Design and Implementation of Microsatellite Telemetry, Tracking and Command (TT&C) Subsystem

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ABSTRACT

The paper describes the design, fabrication, and test of telemetry, tracking and command (TT&C) subsystem on the microsatellite CKUTEX (Cheng Kung University Technology EXPERimental satellite). The objective is to implement a communication subsystem indigenously for the application to self-reliant microsatellite. The subsystem design, circuit fabrication, test, as well as software development are performed to be compliant with the CKUTEX communication requirements. The TT&C subsystem consists of beacon broadcasting circuit, telemetry circuit, and telecommand circuit. The beacon broadcasts with Morse code for the ground station around the world for the tracking of the CKUTEX. In contrast, the telecommand and telemetry are accessed by the CKUTEX team for mission operation and control. The onboard TT&C module is controlled through a microprocessor for mode transition, frequency synthesis, data processing, and communication interface with other subsystems. The overall subsystem is integrated and verified through the end-to-end test.

Keywords: Satellite communication, Frequency synthesis, AFSK modulation and demodulation, AX.25, CKUTEX

I. INTRODUCTION

In 2008, a team of professors and students at NCKU started to develop the CKUTEX (Cheng-Kung University Technology Experimental) microsatellite which aims to demonstrate university capability in satellite development and establish a development platform of microsatellite[1,2]. CKUTEX is a microsatellite with 30 kg and dimension 365x260x399 mm³. The payloads of the CKUTEX include a self-developed space-borne GPS receiver and MEMS based digital sun sensor. When the CKUTEX is launched into orbit, its mission operation relies on the wireless communication. Consequently, it is desired to design a self-made satellite communication subsystem TT&C (abbreviated from Telemetry, Tracking and Command) to accomplish the necessary communication functions.

Based on the mission scenario, after CKUTEX is launched into space, TT&C should be capable of broadcasting beacon with the identification and simple SOH (Status Of Health) information to be tracked by ground stations around the world. When contacting with NCKU ground station which is located at NCKU ASTRC, the ground station will send commands to require CKUTEX to downlink scientific data or change operation mode. Once receiving the commands, TT&C will respond or downlink telemetry data to ground station for further analysis. The design of the TT&C subsystem to fulfill the above operation scenarios is very challenging. In the paper, the design considerations, fabrication details, and integration test of the TT&C subsystem are discussed.

II. SUBSYSTEM OVERVIEW

2.1 TT&C Architecture

The architecture of the CKUTEX TT&C subsystem is shown in Figure 1. The Micro Control Unit (MCU) is the core and responsible for the execution and coordination of tasks in TT&C subsystem. It