Advances in Aerospace Science and Applications.
ISSN 2277-3223 Volume 4, Number 1 (2014), pp. 7-12

http://www.ripublication.com/aasa.htm

Designing a GPS Based Autonomous Flight Control System for an Unmanned Airship

[1]Avdesh Bhardawaj, [2]Aditya Sindhu[*] and [3]Archit Jain

[1]Department of Applied Sciences, ITM University, Sector 23 (A), Gurgaon, Haryana, India.
[2,3,4]Department of EEE, MAIT, Rohini, Delhi, India.

Abstract

An unmanned airship is a remotely piloted aircraft machine which functions either by the remote control of a navigator or pilot. The unmanned airship uses the autonomous flight, navigation and guidance based on the telemetry command of ground station. The Autonomous Flight Control System (AFCS) plays a key role in achieving the given requirements and missions. This paper introduces the overall design architecture of the hardware and software of the flight control systems in a 50m long unmanned airship. It examines the various facets of the design system and offers a few innovations to it for future applications.

Keywords: GPS, AFCS, HILS, PMC, unmanned aircraft.

1. Introduction

The airship finds applications in civil and military services for heavy cargo transportation and stratospheric platform for communication. The stratospheric platform airships are an alternative to satellites to increase the capability of communication networks. To meet the modern trends, the research of unmanned airships is being developed. The unmanned airship is a non- rigid type and the overall length of the hull is 50m, maximum diameter 12.5m, and a fitness ratio of 4. Helium is used for inflating the envelope whose total volume is about 4090m^3 and inverted Y-type tail fins are attached at the rear of the hull. The propulsion system consists of a gas turbine engine, generator, and two propellers that are installed at an electric motor with a tilting system. This tilting system provides a tilting angle from -90° to +120°. The maximum speed of the flight is about 22m/s and the pressure is 5km with the payload of 100kg[1]. The AFCS controls the dynamics of the airship automatically and manages all the information of the installed subsystem. The proposed airship has 6 types of onboard subsystems: Flight control system, electric system, propulsion system, pressurization system, communication system and mission payload system.

2. Materials and Methods

2.1 Design Requirements of AFCS:

AFCS of unmanned airship require accepting up- link commands and data from the Ground Control Stations (GCS), carrying out the commands on a flying airship, monitoring the current status of the subsystems and detecting the fault and failures on the platform, sending the downlink data to the GCS through the air borne data terminal (ADT), providing the autopilot system to control a flying airship airspeed hold, altitude hold mode of autopilot, determining the position and the altitude with the data acquired from the navigation system, performing the flight mission such as point navigation and station keeping by the guidance algorithm and coping with the emergency and performing a function of return home automatically[6]. During these operations, both the component and equipment of all hardware system should withstand vibration, temperature and humidity requirements as follows:

- Temperature : -20 to +50 degree Celsius
- Vibration : 15 to 2000Hz psd of .01g2/ Hz
- Shock : peak acceleration of 20g with 9ms sinewave
- Humidity : < 95%.

2.2 AFCS Architecture

AFCS hardware has several modules such as flight control computer (FCC), GPS/ INS based navigation systems, test boom for measuring the air data, servo actuator for control surface, and switching module for controlling the propulsive system[3].

