SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Near-Earth and Interplanetary Communication Systems (4)

Author: Dr. Atsushi Tomiki
Japan Aerospace Exploration Agency (JAXA), Japan, tomiki.atsushi@jaxa.jp

Dr. Tomoaki Toda
Japan Aerospace Exploration Agency (JAXA), Japan, toda@isas.jaxa.jp
Prof. Hirobumi Saito
Japan Aerospace Exploration Agency (JAXA), Japan, koubun@isas.jaxa.jp
Mr. Hideho Tomita
HIM Technology, Japan, ht3325a@yahoo.co.jp
Prof. Takehiko Kobayashi
Tokyo University , Japan, koba@c.dendai.ac.jp

DESIGN AND IMPLEMENTATION OF KA-BAND COHERENT TRANSMISSION FUNCTION FOR JAXA X-BAND DEEP SPACE DIGITAL TRANSPONDER

Abstract

NASA and ESA have taken full advantage of using Ka-band (32 GHz) for the purpose of high-rate data transmission, precise orbit determination, and planetary explorations in this frequency. JAXA developed a next generation X-band deep space digital transponders for the deep space programs such as Planet-C and MMO. The transponders were designed in 2004 using the commercially-off-the-Shelf (COTS) products in order to reduce the development costs. Those were developed using field programmable gate array (FPGA) of digital signal processors (DSP) attaining regenerative ranging capability, which was not the subject to launch mass limit. As a next step, a Ka-band coherent transmitter function will be provided to extend this X-band transponder capability. Preliminary design on this Ka-band transmitter attachment will be discussed in this paper. A highly stable onboard oscillator has been also examined to enhance the availability of Ka-band telecommunications in deep space. The coherence between uplink and downlink carrier is generated in each direct digital synthesizer (DDS) simply by the multiplicating the numbers corresponding to frequency ratios: 3328/749, 3344/749, and 3360/749, respectively. A reference frequency 8f_o is produced by the synthesized USO. This design utilizes a Ka-band vector modulator for data signal generated from an FPGA (ALTERA FLEX10K100) in the X-band transponder DSP unit. This allows us to use a variety of modulation schemes in the communication systems. The centre frequency is 32 GHz and the transmission bandwidth was up to 100 MHz. A 880f_o phase modulator is used for the Ka-band downlink telemetry, turnaround ranging, and Delta-DOR tones. A breadboard model (BBM) of the synthesized ultra stable oscillator consisted of a DDS, a multiplier, an amplifier, a bandpass filter, and an oven controlled crystal oscillator (OCXO) to realize ultra low phase noise. The synthesizer used a DDS device supplied from Analog Device driven by a 25 MHz clock, yielding a low power operation. This DDS architecture enables us to adjust the output frequency after the launch with a high spectral purity and low power consumption. A new Ka-band transmitter has been designed to attach to the conventional our X-band deep space digital transponder. Ka-band downlink capability will change and enhance the future deep space explorations in ISAS/JAXA by realizing high speed data link, high accuracy navigation, and high precision radio science experiments. Further details will be discussed in the final paper.