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ANALYSIS OF THE STABILITY AND PERFORMANCE OF THE INTEGRATED FAULT TOLERANT CONTROL SYSTEMS

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Abstract. In this paper, the stability and performance of the fault tolerant control system (FTCS) are studied. The analysis is based on a general framework of integrated FTCS, in which the system component failure and the fault detection and isolation (FDI) scheme are characterized by two Markovian parameters. In addition, the model uncertainties and noise/disturbance are treated in the same framework. A more general description of system uncertainties is presented in this work. The sufficient conditions for stochastic stability and the system performance using a Stochastic Integral Quadratic Constraint (SIQC) are developed. To validate the analytical results, we perform a simulation study on an example system. Illustrative simulation results are presented, followed by the detailed discussions on the interaction of the FDI and the controller in the FTCS.

Keywords. Fault tolerant control; system uncertainties; stochastic Lyapunov function; stochastic stability; Markovian process.

1 Introduction

The conventional control system design techniques do not consider scenarios of potential system component faults. As a result, the entire control system may fail with a component malfunction. The fault tolerant control systems (FTCS) are capable of maintaining the system stability and a certain degree of performance in the presence of system component faults/failures, [1][2]. Such design techniques are extremely important in safety-critical applications, such as aircraft, space vehicles, and nuclear plant, etc. In most cases, the FTCS rely on the on-line fault detection and isolation (FDI) and control reconfiguration (CR) to recover the system stability and performance. Due to its importance, the FTC has attracted extensive interests and attentions from both industry and academia during the last two decades, see [3][4][5][6] and the references therein. These methods have offered versatile design schemes and frameworks for FTC systems.