SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advanced Systems (3)

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HIGH-SPEED DOWNLINK COMMUNICATIONS WITH HUNDREDS MBPS FROM 50KG CLASS SMALL SATELLITES

Abstract

Recently technologies of small satellites have been so matured that many earth observation missions have been proposed. However, it is true that small satellite missions still have limitations of satellite functions compared to large satellites. Their main limitations are optical sensing capability as well as down link capability. The purpose of this research is to develop high-speed (typically 250Mbps) communication system which can be applicable to small satellites of 50 kg class. We will demonstrate our technologies on orbit using Japanese Hodoyoshi Satellite 3 and 4 launched in 2014. Conventional communication systems of large satellite have capability of hundreds Mbps through 1Gbps and in most cases they utilize X band (8025-8400MHz) for earth observation. Amplitude-phase modulation schemes are applied since frequency bandwidth is limited. They require digital processing circuits with several hundred MHz clock. Space-qualified devices for these purposes require large power consumption, high cost, and special care for ball grid array devices. RF power amplifiers have to operate in linear region, which causes reduction of power efficiency. The antenna is mounted on movable gimbals, which also requires large power consumption. A conventional high speed communication system requires 100W or 200W as total. On the other hand, 50kg small satellite can generate only as small as 100 W power. A high-speed communication system could be allocated about 20-30W for 10 minutes communication pass. This is the power constraint for high-speed communication system for small satellites. We have been developing the communication subsystem both for flight hardware as well as ground system as follows. We have developed GaN HEMT RF power amplifier with maximum efficiency of 45%. It is found that the nonlinear saturation characteristic is milder than conventional GaAs FET power amplifier. Digital pre-distortion processing for RF input to the power amplifier found to be very effective to reduce the consumption power. Digital processing of pulse shaping filter and pre-distortion are performed with oversampling of factor 2.5 (250MHz). This relatively low sampling rate relaxes digital circuit implementation. The higher harmonics due to this sampling can be eliminated by an analog low pass filter. Resulting transmitted signals will suffer from greater linear/nonlinear distortion than conventional system. Based on Consultative Committee for Space Data Systems (CCSDS) 131.0-R recommendation, a serially concatenated convolution turbo coding (SCCC) turbo equalization system equipped with nonlinear distortion compensation techniques in the receiver has been developed. This powerful ground capability relaxes constraint of on-board instruments.