A NOVEL INSTRUMENTATION SYSTEM FOR MEASUREMENT OF HELICOPTER ROTOR MOTIONS AND LOADS DATA

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Abstract

Recent U.S. Navy-sponsored research has led to the development of a blade-mounted instrumentation system that incorporates several novel features in support of use for Dynamic Interface flight testing applications. The instrumentation incorporates accelerometer sensors for measurement of both blade aeroelastic deflections as well as applied aerodynamic measurement modules that transmit their serial data using an infra-red (IR) link to the helicopter fuselage. Design issues that incorporate requirements for low-cost, ease of installation and removal, self-contained power sources, and secure datalink transmission are detailed and described.

INTRODUCTION

U.S. Navy rotary-wing flight training and operational evaluation requirements have been aided through extensive use of manned flight simulators. These simulations can provide sufficient realism to reduce the number of operational flight hours required for flight and weapons system training, as well as provide scenarios and environmental factors that would be difficult or impossible to achieve on an as-needed basis[1]. With the ever-increasing computational capability in modern simulators, it has become possible to add additional realism by including more complex physical models for the systems represented by the simulator's computers[2]. However, the addition of simulator model sophistication directly impacts the level of detail required in the measurements and data used for correlation with these simulation models. The ultimate application of the system described here is to provide a simplified means of acquiring rotor motion and loads data, using a combination of accelerometer sensors and a Kinematic Observer processing structure, to help the Navy support this correlation activity and enhance the realism of flight simulators.

Acquiring data from helicopter rotor systems in general and isolated rotor blades in particular, is a difficult task, since the instrumentation systems must operate in a severe dynamic environment, where centrifugal loads may range up to 900 “g”s at the rotor blade tip, and vibratory load spectra can extend out past 60 Hz on the main rotor. In addition, acquiring rotating-frame data necessitates the use of either on-blade telemetry or a slip ring assembly for transmitting sensor input power and signal output to the fuselage or ground station for archiving. And finally, accommodating the particular geometric constraints of the rotor hub system may preclude convenient location of traditional motion sensing instrumentation.

While rotor motion and loads data have been collected for flight tests of helicopters for some time[3-11], most of the instrumentation has required specialized blades, mounting hardware, or other significant modifications to the test aircraft. Although such compromises in implementation flexibility may be acceptable on a research aircraft, the design goals for this helicopter rotor data acquisition system was to avoid as many airframe-specific components as possible, thus allowing it to be used on a wide range of Navy fleet rotorcraft directly. This project sought to address this need through development of an instrumentation system that would combine the convenience of using miniature accelerometer sensors, coupled to a Kinematic Observer signal processor, to provide rotor blade motion and loads data that approach this ideal in aircraft application independence.

Background into the original concept of the use of an accelerometer-based measurement approach for extracting blade motions and loads data was given in an earlier AHS paper[12]. The work described here represents an extension of that effort that culminated in the testing of the system on a full-size, man-capable rotor system. Further developments of the theory used in the processing of the accelerometer sensor signals, design of the telemetry system, issues related to the selection of the data converters, and the details of the actual test are given in the sections that follow.

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