2.3 Flight Control Computer (FCC)

The flight control computer adopts a Commercial Off-Shelf (COS) system with ¾ ATR long 7 slot chassis with a power PC 750 single board computer, PCI Mezzanine Cards (PMC) serial I/O module, VME discrete I/O module, VME relay output module, VME analog input module and VME analog output module. The VISTA SCORE power PC Model PC 750 features a multichip module containing a power PC 750 CPU running at 200 MHZ with separate 32Kbytes instruction and data caches and provides 32 Mbytes of DRAM memory with error detection and correction, 16 Mbytes of Flash for program storage and execution, 512 Kbytes of Boot Prom and an internal L2 Tag combined with a dedicated 512KB L2 cache interface. The additional features include two asynchronous RS-232 and two synchronous/ asynchronous RS-432 serial ports, an 8 bit discrete parallel I/O port and a 10/100 BaseT Ethernet interfaces [2]. The PMC serial I/O module offers 8 channels of serial communications including 4 RS-423 asynchronous and 4 RS- 422 synchronous with DMA control engine and 8 Kbytes of dual – ported buffer memory. This module is mainly used to provide additional RS-422 channels for communication of FCC with Airborne Data Terminal (ADT), Airborne Imagery System (AIS), electrically driven thruster, transponder etc. The VME relay output module has 64 double- pole , double throw (DPDT) pre-magnetized relays, which are composed of 32 single pole , double throw (SPDT) 3- pin contacts plus 32 single pole single throw(SPST) 2- pin contacts with any level of AC/DC voltages up to 300 volts and 1 amp maximum. These relays are dedicated to power control and power control loop- back signals for several subsystems such as pressurization system, engine controller, transponder, airborne camera, left/ right inverters and cooling fan. The VME analog input module, implements 32 single ended channels with 12 bit analog to digital converter, receives signals from temperature sensors, pressure sensors and voltage sensors to monitor the current status for envelope, ballonet and ambient of the airship. The VME analog output module provides 24 independent digital to analog converters with 12bit resolution outputs analog command signals to control surface actuators [4].

2.4 GPS / INS Based Navigation System

To measure the attitude, position and velocity information, the airship adopts GPS/INS hybrid navigation system as a main navigation sensing unit. This uses a Digital Laser Gyro (DLG) and a 3 allied signal accelerometers and GPS receiver module for pure inertial, GPS–only and blended GPS/ INS solutions. The acquired information is feedback to FCC through MIL-STD 01553B interface.

2.5 Air Data Boom

To measure the air flow speed, the space age control 100600 straight – node air data boom is installed on the front of the nose cone of the airship. This boom contains static and total head pressure pickups and angle of attack and sideslip vanes. The vanes also called airflow direction transmitters or flow angle sensors are coupled to precision potentiometers to provide an electrical signal indicating airflow direction relative to the airship body axis.

2.6 Servo Actuator for Control Surface

Servo actuators are designed to control and operate the unmanned airship’s control surfaces such as rudder, left elevator and right elevator. Two servo actuators are engaged to each control surface with a hinge, which is designed to reduce the hinge moment down and to increase the reliability. Each servo actuator is composed of Poly-Scientific Clifton Precision 308vs.1 planetary gear heads which are coupled to 400w brushless DC servomotor with an encoder and a servo controller. The servo controller has been designed to convert a 12 bit command signal from RS- 485 port to 20 KHZ Pulse width modulation (PWM) signal. The final signal can be converted to the physical position and feedback of the state of the servo actuator is provided.

3. Discussions

3.1 Software Design of AFCS

The flight software system manages the proper control of all hardware and subsystem components connected to AFCS and carries out the automatic control algorithms associated with the major activities. The flight software is implemented with C-language under the Vx Works real time OS environment. The structure of the software design is given in Fig. 1. The basic module of the flight software is a task processor related with each subsystem and other activities. The data type for the data communication system is defined by using the bit field structure [5]. To perform the function of autonomous flight, navigation and guidance, several autopilots and guidance flight modes are designed and implemented by control laws. The autopilot inner loops consists of the pitch hold, altitude hold, velocity hold and heading hold mode. Based on these autopilot functions the outer guidance loop can be selected and worked by the ground control station selection command.

