Linear State Space Control Theory

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Contents

1 Introduction

This document will introduce linear state space control theory for multiple input multiple output (MIMO) systems. The aim of this is to provide engineering students with an alternative set of notes which explains concepts with more details and less assumptions about their knowledge.

1.1 Prerequisites

1. **Linear Algebra**
   - Vector Spaces
   - Matrix Algebra (inversion, determinant)
   - Concept of rank
   - Concept of row, column, null and left null space
   - Eigendecomposition
2. **Linear dynamical systems**
3. **Linear single input single output control theory**
   - PID control
   - Bode Plots
   - Nyquist diagrams
   - Nyquist stability criterion
   - Pole-zero analysis of systems
4. **Integral Transforms**
   - Fourier Transform
   - Laplace Transform and its application to describing linear systems
5. **Ordinary differential equations**
6. **Convolution**

2 State space description

2.1 Assumptions

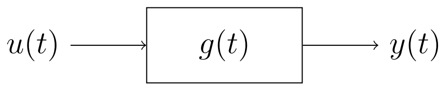

Figure 1: A system in the time domain. $u(t) \in \mathbb{R}^m$, $y(t) \in \mathbb{R}^p$ and $g(t) \in \mathbb{R}^{p \times m}$.

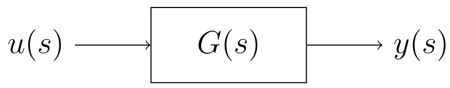

Figure 2: A system in the Laplace domain. $u(s) \in \mathbb{R}^m$, $y(s) \in \mathbb{R}^p$ and $G(s) \in \mathbb{R}^{p \times m}$.

Figure 1 shows the block diagram of a system in the time domain. For all theory derived in this course, we make three key assumptions. Before you apply any of this theory to a real world system, you must make sure it satisfies the following three conditions (most systems do not):

2.1.1 Linearity

Consider the system $g(t)$ in fig. 1. If an

2.1.2 Representable by ordinary differential equations

2.1.3 Time invariance