira Gayadeen at sandira.gayadeen@diamond.ac.uk

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