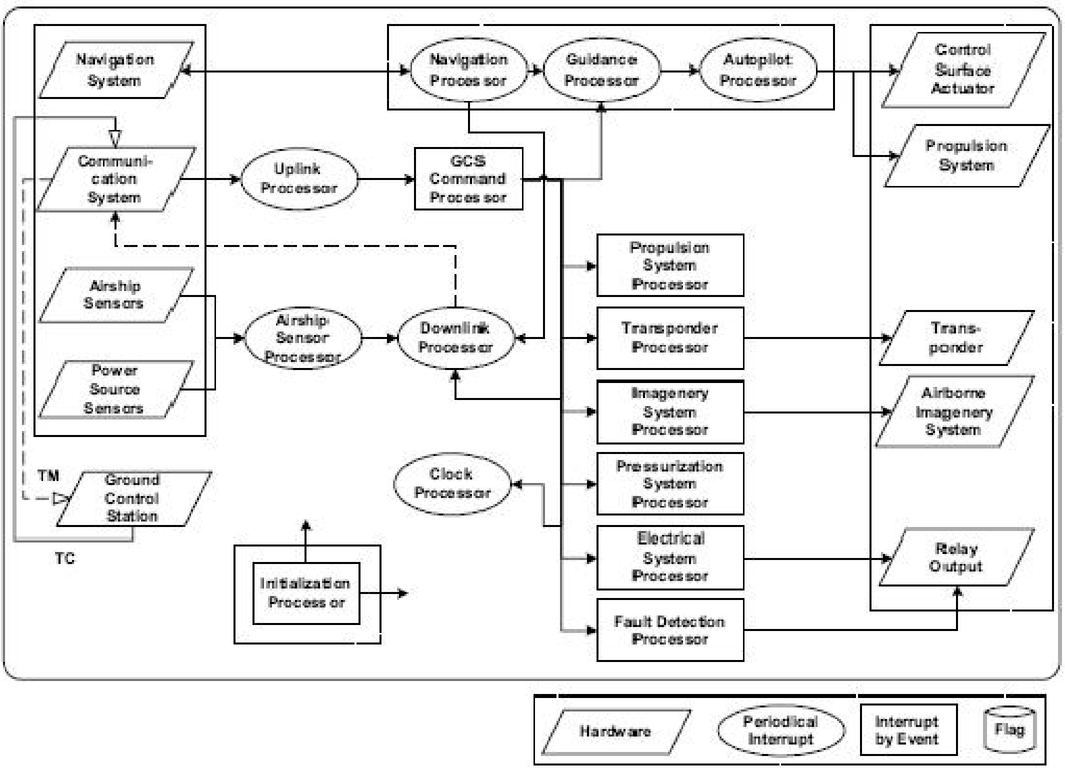

Fig. 1: Software Structure of Flight control.

3.2 Simulation and Evaluation

The system components and the hardware are subjected to test procedures to evaluate the performance of the airship. This test includes the acceptance test and the interface test with other subsystems. For the testing of autopilot and guidance algorithm, a non-linear 6 degree of freedom simulation program for the unmanned airship was developed which is used for the simulation and for the checking of the designed control laws and for the evaluation of the task processor, the Procedure- In-the-Loop-System (PILS) was used for the verification of the performance and debugging of the error of the coding algorithm. After the subsystem level tests, the AFCS should be installed in the unmanned airship and the ground integration test will be performed to verify the operation with the working of the engine.

4. Conclusion

AFCS is designed for an unmanned airship with its hardware and software structure. The various requirements for the design were presented and the autopilot and guidance algorithm have been developed. The unmanned airship with the autopilot were simulated and tested using the HILS structure and the various flight conditions. More research is needed for developing greater automation.

References

[1] E.H.J.Pallett, T.Eng.(CEI), A.M.R.Ae.S., F.S.L.A.E.T,“Automatic Flight Control “, *Granada, London Toronto, Sydney, NewYork.*
[2] Kim,D.M.et., “Development of an Unmanned Airship System”, *Proceeding of 4th International Airship Convention And Exibition*, July 2002.
[3] Yeom, C.H. et al., “System Integration Standard for KARI 50m Unmanned Airship”, *KARI Technical Report*, May 2002.
[4] Ahn, I.G. et al., “Development Standard of Flight Control System for KARI 50m Unmanned Airship”,*KARI Technical Report*, May 2002.
[5] Ryu, H. et al., “Design of FCC Software for KARI Unmanned Airship”, *KARI Technical Report*, May 2002.
[6] Donald McLean, “Automatic Flight Control Systems”, Prentice Hall International, series In Systems and Control engineering, 1990.